THE GOVERNANCE OF
AQUIFER INJECTION
USING COAL SEAM GAS PRODUCED
WATER
IN THE
SURAT CUMULATIVE MANAGEMENT AREA,
QUEENSLAND, AUSTRALIA,
AND THE
POWDER RIVER BASIN, WYOMING, USA

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Arts, Education, Law
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Submitted in fulfilment of the requirements of the degree
Doctor of Philosophy

September 2019
ABSTRACT

The sustainable governance of groundwater is of the utmost importance in an arid country like Australia. Groundwater is relied on by our agricultural and pastoral communities. Groundwater is also a significant issue in mining, oil and gas extraction and energy production. Recent conflicts between pre-existing pastoral and agricultural groundwater users and more recently introduced coal seam gas (CSG) industry in Australia highlight the difficulties in governing our groundwater resources. These are not simple concerns either. Debate over how to manage the Great Artesian Basin (GAB) resources, which underly most of Queensland, has been simmering for over a century and despite our best efforts, key GAB aquifers continue to display declines. In one way or another, the sustainability of groundwater is important for Australia, and particularly for the whole of the Queensland economy.

A relatively unknown process in Queensland called Managed Aquifer Recharge (MAR), or aquifer injection, has been recently adopted by the CSG industry in the Surat Cumulative Management Area (CMA), Queensland, to replace potable groundwater in GAB resources. CSG produced (or associated) water is produced along with the CSG. Aquifer injection using CSG produced water is a process that can therefore assist in the sustainable management of groundwater resources. Identification of any regulatory mechanisms that enable safe aquifer injection in the CSG context, could assist with respect to conflicts between the different groundwater users, but could also contribute to the sustainable governance of groundwater resources generally. A comparison between the regulatory frameworks for aquifer injection using CSG produced water and associated outcomes in the Surat CMA, Queensland, and the Powder River Basin (PRB), Wyoming, provides the opportunity to determine whether regulatory initiatives can enable positive outcomes for valuable groundwater resources. Answering this question will have relevance for the CSG industry (and other extractive industries). It will also be relevant for agriculture, pastoralists and rural communities and the wider community that understands that our precious groundwater resources demand our care and attention.

Based on a broad literature review of common pool resource (CPR) theory, adaptive management, and scholarship involving MAR, I develop a detailed set of design principles, termed the ‘Aquifer Injection and Augmentation design principles’ (AIA design principles). These are based
on Ostrom’s\(^1\) design principles for CPRs and are illustrated using a heat map. Green, amber or red colours depict whether the specific AIA design principle is present, somewhat present or absent. My analysis is based on document analysis (of more than 303 permits, licences, environmental authorities and supporting documents), and quantitative and qualitative data (semi-structured interviews with 33 participants and 39 relevant public submissions) in respect of two case study jurisdictions: the Surat CMA, Queensland and the PRB, Wyoming. This enables jurisdiction specific evaluations against the AIA design principles and the production of corresponding heat maps which are compared to the empirical outcomes for the governance arrangements. The empirical outcomes considered include the physical outcomes for aquifer injection of CSG produced water in each jurisdiction, such as the quantum of water reinjected and any issues involving groundwater quality. Additionally considered empirical outcomes also include the rate of uptake for the process as well as the existence of any documented conflict and lack of trust for the process or around groundwater governance generally.

My key findings relate to both the governance of groundwater and aquifer injection of CSG produced water. I demonstrate that the presence (or absence) of the AIA design principles correlate with findings of relative success in terms of sustainability of the governance of the groundwater system, extraction of CSG produced water and injection. In addition, transparency of reliable information, such as decisions and reports that involve the groundwater resource and upon which the regulators base decisions, appear to enable sustainable groundwater governance, and aquifer injection of CSG produced water. I also demonstrate that adaptive management can assist in reducing uncertainty and thereby enable aquifer injection using CSG produced water, but a lack of transparency around decision making can limit the effectiveness of an adaptive approach.

Specifically, for the governance of the injection activity, a lack of clear and transparent rules (such as a permit) for the injection process, a lack of rules that consider local geographic (and social) factors and fragmentation between government agencies appear to be impediments to the effective governance of this activity. The role of an ability for relevant stakeholders to participate in rulemaking, and their rights to organise themselves in terms of rulemaking is unclear, particularly where monitoring and sanctions for rule breaking are present. Moreover, unquantified economic benefits of injection appear to be relevant, but further economic analysis of this issue is necessary. These findings highlight weaknesses and strengths of the current governance frameworks around groundwater and aquifer injection in the Surat CMA, Queensland and PRB, Wyoming.

I recommend three initiatives for the governance of groundwater and specifically, aquifer injection of CSG produced water. First, a commitment to transparency of reliable information is paramount. Once transparency is embedded, my second proposed initiative is the adoption of a broad and inclusive adaptive management approach which can enable sustainable outcomes. My third recommendation is to adopt broadly inclusive and transparent deliberative participation on regulatory reforms for the Surat CMA relating to groundwater generally, the extraction of CSG produced water, and injection. This deliberation will assist in transforming current governance arrangements to enable sustainable outcomes in that jurisdiction where the CSG industry (and other extractive resources impacting groundwater) are expanding.

With increasingly boom and bust cycles involving surface water hydrology, groundwater is an extremely important buffer for water security. Sustainable development of groundwater will be even more critical for our health, wellbeing and survival in the future. Initiatives that deliver sustainable outcomes for our precious groundwater resources are therefore acutely necessary.
STATEMENT OF ORIGINALITY

This work has not previously been submitted for a degree or diploma in any university. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made in the thesis itself.

Signature:

Date:
PERSONAL ACKNOWLEDGEMENTS

I am indebted to my supervisors, Professor Poh-Ling Tan and Professor Don Anton, for encouraging and inspiring me, and who have patiently supported me throughout this research journey. I am also very grateful to the vibrant Griffith Law School. The professional and administrative staff, as well as the current cohort of PhD students, makes it a happy and productive institution in which to undertake a PhD.

Thank you to all the participants who generously gave their time in interviews so that I could unpack the many issues that influence the governance of groundwater and aquifer injection in the coal seam gas space. Your input made the project so much more enjoyable and interesting.

Most importantly, I would like to acknowledge and thank my family, my husband, Peter, and three adult children, Sophie, Charlotte and James. Without their support, inspiration and many long discussions around the dinner table, this thesis would not have been possible.
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STATEMENT OF ACKNOWLEDGEMENT
OF PUBLICATIONS AND EDITORIAL ASSISTANCE

Some of the original material in Chapter 1 was included in the following article published during my candidature:


Some of the original material in Chapter 7 was included in the following article accepted for publication during my candidature:


I have also published the following chapter relating to the governance of groundwater in the coal seam gas and mining context, which did not include original material from this thesis but, nonetheless, formed background to the research:


I also delivered the following conference paper during my candidature, which also presented some of the themes discussed in this thesis:

• Robertson, Jacqui, ‘MAR in the CSG Context: Weaving a Robust Fabric within Environmental Protection and Water Frameworks,’ (February 2018) Australian NELA Colloquium, Hobart.

I received editorial assistance in the formatting of the thesis, proofreading the main text and copyediting of the footnotes and references by Jessica Cox of Quick Fox Editing.
LIST OF ABBREVIATIONS AND ACRONYMS

AIA  Aquifer injection and augmentation

AIA DP Aquifer injection and augmentation design principle

AM  Adaptive management

APD  Application for permit to drill (US and Wyoming)

APPEA the Australian Petroleum Production and Exploration

AP LNG Australia Pacific LNG Pty Ltd (including subsidiaries and joint venture partners)

Arrow Arrow Energy Pty Ltd (including subsidiaries and joint venture partners)

ASR  Aquifer storage and recovery

ATP  Authority to prospect

BR and Moonie WP Water Plan (Border Rivers and Moonie) 2019 (Qld)

BTEX Benzene, toluene, ethylbenzene and xylene

Burnett WP Water Plan (Burnett Basin) 2014 (Qld)

CBM Coal Bed Methane

C-B WP Water Plan (Condamine and Balonne) 2019 (Qld)

CCA  Central Condamine Alluvium

CFR  Code of federal regulations

CMA  Cumulative Management Area

COAG Council of Australian Governments

CPR  Common pool resource

CSG Coal Seam Gas

CSG WMMP Coal Seam Gas Water Monitoring and Management Plan

Cth Commonwealth

DP  Design principle

EA  Environmental approval
EIS  Environmental Impact Statement

EP Act  Environmental Protection Act 1994 (Qld)

EPBC Act  Environment Protection and Biodiversity Conservation Act 1999 (Cth)

Fitzroy WP  Water Plan (Fitzroy Basin) 2011 (Qld)

FLPMA  US Federal Land Policy and Management Act 1976

GAB  Great Artesian Basin

GABORA  Water Plan (Great Artesian Basin and Other Regional Aquifers) 2017 (Qld)

GL  Gigalitre

IAA  ‘Immediately affected area’ within the terms of Chapter 3 Water Act 2000 (Qld)

IAR  Impact assessment report under the State Development and Public Works Organisation Act 1971 (Qld)

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

IWRM  Integrated water resources management

KM  Kilometres

L  Litres

LAA  ‘Long term affected area’ within the terms of Chapter 3 Water Act 2000 (Qld)

MAR  Managed aquifer recharge

Mg/L  Milligrams per litre

ML  Megalitre

MOU  Memorandum of Understanding

NWI  National Water Initiative

OGIA  Office of Groundwater Impact Assessment

Origin  Origin Energy Limited (including subsidiaries and joint venture partners)

P&G Act  Petroleum and Gas (Production and Safety) Act 2004 (Qld)

PL  Petroleum lease

POD  Plan of development

PRB  Powder River Basin
QDES  Queensland Department of Environment and Science. Since the machinery of government changes following the 2017 state election, this department is the relevant administering agency for Queensland’s environmental protection legislation. Formerly, this department was the Queensland Department of Environment and Heritage Protection, the Queensland Department of Environment and Resource Management, and the Queensland Environment Protection Agency.

QDEHP  Queensland Department of Environment and Heritage Protection, the former Queensland environmental regulator

QDERM  Queensland Department of Environment and Resource Management, a former Queensland environmental regulator

QDEX  Queensland Government Queensland Digital Exploration Reports System

QLD  Queensland

QDNRME  Queensland Department of Natural Resources, Mines and Energy, the current Queensland regulator responsible for the governance of water as well as mineral, petroleum, oil and gas resources

QGC  QGC Pty Ltd (including subsidiaries and joint venture partners)

RIDA  Regional interest development approval under the Regional Interests Planning Act 2014 (Qld)

Santos  Santos Ltd (including subsidiaries and joint venture partners)

SAR  Sodium absorption ratio

SDWA  US Safe Drinking Water Act 1974 (42 USC §300f et seq (42 USC Ch 6A Subch XII) (2017))

Senex  Senex Energy Ltd (including subsidiaries and joint venture partners)

SES  Social ecological system

su  Standard unit

TDS  Total dissolved solids

UIC  Underground injection control

USA  United States of America

US BLM  United States Bureau of Land Management, responsible for managing federal public lands

USC  US Code (legislation)

US DOI  US Department of Interior

USGS  United States Geological Survey
UWIR  Underground Water Impact Report

Water Act  Water Act 2000 (Qld)

Water Supply Act  Water Supply (Safety and Reliability) Act 2008 (Qld)

WCM  Walloon Coal Measures

WDEQ  Wyoming Department of Environmental Quality, the Wyoming state environmental regulator

WGS  Wyoming Geological Survey

WP  Water plan

WS  Wyoming Statutes

WSEO  Wyoming State Engineer’s Office, the Wyoming state water regulator

WOGCC  Wyoming Oil and Gas Conservation Commission, the Wyoming state oil and gas resources regulator

WYO  Wyoming
**GLOSSARY**

An **aquifer** is ‘a layer or layered sequence of rock or sediment comprising one or more geological formations that contains water and is able to transmit significant quantities of water under an ordinary hydraulic gradient’, such as ‘sands, gravels, solutionally weathered limestones and fractured sandstones’.²

An **aquitard** is a ‘formation of lower permeability that may transmit quantities of water that are significant in terms of regional groundwater flow, but from which negligible supplies of groundwater can be obtained’, such as ‘fluvial and glacio-fluvial silts and sandy clays, sedimentary rocks with few fractures and fractured crystalline rock’.³

An **aquiclude** is ‘a saturated geological unit of such low permeability that [it] is incapable of transmitting significant quantities of water under ordinary hydraulic gradients and can act as a barrier to regional groundwater flow’, such as ‘clays, shales and metamorphic rocks’.⁴

**Artesian water** means ‘water that occurs naturally in, or is introduced artificially into, an aquifer, which if tapped by a bore, would flow naturally to the surface.’⁵

**Artesian bore or well** is a bore or well ‘drilled into confined aquifers that are under pressure. In artesian wells [or bores], the piezometric level is above the ground surface, meaning that water could flow to the surface unaided.’⁶ In Queensland, Australia, the term is defined as including ‘a shaft, well, gallery, spear or excavation, and any works constructed in connection with the shaft, well, gallery, spear or excavation, that taps an aquifer and the water flows, or has flowed, naturally to the surface.’⁷

For **associated water**, see definition of produced water below.

**Bore** is short for borehole and is the term used in Australia for ‘a deep hole of small diameter bored to the aquifer.’⁸

**Coal seam gas** (CSG) or **coal bed methane** (CBM) occurs in conjunction with coal seams and is ‘usually “dry”, being almost entirely methane with very little of the heavier hydrocarbons such as

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³ Hiscock and Bense, above n 2.
⁴ Ibid.
⁵ Water Act 2000 (Qld), sch 4.
⁷ Water Act 2000 (Qld), sch 4.
propane or butane and no natural gas condensate’. The methane can be in a near liquid state and the water pressure and reservoir pressure hold the gas in place. CSG is the term most often used in Australia and CBM is the term most often used in the USA.

A **confined aquifer** is ‘contained between two aquitards or aquicludes’. 

**Conventional gas** ‘is a combustible mixture of hydrocarbon gases found alone or with oil in oil fields’. Entrapment of the gas is usually structural and extraction is often helped by natural pressure in the reservoir; very little water is displaced in the process. The water that is displaced is usually extremely salty, sometimes 10 to 11 times saltier than seawater.

**Groundwater** or ‘**underground water**’ is water that is resident in an aquifer.

**Hydraulic fracturing** or ‘fracking’ is where fluids consisting of water, sand and chemical additives are injected into the formation in order to open or enlarge fractures in the rock and proppant material keep the fractures open.

**Produced water** or ‘**associated water**’ is the water that is extracted (or produced) along with the unconventional gas during extraction.

**Shale gas** is a natural gas dispersed within source rocks such as shales and carbonates. These deposits are usually found at much greater depths compared to CSG.

**Subartesian water** means ‘water that occurs naturally in, or is introduced artificially into, an aquifer, which if tapped by a bore, would not flow naturally to the surface.’

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10 Ibid.
11 Hiscock and Bense, above n 2.
12 John Williams Scientific Services Pty Ltd, above n 9, 9.
13 Ibid.
16 John Williams Scientific Services Pty Ltd, above n 9.
17 Ibid.
18 Water Act 2000 (Qld), sch 4.
Subartesian bore or well ‘includes a shaft, well, gallery, spear or excavation, and any works constructed in connection with the shaft, well, gallery, spear or excavation, that taps an aquifer and the water does not flow and never has flowed naturally to the surface.’\(^{19}\)

Surface water refers to water that is found in rivers, lakes, wetlands and overland flows, such as stormwater and flood water.

Tight gas is a poorly defined category of unconventional gas most often dispersed in low permeability rocks, which require large-scale fracturing to extract the resource.\(^ {20}\)

An unconfined aquifer ‘exists when a water table is developed that separates the unsaturated zone above from the saturated zone below’.\(^ {21}\)

Unconventional gas includes coal seam gas (or coal bed methane), tight gas, tight oil and shale gas.\(^ {22}\) Large amounts of water of variable quality are produced as part of all unconventional gas extraction.\(^ {23}\)

A well is the US term for a bore.

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\(^ {19}\) Water Act 2000 (Qld), sch 4.
\(^ {20}\) John Williams Scientific Services Pty Ltd, above n 9.
\(^ {21}\) Hiscock and Bense, above n 2.
\(^ {23}\) John Williams Scientific Services Pty Ltd, above n 9.
PART A: THE COAL SEAM GAS WATER PROBLEMATIQUE

CHAPTER 1: THE RESEARCH AGENDA

1. Coal Seam Gas (CSG) production impacts on water

This research topic began in both my professional and personal life. While acting for mining, quarries and large residential developers in private legal practice, I noticed one recurring problem: water. For mines and quarries, water is a big issue because groundwater filling up the pit must be pumped out continually so that the resource, whatever it is, can be dug out. For large residential developments, the need to service them with water (and plumbing) is complicated. On the personal side, many of my friends and family are farmers producing for cities, and export to the world: sugar, dairy, cattle, poultry and pigs. There was always something that concerned them as well: water. They weren’t just simple concerns either. Water issues can mean the difference between thriving, surviving or going under.

At that time, the most troublesome problem involving water and development appeared to involve the coal seam gas industry. Conflict between the coal seam gas (CSG) industry and farmers in Australia has been so heated that it has spilled over into the cities and Parliament. Mostly, when I tell people that I am researching how the CSG industry impacts water resources, they assume that I am researching fracking (hydraulic fracturing). Common questions posed are: is fracking good or bad; is the CSG industry good or bad? Fracking is certainly a process that is worthy of concern. Yet, only 8% of wells are fracked in Queensland. By contrast, I consider that the impacts of the CSG industry on water resources is far more concerning, particularly for an arid country dependent on

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24 The Queensland Government enacted the Petroleum and Gas (Production and Safety) Act 2004 (Qld) to provide specifically regulated unconventional gas extraction; other states have restricted or banned it. A gas moratorium has been in place in Victoria since 2012, which has been extended to 2020. See: Media Statement by the Premier: Daniel Andrews MP, Victoria Bans Fracking to Protect Farmers (30 August 2016) <https://www.premier.vic.gov.au/victoria-bans-fracking-to-protect-farmers/>. In NSW, there are restrictions on gas exploration within areas important for horse breeding and viticulture, as well as within 2 km of residential areas. See: State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007 (NSW), cl. 9A.

25 Although fracking is more commonly used with respect to shale gas development, during 2014, only 8% of all petroleum and gas wells have been hydraulically fractured in Queensland. See: Department of Environment and Science, Queensland Government, Fracking <https://environment.des.qld.gov.au/management/non-mining/fracking.html>.
water for much of its prosperity. Since 2004, the CSG industry has expanded so quickly that it is now the largest extractor of water from the Great Artesian Basin (GAB) in its area of operations in Queensland.\textsuperscript{26} Yet, key aquifers in the area show declining trends.\textsuperscript{27} I was perplexed that fracking takes up so much of our attention, while there are continued declines in groundwater resources. Since the relatively recent introduction of CSG production, CSG projects in Queensland have developed into a billion-dollar industry.\textsuperscript{28} Whatever the merits of the industry, we must assume that it is now here to stay. Therefore, we ought to acknowledge and address its place within our water governance\textsuperscript{29} framework.

This thesis focuses on the impacts of CSG projects on groundwater resources due to the necessary production of water during CSG extraction. In the thesis, this water is referred to as

\begin{footnotesize}
\begin{enumerate}
\item All aquifer formations in the Surat CMA area have more water leaving the system than recharging, and key groundwater formations have declining trends: Klohn Crippen Berger, above n 26, v and 94, and see below chapter 5 section 2, at p 153–155 for more detail.
\end{enumerate}
\end{footnotesize}
‘produced water’. A potential practical solution to the problem of the production of water along with the CSG is to reinject the unwanted water back into thirsty groundwater formations. As a lawyer, I wondered whether there were governance initiatives relating to aquifer injection involving CSG produced water that could enable ‘sustainable’ development of our groundwater resources? If there were, they may also assist mining and quarries, as well as facilitate conjunctive management of surface and groundwater to promote water security generally. The research project started at this point: a humble goal, a small question involving a relatively rarely used activity in Queensland (aquifer injection) that might make a difference in a much broader context. But, as the reader will discover, it ended at another point entirely. Like all governance problems, the solution to this question has not been straightforward.

Significant issues around water governance and CSG development involve the quantum of extraction and related impacts on groundwater, as well as how to manage the produced water after extraction. This is because CSG projects directly compete with agriculture and pastoralists for water resources. The gas resource is often located very near or is itself a groundwater source. Most of the water produced during CSG extraction comes from the Surat geological basin, which is located within the GAB. The Walloon Coal Measures, which are the source of the CSG in the Surat Basin, is itself a GAB aquifer. It is also the source of groundwater for agriculture and underlies the Condamine Alluvium, which is the largest allocated groundwater source in Queensland. All regional towns, stock and domestic uses, feedlots, irrigation, and industrial activities in the same area rely on groundwater. Surface supplies from the river systems are extremely limited. The declining trends of

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30 In Queensland, the term ‘associated’ water is used due to definitions provided in the Water Act 2000 (Qld), see chapter 5 section 3(b)(iii) below p 170. However, elsewhere in the world, ‘produced water’ is more commonly used and is therefore the term adopted in this thesis.

31 The concept of ‘sustainable development’ is discussed in chapter 2 section 1, below p 38.


33 Approximately 80% of CSG produced water comes from the Surat Basin. See: Office of Groundwater Impact Assessment, UWIR draft (2019), n 26, 56. CSG resources are also located in the deeper Bandanna and Cattle Creek formations in the Bowen Basin, which is below the GAB, within the Surat CMA.


the groundwater resources in the same area suggest that groundwater in these formations has been overallocated through the historic and existing groundwater allocation.\(^{36}\)

This context is like other parts of the world that produce CSG. In parts of the Rocky Mountains West, such as the Powder River Basin (PRB) in Wyoming and Montana,\(^ {37}\) the CSG reserves are located within the main potable water sources.\(^ {38}\) The Fort Union Formation is the source of the CSG as well as the main potable water source for the town of Gillette, Wyoming, because ‘the coal measures transmit more water than the sandstones.’\(^ {39}\) There are approximately 14,000 permitted non-CSG water wells and more than 36,000 CSG wells were drilled in the PRB during the peak production years prior to 2010.\(^ {40}\) Groundwater is similarly a key water source in Wyoming for domestic, stock and industrial uses. Water level declines in coal seam aquifers of 600 feet (or approximately 183 metres) and more were documented by the US BLM due to CSG development in the PRB.\(^ {41}\) CSG development generally has a very large impact on non-CSG groundwater users.

\(^{36}\) Allocation rules for CSG and non-CSG groundwater extractors are discussed in chapter 5, below.


Certainly, there are other issues related to the CSG industry that are concerning: impacts to greenhouse gas emissions from CSG extraction; impacts on other agricultural land uses; well integrity; and, of course, fracking and its impacts on groundwater contamination. Hydraulic fracturing or ‘fracking’ is where fluids, consisting of water, sand and chemical additives, are injected into the formation in order to open or enlarge fractures in the rock, and proppant material keeps the fractures open. While fracking has drawn much concern as a possible contamination risk, much of the research has been conducted in the USA, where the formations are typically drier and harder in comparison to Australian reserves. Recent studies suggest that the primary risks associated with fracking wastewater are from improper handling and storage on-site, and the injection of this wastewater into disposal wells. In Australia, fracking uses significantly less water. Additionally, the additives that have been most highly publicised as having environmental and health impacts –

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43 Refer to above n 24.


46 Glowacki and Henkel, above n 15.


48 Mills and Seifreid, above n 45, 11.

49 Davies, Gore and Khan, above n 47, 10985.
benzene, toluene, ethylbenzene and xylene (‘BTEX’) – have been essentially banned in Queensland since 2010,50 and in NSW in 2011.51 Fracking, greenhouse gas emissions and competition for agricultural land all raise important environmental issues. For these very important concerns, unfortunately, this thesis has no room. This research project centres on the key environmental issue that relates to water resources: the management of groundwater that is produced along with the gas.

Before embarking on this research, I must first explain why CSG extraction involves such large quantities of groundwater, what usually happens to that water and the governance issues that have been raised about that process. I will then explain what an aquifer injection is and the issues around the existing governance of that activity. That will lead me to the research question and how I intend to answer it.

a) **CSG production and CSG produced water generally**

Coal formations occur in strata where, over time, sedimentary organic material has been covered by further sedimentary layers. CSG is generated within the coal deposits through thermogenic (heat-driven) and/or biogenic (microbe-driven) processes.52 The process of sedimentation produces alternating permeable aquifers (such as sandstone and the coal measures) and impermeable aquitards and aquicludes (siltstone and mudstone). Subsequent uplift halts the sedimentary process and erosion of the exposed layers results in water intrusion, which then travels through the permeable aquifer layers.

The CSG binds to the ‘coal reservoirs by absorption and adsorption on or within macromolecular nanopores, pores, cleats and/or fractures’ and is usually found in a water-saturated condition.53 The water can be the product of the peatification and coalification process, or from

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50 Environmental Protection Act 1994 (Qld), s 206; Environmental Protection Regulation 2019 (Qld), s 70; Maria Comino, Poh-Ling Tan and David George, ‘Between the Cracks: Water Governance in Queensland, Australia and Potential Cumulative Impacts from Mining Coal Seam Gas’ (2014) 21 The Journal of Water Law 219; Department of Environment and Science, above n 25.
53 Flores, above n 52; Barrett, above n 14, 10663.
recharge through the permeable aquifer (it is usually the latter).\textsuperscript{54} Often, the formation supplies good-quality potable water. Shallow coal deposits can be mined but the deeper formations are now being utilised for their methane production.\textsuperscript{55} In Australia, CSG extraction occurs from coal seams that are generally from 200 m to 1 km deep.\textsuperscript{56} In the USA, they are typically no more than 1.6 km deep (5000 feet).\textsuperscript{57} As the CSG forms onto the surface of the coal particles, the coal seam is therefore both the source and reservoir for the gas.\textsuperscript{58} ‘Conventional’ methods of drilling, whereby a well is drilled into the reservoir to release the gas, are not possible because the gas resource is adsorbed throughout the seam. As the CSG resource occurs over relatively large areas, multiple wells (of the type shown in Figure 1, below) are drilled into the coal seam and the water must first be extracted, de-pressurising the coal measures so that the gas can separate from the coal matrix and be pumped out.

\textsuperscript{55} Barrett, above n 14, 10662.
\textsuperscript{56} John Williams Scientific Services Pty Ltd, above n 9.
\textsuperscript{57} All Consulting, above n 39, 10.
\textsuperscript{58} Office of Groundwater Impact Assessment, above n 26, 5.
The quality and quantity of the produced water depend on the geology and hydrology of the target formation, as well as the underlying and overlying units, and will change over the life of a project. This variability presents difficulties in treatment management. Quality and quantity are often related to the depth of the coal seam with younger, shallower coals being more porous and, therefore, having higher water content.

The chemical composition of the produced water also depends on the depositional environment and thermal maturity of the coal, the flux of freshwater into the formation from surrounding formations, and the time of residence of the water. Characteristics generally

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61 Barrett, above n 14, 10663.
associated with produced water are high salinity and high total dissolved solids (TDS), a high sodium absorption ratio ('SAR' or sodicity) and high alkalinity. TDS is the total amount of salts or mobile charged ions dissolved in the water, usually including sodium, potassium, magnesium, calcium, strontium, barium, iron, aluminium, bicarbonate, chloride and sulphates. The variable nature of the produced water means that universal treatment methods are not available. It also means that water treatment plants need to be capable of treating variable qualities and quantities of produced water, which is quite different from the context of other treatment plants that, for example, treat municipal wastewater. Furthermore, the topography of the land where the water is extracted also impacts on the available disposal methods.

The TDS of the CSG produced water from the Walloon Coal Measures generally varies from slightly brackish to saline, ranging from 1000 mg/L to 10,000 mg/L, but the mean is 3000 mg/L. To put this in context, up to 1000 mg/L is usually described as ‘potable’ or ‘fresh’, 1000–2000 mg/L as ‘slightly brackish’, 2,000–3,000 mg/L as ‘brackish’, 3,000–5,000 mg/L as ‘highly brackish’, and 5,000 mg/L as ‘slightly saline’. The water quality of the aquifers above and below the Walloon Coal Measures is also variable, but they are generally less saline. The mean TDS of the Condamine Alluvium is 1,500 mg/L, the Gubberamunda Sandstone is 1,000 mg/L, the Springbok Sandstone is 1,000 mg/L, the Hutton Sandstone is 1,500 mg/L, and the Precipice Sandstone is 200 mg/L. The salinity of the Fort Union Formation (the source of CSG produced water) in the PRB, Wyoming, averages between 1,000 and 1,350 mg/L.

The quantities of water involved in CSG extraction are immense. The production of water is greatest in the initial stages of pumping prior to accessing the CSG, and the amounts reduce as the

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64 Millar, Coupertwaite and Moodliar, above n 60, 672.


68 Ibid, 190.

69 Ibid, 204–206; see also chapter 6, section 2(a)(ii) below at p 205–207.

Aquifer injection in the Coal Seam Gas context: Part A: Chapter 1: Problem and context

CSG recovery increases until the quantum of gas recovery becomes un-economic (see Figure 2 below). Estimates of the production of water associated with the Queensland CSG industry have varied (from 140 GL/y to 300 GL/y)\(^\text{71}\) for the peak producing years. The most recent assessment sets the figure at 65 GL/y, increasing to about 110 GL/y in the next three years, with the average water extraction predicted to be 70 GL/y.\(^\text{72}\) The contrasting predictions reveal the uncertainty that has been a hallmark of the advent of the CSG industry. Estimates with respect to the USA also vary. Production of water in the Wyoming portion of the PRB for 2007 was approximately 101 GL/y,\(^\text{73}\) and during 2008 for the entire USA, it was 180 GL.\(^\text{74}\) The International Energy Agency puts this latter quantity in perspective by noting that it is the same quantity as the ‘annual direct water consumption of the city of San Francisco’.\(^\text{75}\)

![Figure 2. Typical gas and water flow in CSG production (adapted from the Office of Groundwater Impact Assessment\(^\text{76}\))](https://www.business.qld.gov.au/industry/mining-energy-water/resources/environment-water/coal-seam-gas/_surat-cma_uwir)

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\(^{72}\) Office of Groundwater Impact Assessment, UWIR (2016), above n 26, 88; for an explanation for the earlier over-estimations of groundwater production, see: James Underschultz, Sue Vink and Andrew Garnett, ‘Coal Seam Gas and Associated Water Production in Queensland: Actual versus Predicted’ (2018) 52(April 2018) *Journal of Natural Gas Science and Engineering* 410. The more recently released draft UWIR (2019), which is yet to be approved, has revised estimations of annual extraction over the life of the industry of 51 GL/y, with the extraction for 2018 estimated at about 60 GL and a maximum extraction of 110 GL in 2023: Office of Groundwater Impact Assessment, UWIR Draft (2019), above n 26, 102.

\(^{73}\) Copeland and Ewald, above n 70, 154.

\(^{74}\) International Energy Agency, above n 32, 35.

\(^{75}\) Ibid.

\(^{76}\) Office of Groundwater Impact Assessment, UWIR (2016), above n 26, 5.
In addition to competition for the water resource and the immense quantities involved, estimates of how long it would take to recharge the relevant aquifers (or naturally reverse the impacts of extraction) are a key concern. The GAB, in which the Walloon Coal Measures are located, is one of the world’s largest groundwater systems.\textsuperscript{77} The larger the system, the larger the response time for groundwater to move through the system (for both stress and recharge events).\textsuperscript{78} For the GAB, the response time could be from hundreds to thousands of years.\textsuperscript{79} These types of aquifers are considered non-renewable resources and require careful management.\textsuperscript{80}

The large quantity of water that is extracted as part of CSG development is not just an allocation issue. The disposal of CSG produced water creates a practical as well as an environmental issue. Because the quality of this produced water varies widely from drinkable to hazardous (principally in terms of TDS, SAR and electrical conductivity), management practices relating to the disposal of the water also vary.\textsuperscript{81} Furthermore, the production of water along with the gas is a substantial economic issue for the industry. Because CSG wells produce more water and less gas than conventional wells,\textsuperscript{82} the cost of disposing the CSG produced water is a significant expense and impacts on the viability of a project.\textsuperscript{83} Finally, the production of water by the CSG industry creates a unique opportunity for nearby agribusiness, which ought not to be wasted.\textsuperscript{84}

\textbf{b) Current management of water produced from CSG projects}

In Queensland, Australia, where most CSG production occurs,\textsuperscript{85} evaporation ponds have been used historically as the primary management option, but that practice is now recognised as presenting significant ecological risks.\textsuperscript{86} At one time, aquifer injection was proposed as a preferred

\textsuperscript{77} Klohn Crippen Berger, above n 26, i.
\textsuperscript{78} Ibid, iv.
\textsuperscript{79} Ibid, iv.
\textsuperscript{81} Herlihy, above n 65, 461.
\textsuperscript{82} All Consulting, above n 39, 16.
\textsuperscript{85} In NSW, while exploration is extensive, production of water is minimal because the industry has not reached an operational phase.
\textsuperscript{86} Davies, Gore and Khan, above n 47.
disposal option for the management of CSG water, but the Queensland Government’s official CSG Water Policy 2012 places it as an equally preferred option for the ‘beneficial re-use’ of the produced water. The CSG Water Policy 2012 requires that CSG produced water, first, be beneficially reused (by the environment, existing or new water users, and existing or new water-dependent industries); second, be treated and disposed of in a way that avoids then minimises and mitigates impacts on the environment. Injection is an example of a beneficial re-use of the water (the first option for post-production management). The peak body for the petroleum and gas industry in Australia, the Australian Petroleum Production and Exploration Association (APPEA), notes that 40 GL (out of 60.5 GL extracted) was provided to third parties for beneficial re-use in 2016–2017. Yet, many evaporation ponds, albeit named as ‘regulated dams’ or ‘holding ponds’, remain due to the practical issues associated with post-production uses. In July 2011, studies undertaken by Klohn Crippen Berger for the then Queensland Department of Environment found that it was theoretically possible to inject treated produced water into different parts of the Central Condamine Alluvium aquifer (the main source for agriculture in the Surat Basin) as long as ‘correct pre-treatment is undertaken and water compatibility constraints are understood’. The Reedy Springs Aquifer Project, undertaken by AP LNG’s upstream partner Origin, successfully trialled injecting produced water at a rate of 36 ML/day via 12 injection wells into the deeper Precipice Sandstone formation, which underlies the Walloon Coal Measures in the GAB. The total quantum of recharge, as at June 2017, was 15 GL of treated CSG produced water. The project operator was conditioned via its environmental permits at the Commonwealth (or federal) level to conduct the trial. Other trials have been explored by the other

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88 The term ‘beneficial re-use’ or use is a term given to a further use that is distinct from a waste disposal. The term relates to the water being able to be re-used and is distinct from the term used in the Western States in relation to the Doctrine of Prior Appropriation, which relates to the original extraction; see chapter 3 section 3(b)(ii) below p 100.
89 Queensland Department of Environment and Heritage Protection, CSG Water Policy, above n 65.
91 Department of Environment and Resource Management, which is now the Department of Environment and Science.
94 EPBC 2009/4974 (21 February 2011) (Cth); historic EPPG00853213 (18 February 2016) (Qld). The relevant conditions are set out in Appendix 6 of this thesis.
main gas producers.\textsuperscript{95} The Roma Managed Aquifer Recharge Study by Santos and CSIRO and URS Pty Ltd aimed at exploring the potential of using produced water to augment the potable water supplies of the Maranoa Regional Council in Queensland.\textsuperscript{96} A field of wells would inject 3–10 ML of treated produced water into the Gubberamunda Formation.\textsuperscript{97}

In the USA, in 2012, 93% of all produced water from onshore oil and gas wells (for both conventional and unconventional gas) was injected into disposal wells.\textsuperscript{98} For the lower quantity and quality produced water from the unconventional gas deposits in the San Juan Basin in New Mexico and Colorado, and the Uinta Basin in Utah, disposal is predominantly via deep bed injection wells.\textsuperscript{99} These wells target non-potable and non-useable formations.\textsuperscript{100} In contrast, where the produced water is high in quality and quantity (such as in the PRB in Wyoming and Montana, the Raton Basin in Colorado, and the Marcellus Basin in Pennsylvania) disposal methods are predominantly surface discharge, including infiltration impoundments.\textsuperscript{101}

There are numerous projects of varying methods that inject water into aquifers used for both potable and non-potable uses in the Rocky Mountain Basin jurisdictions. The source of drinking water in Gillette, Wyoming, USA, was augmented by CSG produced water through injection into the sandy aquifer serving the city.\textsuperscript{102} During the peak CSG production years in 2008–2009, the predominant disposal method of CSG produced water in Wyoming was unlined impoundments, which allow infiltration to unconfined aquifers.\textsuperscript{103} Approximately 64% of CSG produced water in

\textsuperscript{95} Millar, Coupertwaite and Moodliar, above n 60, 684.
\textsuperscript{96} Davies, Gore and Khan, above n 47, 10994.
\textsuperscript{97} Davies, Gore and Khan, above n 47.
\textsuperscript{98} Veil, above n 22, 10.
\textsuperscript{99} Day and O’Hayre, above n 38, 11.
\textsuperscript{100} For an explanation of the difference between injection wells that target useable and non-useable aquifers in the USA under the Safe Drinking Water Act 1974 (42 USC §300f et seq (42 USC Ch 6A Subch XII) (2017)), see below chapter 3, section 3(a)(iv) at p 98 and section 3(b)(iii) at p 106. The term ‘useable’ is adopted to describe aquifers that are not necessarily potable but can still be the source of water used for various purposes, such as in industrial and agricultural applications. For the range of ‘useable’ groundwater quality, see above pp 8–9 for examples of mean TDS of key aquifers in the GAB.
2008 was discharged into unlined reservoirs and only 3% was discharged via a vertical underground injection wells, which target both usable and non-useable aquifers.\textsuperscript{104} The quantum injected via wells constituted approximately 4.3 GL of 145.6 GL produced in that year. A key issue for injection in the PRB related to the ability of the confined geological formations to receive the CSG produced water.\textsuperscript{105} Obviously, the existence of other disposal methods was also relevant (as the statistics relating to impoundments suggest).

Regardless, since 2005, 528 underground injection control (UIC) permits, which target usable aquifers, were issued by the Wyoming Department of Environmental Quality (for both general and individual permits). At the end of 2018, there remains in force 182 permits for aquifer injection projects using CSG produced water in the PRB.\textsuperscript{106} Most of these are now shut-in, due to a lack of CSG production. Even though underground injection in Wyoming was not the primary water disposal method used, it was by no means an irrelevant one. Underground injection of CSG produced water in Wyoming was through numerous injection wells, which were usually relatively unsophisticated and injected smaller amounts of water. One facility, the Salt Creek Injection facility at Midwest north of Casper, was like the injection facilities at Reedy Creek in Queensland (mentioned above).\textsuperscript{107} The Midwest facility is permitted to inject approximately 48 GL/y through 6 injection wells. But, in the fourth quarter of 2008, it injected only 1.2 GL (using 3 wells) of CSG produced water from a 42-mile water pipeline from various CSG fields.\textsuperscript{108}

In summary, surface disposal was and is the most common CSG produced water management option adopted in both Queensland and Wyoming. Despite this, aquifer injection has been shown to be a viable option to redress the impacts of CSG extraction in Queensland and is a well-recognised option utilised in Wyoming.

\textsuperscript{104} Steinhorst, Fischer and Williams, above n 103, figure 1, 25.
\textsuperscript{106} This quantum is sourced directly from the Wyoming Department of Environmental Quality’s database which is available at: Wyoming Department of Environmental Quality, Login (GEM) <http://deq.wyoming.gov/wqd/underground-injection-control/resources/gem-login/>.
\textsuperscript{107} Operated by Anadarko Petroleum Corporation, Carbon Creek Energy LLC and now Concord Water Services LLC.
\textsuperscript{108} Or 7,842,238.9 barrels of CSG produced water.
c) CSG Governance issues

The current literature concerning CSG produced water in Australia notes that the legislative regime is still unprepared to manage water-related impacts of CSG projects adequately. Some consider the legislative requirements as too complex, restrictive and lacking uniformity across projects.\(^{109}\) For others, a lack of peer-reviewed monitoring appears to be a flaw in the system.\(^ {110}\) A further criticism of the regulatory regime in place in Queensland is that the method of assessment fails to adequately address cumulative impacts of projects on a regional level,\(^ {111}\) and there are questions as to the application of the precautionary approach and adaptive management.\(^ {112}\) A comprehensive review of the industry by the Queensland Competition Authority argued for a consolidation of the governance of CSG produced water into a single government entity.\(^ {113}\) The former National Water Commission (NWC)\(^ {114}\) called for water use by resources projects to be rolled in to the water accounting and planning process.\(^ {115}\) Finally, the intense competition between the

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Aquifer injection in the Coal Seam Gas context: Part A: Chapter 1: Problem and context

CSG industry and other water users for diminishing groundwater resources has been highlighted, suggesting an important area for research and reform.

The US literature highlights that the current regime was developed on a waste disposal model for produced water but the assumption that the water is a waste is rapidly changing. Environmental issues relating to surface disposal options have been highlighted along with the absence of any legislative requirements to beneficially re-use the water. More comprehensive regulation of the extraction of and accounting for the quantities produced has been recommended. Streamlined mechanisms have also been recommended to encourage aquifer injection to augment potable water sources. These reforms could then mitigate the hydrological impacts of CSG production. In short, it has been widely argued that governance issues continue to allow aspects of CSG development to impact groundwater resources.

2. Managed Aquifer Injection (MAR)

a) Purpose, process and safety issues

As mentioned, aquifer injection of CSG produced water has been adopted to dispose of fair-quality produced water into usable aquifers (as opposed to highly saline produced water into unusable aquifers). In this context, aquifer injection of CSG produced water is a type of Managed

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120 Benson et al, above n 102.
121 Buccino and Jones, above n 101; Barrett, above n 14, 10683.
122 Myers, above n 38, 193.
Aquifer injection in the Coal Seam Gas context: Part A: Chapter 1: Problem and context

Aquifer Recharge (MAR) that provides an opportunity for conjunctive management of surface water and groundwater resources.

MAR is the broad term given to the collection of techniques used to intentionally augment groundwater supplies\(^ {123}\) and has been defined as ‘the purposeful recharge of water to aquifers for subsequent recovery or environmental benefit’.\(^ {124}\) MAR is used to augment traditional supplies as well as restoring over-exploited aquifers,\(^ {125}\) and is normally achieved ‘through mechanisms such as injection wells, and infiltration basins and galleries for rainwater, stormwater, reclaimed water, mains water and water from other aquifers that is subsequently recovered for all types of uses’.\(^ {126}\) Aquifers that lie beneath a layer of clay or other impervious material (known as a ‘confined’ aquifer) require injecting water through a well to recharge.\(^ {127}\) Infiltration is used for unconfined aquifers where water seeps through the permeable layer.\(^ {128}\) MAR projects involve a number of operational phases: access to the source water, injection/recharge, recovery of stored water and end use.\(^ {129}\) Treatment requirements are usually part of the regulatory measures governing the recharge process and differ depending on the type of source water used and the quality of water in the target aquifer used for storage. Not all MAR projects intend recovery of stored water. Some are simply designed for environmental benefit, such as with respect to preventing saltwater intrusion,\(^ {130}\) or even as a water disposal method, such as with respect to the Cloudbreak Mine in the Pilbara, Western Australia.\(^ {131}\) Dillon et al distinguish projects that focus on merely increasing water levels without

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\(^ {126}\) Dillon et al, Managed Aquifer Recharge: An Introduction, above n 124, 2.

\(^ {127}\) Ibid, 3.

\(^ {128}\) Ibid, 3.


\(^ {131}\) Fortescue Metals Group, 13th International River Symposium Fortescue’s Cloudbreak Mine Managed Aquifer Recharge (2010)
attention to water quality (terming them ‘aquifer recharge’) from projects that focus on both water quantity and water quality (termed ‘managed aquifer recharge’).  

To date, the focus of MAR projects has mostly involved Aquifer Storage and Retrieval (ASR) projects that are centred on sewage, stormwater and excess surface water allocations. As mentioned, this is now being acknowledged as extending to the re-use of water produced during mining and unconventional gas extraction, where produced water is reinjected into useable aquifers. Despite aquifer injection proving to be an effective tool for the management of CSG produced water, no scholars have addressed the regulatory issues that such a process faces when it is used by resources projects.

Artificially recharging aquifers, particularly by the infiltration method, is not a new nor innovative strategy. The first publication on the topic was written in the USA in 1937. Artificial recharge through the use of basins, furrows or ditches, flooding, and even vertical pits and shafts had been used at that time to augment groundwater supplies used for domestic, irrigation or industrial uses in Arizona, California, Oregon, Texas, Utah and Washington state. The authors of that text noted:

spreading water for underground storage is no longer an experimental project. It is becoming increasingly apparent to those that have given the matter much thought that underground storage presents great possibilities. There are greater subsurface storage reservoirs available in most regions than surface reservoirs and in some regions, this is the only means of storage. It can be practiced with more or less success in any region where pumping from wells is the principal means of furnishing water supplies for municipal, industrial, or irrigation use. In many cases it is more economical than surface storage, because the works necessary for storage are not as extensive or costly, and also because there are no evaporative losses. ... Because of the high cost of sinking shafts or pits, their use is not economical if surface spreading can be employed.

Bloetscher, Muniz and Witt divide the different recharge activities into four broad groups: artificial aquifer creation, aquifer recharge, aquifer storage and recovery (ASR), and aquifer reclamation. Aquifer reclamation and aquifer recharge are used to sustain long-term demands,

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132 Dillon et al, Sixty Years of Global Progress, above n 123, 3.
133 Ibid, 2.
135 Mitchelson and Muckel, above n 134, 2.
136 Mitchelson and Muckel, above n 134, 80.
137 Bloetscher, Muniz and Witt, above n 130.
while ASR is focussed on a shorter timeframe because ASR involves injection and recovery from the same well or bore. Bloetscher, Muniz and Witt highlight that:

all these strategies are proven, cost effective programs, capable of successfully using existing waters and sources that are managed for long term water supply.

Key concerns are usually centred on aquifer contamination by microbiological constituents, heavy metals and organics, solvents, and synthetic chemicals. Therefore, there is a need for regulation of the injectate quality characteristics. The risk profile of the project will usually dictate the water quality required and the monitoring program for the injectate and target formation, both during and after recharge. For example, more extensive monitoring (and treatment) is required for injection directly into high-quality aquifers that are used as potable sources of water, as opposed to saline aquifers or ones where the water is used for irrigation or industry. In addition, injection pressures through wells or bores must also be regulated to ensure that the target aquifer is not fractured, or that the process does not create seismic activity.

Public acceptance of treated wastewater being injected directly into potable aquifers is not always assured. In the past, augmentation of aquifers using treated wastewater in the USA arguably may have avoided community backlash because the injection was indirect and ‘under the radar’ of the local community. For example, since at least the mid-1970s, injection wells have used treated wastewater in the USA. Injection of recycled water into potable groundwater resources has occurred (using varying pre-treatment methods) in Texas (1985), Arizona (1999), Los Angeles (1993, 2008 and 2012), Southern California (2005) and Denver (2009). Relatively recent US research confirms that public sentiment favours water recycling where it is indirect, such as through injection into groundwater resources where it may reside for a period of time, rather than directly

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138 Ibid, 8.
140 Bloetscher, Muniz and Witt, above n 130, 189.
141 The type of ‘wastewater’ used, the hydrogeological and geological properties of the target aquifer, and the water uses and users of the groundwater.
143 Pyne, above n 139, 402.
145 In Orange County, California, in 1976: Committee on the Assessment of Water Reuse as an Approach for Meeting Future Water Supply Needs, above n 130, 45. Injection wells were also used earlier in the West Basin (between Inglewood and the Palos Verdes Peninsula) in California, see: Elinor Ostrom, n 145: The Evolution of Institutions for Collective Action (Canto Classics Edition, 2015 ed, 1990), ch 4.
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into potable (surface) reservoirs or rivers.\textsuperscript{147} Since these early projects, greater attention to communication strategies and treatment process has been employed in the US to ensure public acceptance of the projects.\textsuperscript{148} A cautious approach exists in Australia in terms of public acceptance of treated wastewater augmenting potable aquifers. In a study in 2011, stormwater recycling involving MAR was perceived to be acceptable if the recovered uses of the water had limited human contact.\textsuperscript{149}

During the peak CSG development years in Wyoming, injection of produced water from coal bed methane into aquifers of a similar water quality was considered by the Wyoming Department of Environmental Quality (WDEQ) as ‘an excellent method of disposal of this water in a manner that preserves the groundwater resource for future generations.’\textsuperscript{150} The WDEQ noted that:

with proper disinfection to prevent the spread of bacteria, and with care to inject only into aquifers of similar quality, injection can be a method of minimizing environmental impacts caused by the production of coal bed methane [CSG].\textsuperscript{151}

This view was confirmed during an interview in 2017 with the WDEQ. As part of this research, the author interviewed the cohort of staff involved with the underground injection of CSG produced water (including during the peak CSG production years) in Wyoming. They considered that the key issue of the underground injection control program in Wyoming relating to CSG produced water was not environmental impacts to groundwater resources (explaining that there had been no surprises in the long history of injection) but, instead, the failure of adequate historic bonding arrangements.\textsuperscript{152} A review of a large sample of the underground injection permits by the author

\textsuperscript{147} B Haddad et al, The Psychology of Water Reclamation and Reuse, Survey Findings and Research Road Map (WateReuse Foundation, 2009).
\textsuperscript{150} This was stated in approval letters by the WDEQ to operators in 2002, extending coverage of the general permits to specific facilities. See: Letter from WDEQ to J M Huber Corp, 6 May 2002 regarding Trembath 5C5-3 WYS-033-056 in the WDEQ’s GEM database available at: Wyoming Department of Environmental Quality, Login (GEM) <http://deq.wyoming.gov/wqd/underground-injection-control/resources/gem-login/>.
\textsuperscript{151} Letter from WDEQ to J M Huber Corp, above n 150.
\textsuperscript{152} Bonding is the financial assurance paid by operators to the regulator in order to ensure that adequate rehabilitation of wells is conducted: Interview with Participants W8–18 (Sheridan Wyoming, 16 August 2017). Once the industry had contracted severely, many injection facilities were simply abandoned by operators: K Bills Walsh and J H Haggerty, ‘I’d Do It Again in a Heartbeat: Coalbed Methane Development and Satisfied Surface Owners in Sheridan County, Wyoming’ (2019) The Extractive Industries and Society 6 (2019) 85. This issue has been largely resolved through legislative amendments: in March 2018, Senate File 0016 was passed, which now requires the WDEQ to promulgate financial assurance requirements for ‘plugging, abandonment, post-closure monitoring, corrective actions and site reclamation’ for both class 1 hazardous waste as well as non-hazardous or class V UIC facilities: WS § 35-11-302(a)(viii) (2018) and 2018 Wyo Sess Laws SF0016.
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revealed that there were very few instances involving any exceedances that could be considered to have detrimentally impacted the groundwater resource.\textsuperscript{153}

as to the recharge activities that have occurred in queensland, it is difficult to state categorically that there have been no negative environmental impacts on the groundwater resources. both the queensland department of environment and science’s compliance activities and some operators’ reporting lacks transparency.\textsuperscript{154} however, the publicly available reedy creek facility’s groundwater reports and third-party studies suggest that reinjection activities have not exceeded the conservative ea water quality thresholds for the groundwater resource. therefore, arguably, aquifer injection of csg produced water is, now, beneficially augmenting groundwater resources in queensland.

b) \textit{MAR governance issues}

current literature relating to mar generally relates to recycling and using excess surface water\textsuperscript{155} as the injectate source water. from the author’s review of the literature, there is no academic research considering the governance or regulatory issues of mar, or simple aquifer injection,\textsuperscript{156} using better-quality produced water from csg projects in either the usa or australia. nonetheless, aquifer recharge of csg produced water presents a practical solution to the problem of the water impacts of csg projects. therefore, a more general academic assessment of the governance arrangements of that process is relevant.\textsuperscript{157}

scholars argue that mar is an innovation in respect to water supply, which needs to be the subject of regulatory ‘renovation’ in australia.\textsuperscript{158} similarly, a report in the usa by the committee on sustainable underground storage of recoverable water in 2008 noted that these projects are

\textsuperscript{153} out of a sample of 157 permitted injection facilities (including historic as well as currently authorised wells) involving 272 discreet injection wells, no formal administrative actions led to sanctions. a total of 57 letters of violation of permit limits were issued by the wdeq for this sample of permits since 2005; all of which were resolved very quickly. generally, the non-compliances related to relatively minor pressure, pH or bacterium exceedances often relating to operational issues. the permits are listed in appendix 3 and specific examples of operational issues that occurred in wyoming with the injection wells in the csg context are discussed in chapter 4 (sanctions). a spreadsheet summarising this data is included as appendix 10.

\textsuperscript{154} discussed in chapter 6 sections 1(a) (iii), below p 190–194 and chapter 6 section 5(ii) below p 220.

\textsuperscript{155} such as flood water, river water or treated sewage.

\textsuperscript{156} to avoid disputes regarding terminology, this thesis adopts the term ‘aquifer injection’ for the intentional recharge of aquifers using wells rather than the broader term mar.

\textsuperscript{157} robertson, above n 90.

\textsuperscript{158} michael bentt, alex gardner and katie vincent, ‘regulatory renovation for managed aquifer recharge using alternative water resources: a western australian perspective’ (2014) 24(1) journal of water law 5. see also: yie yuan, michele i van dyke and peter huck, ‘water reuse through managed aquifer recharge (mar): assessment of regulations/guidelines and case studies’ (2016) 51(4) water quality research journal 357, where yuan, van dyke and huck note that detailed regulations or guidelines for mar are unavailable in most countries; ross, above n 115.
'among the most complex to implement, unless a state has addressed these issues in a statutory scheme that was created specifically for the regulation of these projects'.}

Academic literature relating to MAR recommends that the process ought to be part of an integrated catchment management strategy, which governs both water quality and quantity issues. Many argue that there is a need for certainty of entitlements for the multiple phases of a MAR project: to access water for recharge, aquifer storage, recovery of stored water and rights to transfer the recovered water. There also appears to be a need for economic incentives for undertaking MAR. A unified approach to assessments, including State-based MAR guidelines and

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160 Dillon et al, above n 124, x; Ross, above n 115.


policy, is necessary. Nevertheless, no scholars have considered whether these recommendations apply in the CSG context.

3. **An introduction to the research**

Governance issues exist relating to both the production of excess groundwater during CSG extraction as well as aquifer injection more generally. Science and technology appear to have leapfrogged existing legal frameworks relating to both activities. This thesis meets calls for social research examining groundwater management generally, governance arrangements for MAR, as well as MAR specifically in the CSG context.

a) **Methodology for this research**

(i) **Research questions and limitations of the research**

The focus of this research is to determine whether there are governance initiatives that will help alleviate the negative impacts flowing from the production of CSG produced water on groundwater resources. The term ‘framework’ in this study means the entire body of rules that govern the activity in a jurisdiction. This study is predominantly a water governance research topic, albeit within the context of CSG development. The subject of the research involves the first two operational phases of a MAR project: access to the groundwater during CSG extraction and subsequent injection in the aquifers.

The research questions and sub-questions are as follows:

Are there governance initiatives for aquifer injection and augmentation using CSG produced water, which may enable or inhibit sustainable groundwater governance?

1. What are the measures of sustainability chosen in this study?
2. What governance design principles are recommended for aquifer injection and augmentation using CSG produced water (termed ‘aquifer injection and augmentation design principles’)?
3. What are the legal mechanisms that govern aquifer injection of CSG produced water in two case study jurisdictions?

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164 Dillon et al, *Managed Aquifer Recharge: An Introduction*, above n 124, 41–42; Parsons et al, above n 129, 72 and 74; Dillon et al, Sixty Years of Global Progress, above n 123, 22 where the authors state that ‘development of MAR has occurred at different rates … for various reasons, including … having clear approval processes’.


166 Dillon et al, Sixty Years of Global Progress, above n 123.

167 Mitchell et al, above n 165.
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4. What does the empirical data suggest about the relative success or ‘not success’, in terms of sustainability, of the particular case study governance framework relating to:
   a. The overall groundwater system;
   b. Extraction of groundwater in the CSG context; and
   c. Injection of groundwater

5. Have the regulatory frameworks in each jurisdiction adopted the aquifer injection and augmentation design principles? If so, how?

6. Did success (or ‘not success’) of the overall governance framework for groundwater and for extraction of CSG and injection in a particular case study jurisdiction correlate with the adoption (or absence) of the aquifer injection and augmentation design principles?

7. What does the analysis suggest about the importance of the various aquifer injection and augmentation design principles for groundwater governance, and the separate operational phases of aquifer injection using CSG produced water?

8. What features of a governance framework can enable or, alternatively, hinder aquifer injection and augmentation using CSG produced water?

Issues surrounding the ‘wastewater’ produced by other types of unconventional gas extraction, such as tight gas, tight oil and shale gas, 168 are outside the scope of this study. In Australia, the production of shale gas and tight gas is in its infancy. 169 In contrast, the production of CSG in Australia has been occurring for decades. 170 Therefore, the industry is established and the issues surrounding excessive ‘wastewater’ production have led to significant conflict as well as scientific, political and legal analysis. In addition, it should be noted that there are further variables in the study of the extraction of shale gas and tight gas compared to the extraction of CSG. Shale gas and tight gas generally involve more fracking, due to the location of these resources being typically in deeper, low-fracture, low-permeability formations. 171 Therefore, by restricting the study to aquifer injection projects involving CSG produced water, these additional issues can be eliminated, and the study can build on the research that has already taken place with respect to CSG projects.

168 Veil, above n 22, 19.
169 In contrast, in the USA, production of both CBM and shale gas is occurring; Hancock and Wolkersdorfer, above n 109.
171 Department of Environment and Science, above n 170; All Consulting, above n 39.
I have already mentioned that fracking, greenhouse gas emissions and competition for agricultural land is outside the scope of this thesis. There are other topics that also require individually targeted research outside of this thesis. These include, for example, the impacts of CSG projects on biodiversity values. Also, while the research considers trust in terms of the governance framework relating to CSG activities, it does not directly consider trust as this relates to the CSG industry’s ‘social licence to operate’. The focus of research relating to the CSG industry’s ‘social licence to operate’ involves broader aspects of CSG operator activities, which do not necessarily involve governance of water resources. The use of water in CSG projects other than through the extractive process, such as for dust suppression or in exploration (or hydraulic fracturing), is also outside the scope of this research. Similarly, the use of water resources in other contexts, such as by agriculture and urban uses, is also outside the scope of this research. These are all important aspects of CSG production, which warrant specific attention in their own targeted research.

As discussed in the section describing MAR, groundwater recharge can occur using a variety of techniques. Recharge using CSG produced water in Wyoming was primarily via infiltration ponds rather than direct injection, although there were many direct injection wells. In Queensland, direct injection has occurred and CSG storage reservoirs have not been used intentionally as infiltration devices. There are different requirements for pre-treatment of water for infiltration and injection. This study will focus on injection because that method has been used in Queensland and was therefore, the common activity relating to CSG produced water in both jurisdictions. This will enable a direct comparison to be made.

172 The issue of trust is discussed further in chapter 7 section 2, at pp 268-271.
174 Committee on the Assessment of Water Reuse as an Approach for Meeting Future Water Supply Needs, above n 130.
(ii) Research paradigm and method

The research paradigm adopted in this research reflects Critical Realism, which highlights that all knowledge is partial, incomplete and fallible.\textsuperscript{175} I consider that quantitative evidence (such as monitoring data) is important but also that the relevant stakeholders’ perceptions of the governance framework are relevant, and these can shed light on the reality of the legal framework in action. This is because the research assumes that stakeholders are ‘boundedly rational’ individuals.\textsuperscript{176}

A four-phase sequential mixed method research methodology was considered to be the best framework to answer the overarching research question (i.e., are there governance initiatives for aquifer injection and augmentation (AIA) using CSG produced water that enable sustainable groundwater governance?). The sequential mixed-methods research methodology was adopted within the context of a comparative study. First, to frame and direct further data collection, a literature review relating to ‘sustainability’ and governance of CSG activities and MAR was necessary. A literature review of various theories relating to natural resource governance was also conducted, including adaptive management, adaptive governance and common pool resources. Because the research is applied law reform research, considering the law in a real-life context seeking a solution to a real-world problem (i.e., the production of excessive ‘wastewater’), a comparative legal method involving two case-study jurisdictions was undertaken. Second, a ‘black letter’ doctrinal investigation shed light on the regulatory mechanisms in place. Third, empirical quantitative data from permits and monitoring reports was also considered to evaluate the law ‘in action’. Finally, qualitative data such as opinions of stakeholders within that system provided further relevant information. This follows the approach adopted (and recommended) by eminent scholars for other water governance research projects.\textsuperscript{177}


\textsuperscript{176} The term ‘boundedly rational’ refers to the idea that decision-makers make decisions rationally rather than irrationally, and within the limits of their cognitive abilities and known information and time: Herbert Simon, Models of Man (Wiley, 1957); Herbert Alexander Simon, Models of Thought (Yale University Press, 1979); Herbert Alexander Simon, Models of Bounded Rationality (MIT Press, 1982); Herbert Alexander Simon, Administrative Behavior: A Study of Decision-Making Processes in Administrative Organizations (Free Press, 4th ed, 1997).

(iii) Identification of case study jurisdictions

The Surat cumulative management area (CMA) in Queensland, Australia, and the PRB in Wyoming, USA, were chosen as the case-study jurisdictions for this research. There are broad similarities between Australia and the USA that are conducive to a comparative legal research method. Both are within the same family of legal systems, known as ‘common law’ systems. Both rely on a constitution, state and federal laws. They also feature similar socio-economic and socio-cultural environments with a history of homestead settlement and with established agricultural, pastoral and mining uses.

Queensland is the largest producer of CSG in Australia and 90% of production occurs in the Surat Basin (from the Walloon Coal Measures) and Bowen Basin (from the Permian Coal Measures) within the Surat CMA. Due to the in-depth information that has been published for the Surat CMA, this research will focus on that area.

Wyoming was found to have the most in common with the Queensland setting after comparing the Western Rocky Mountain States where CSG production is centred, along with the CSG industry, the regulation of CSG development and associated production of water, and the qualities and quantities of produced water. Wyoming has the greatest similarity to Queensland: they both have split ownership of land and mineral estates, restricted local regulation of CSG projects and very large quantities of variable quality produced water in the state. The existence of injection facilities, involving CSG produced water targeting useable aquifers, led to Wyoming being ultimately selected as the case-study jurisdiction for this project. Because CSG production has predominantly occurred in the PRB, this coal producing area was selected as the second case-study jurisdiction.

181 All Consulting, above n 39.
182 The term ‘split ownership’ or ‘split estate’ refers to the situation where the surface owner of the land is not the same as the owner of the various natural resources that lie within the sub-strata of that land, such as minerals, oil or gas: Allan R Collins and Kofi Nkansah, ‘Divided Rights, Expanded Conflict: Split Estate Impacts on Surface Owner Perceptions of Shale Gas Drilling’ (2015) 91(4) Land Economics 688.
(iv) The research steps taken in more detail

A pictorial representation of the research method is presented in Figure 3, below. The key steps are discussed below.

**Figure 3. Research steps**
Aquifer injection in the Coal Seam Gas context: Part A: Chapter 1: Problem and context

The detailed literature review of the governance of unconventional gas projects and MAR, or groundwater injection, was conducted and published in 2018. The literature review for ‘sustainability’, adaptive management and common pool resources is presented in Chapter 2. The black letter law analysis of the regulatory frameworks in Queensland and Wyoming are presented in Chapters 3 and 5.

The research has involved collecting a large amount of data from an extensive number of documents from both jurisdictions. Because permits and documents are constantly being updated, especially in Queensland where CSG operations are expanding, the documents and permits are generally current up until 30 May 2019. A content analysis of 159 permits (out of 528 Underground Injection Control (UIC) permits that had been issued since 2005), accompanying environmental assessments, monitoring reports and correspondence was undertaken for the Wyoming CSG projects. The specific UIC permits considered were chosen because they were all of the permits (both currently authorised as well as historic) issued with respect to four of the major CSG producers (and related companies) who used injection as a disposal technique in Wyoming during the peak production years around 2009: Anadarko Petroleum Corporation, Yates Petroleum Corporation and JM Huber Corporation as well as all the currently authorised permits of High Plains Gas LLC. A sample of water licences for CSG produced water extraction relevant to a number of UIC wells, were also analysed. These are all listed in Appendix 3. Similarly, a content analysis of 97 environmental approvals, subsidiary management plans and reports for all the operational Queensland CSG projects was undertaken to extract relevant quantitative data. These documents are listed in Appendix 4.

The information sought and collected from this content analysis included both quantitative and qualitative data. The Wyoming UIC permits and the Queensland subsidiary environmental management plans provided information relating to permit requirements for the separate projects. This information was used to determine the scope of the legal mechanisms regulating the activity. The accompanying environmental assessments, monitoring reports and correspondence provided information relating to the quantum of CSG produced water extracted and injected, data in respect of non-compliances with permits, water quality requirements for injection, the results of feasibility analyses and reasons given for not adopting aquifer injection. This empirical data assisted in determining the relative success of the regulatory framework.

183 Robertson, above n 90.
184 Who acquired many facilities from Marathon Oil, a subsidiary of Pennaco.
Qualitative data were collected through semi-structured interviews in both jurisdictions and supplemented the data obtained from the permits, management plans, monitoring data, reports, correspondence and submissions in the public domain. A simple stakeholder analysis, which involved identifying individuals or groups of individuals who may be affected by the governance arrangements, was undertaken during the literature review and doctrinal analysis of the regulatory frameworks. Purposive sampling of participants was achieved through the literature review, the comparative doctrinal analysis and the relevant documents analysed. Data gathered in these interviews allowed for triangulation against the data collected through the documents. Ethics approval was obtained (and fully complied with) from the Office for Research, Griffith University, in April 2017. Participants were contacted by phone calls and emails. The interviews were conducted in person or by telephone (when necessary) using a pre-approved list of questions and generally lasted between 1 and 2 hours. A handful of interviews lasted longer. The ethics approval, pro-forma emails and list of questions are in Appendix 1. Because the subject matter of the research involved some sensitivity, commercial and otherwise, for many of the participants, notes were taken in the interviews rather than audio recordings. Summaries of the interviews were made from the notes taken by me and these were subsequently emailed to the participants for verification. The summaries and notes are kept on file. The interview summaries were redacted of any identifying information, other than the broad stakeholder group from which the participant was drawn. In very few cases, the participants made corrections to the summaries of interviews provided. Qualitative data were also collected from 39 submissions to the 2018 Commonwealth Senate Inquiry into Water use by the Extractive Industry and the 2017 Independent Review of the 2013 Environmental Protection and Biodiversity Conservation Act Amendment – Water Trigger. These submissions are included in the list of Queensland documents in Appendix 4.

The Wyoming interviews were conducted in August and September 2017. Seven semi-structured interviews were undertaken in Wyoming with 20 participants. Figure 4 below shows the stakeholder groups and number of interview participants in Wyoming:

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186 This corresponds to steps 1 and 2 in the methodology described by MS Reed, et al, ‘Who’s in and Why? A Typology of Stakeholder Analysis Methods for Natural Resource Management’ (2009) 90(5) Journal of Environmental Management 1933, 1936. Step 3, whereby the relationships between stakeholders are identified and analysed, was not undertaken and is an accepted limitation of this research.

187 Full research ethics clearance 2017/237, see Appendix 1.


A limitation of this research was the inability to interview relevant local government representatives in Wyoming. Since 2010, there has been a severe contraction in the CSG industry in the PRB. By 2017, many staff had moved on from the local government agencies and it was therefore difficult to obtain the identities of relevant participants who could provide the perspective of the local government during the peak productive years. No ranchers with UIC facilities on their land were interviewed, due to timing and the logistical constraints of the project. This means that, in comparison to the Queensland group, the group of participants is more heavily weighted towards the regulatory agencies. Nonetheless, the participant group did include two participants from the two separate peak landholder organisations, who had extensive experience with landholders during CSG development in Wyoming. Recently published academic research involving 10 landholder participants (and 6 lawyers) provided general support for the data collected as part of this research.\textsuperscript{190}

Ten semi-structured interviews were undertaken in Queensland with 13 participants between July 2017 and March 2019. Figure 5 below shows the stakeholder groups and number of interview participants in Queensland:

\textsuperscript{190} Bills Walsh and Haggerty, above n 152, 88.
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A key limitation of the interviews conducted in Queensland was the reluctance of current government staff and industry representatives to be interviewed, despite anonymity being assured. A surprising finding was the intense risk aversion of these stakeholders to be engaged in policy analysis, especially analysis that may critique existing regulatory mechanisms.\(^{191}\) A seminar was presented to the Queensland Department of Environment,\(^{192}\) which was attended by only two very junior employees, who had had no experience of regulation of aquifer injection. Numerous attempts to contact the Commonwealth regulator went unanswered. Numerous overtures to the water regulator were similarly unproductive. Ultimately, the participants who were representatives of that agency were retired staff. At least 8 representatives of industry and government were involved in ‘off the record’ discussions which, nonetheless, guided the research. I consider that the large amount of documentary data relating to the Queensland projects as well as public submissions (39) compensates for this research method limitation.

\(bb\) **Structure of the thesis**

This research is presented in four parts.

**Part A**, which includes this chapter and Chapter 2, broadly outlines the need for this research and the theoretical models underpinning the research. In Chapter 2, I discuss the literature, which provides the theoretical models underpinning the analysis of the regulatory frameworks in action in Queensland, Australia, and Wyoming, USA. It is a significant chapter where I discuss the

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\(^{191}\) There is more discussion of this issue in chapter 7 section 2 (a) at p 267.

\(^{192}\) Now the Department of Environment and Science, which at the time was the Department of Environment and Heritage Protection.
broad goal of sustainability, adaptive management, common pool resources and the scholarly
recommendations for MAR projects. The preceding analysis enables me to formulate ‘aquifer
injection and augmentation design principles’ (AIA design principles) that can be used to evaluate
the governance frameworks in the Surat CMA and PRB.

Part B takes the analysis to Wyoming, USA. Chapter 3 describes the setting then details the
regulatory framework, which governs aquifer reinjection in that jurisdiction. Again, this is a weighty
chapter, which provides the context for the analysis conducted in Chapter 4. Chapter 4 presents the
regulatory framework and empirical data for the PRB by reference to the aquifer injection and
augmentation design principles.

Similarly, Part C describes and analyses the Queensland setting. Chapter 5 describes the
Queensland context then details the regulatory framework in place. Chapter 6 presents the
regulatory framework and empirical data for the Surat CMA by reference to the aquifer injection and
augmentation design principles.

Part D is the concluding part of this research, which presents the overall findings. Chapter 7
presents the discussion, comparing the regulatory frameworks and empirical data for both
jurisdictions and analysing them in terms of the aquifer injection and augmentation design
principles. Chapter 8 concludes the thesis by answering the overarching research question and
presenting reflections on the research findings and method as well as policy initiatives, in particular
for Queensland.

The research questions and where they are specifically addressed in the thesis are presented
in Table 1 below. Each question is presented at the end of the relevant chapter in a shaded text box,
for easy reference, and is followed by my relevant research findings.
Table 1. List of research questions and where they are situated within the thesis

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Chapter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are there governance initiatives for aquifer injection and augmentation using CSG produced water that may enable or inhibit sustainable groundwater governance?</td>
<td>Chapter 8</td>
</tr>
<tr>
<td>1. What are the measures of sustainability chosen in this study?</td>
<td>Chapter 2</td>
</tr>
<tr>
<td>2. What design principles are recommended for aquifer injection and augmentation using CSG produced water (termed the ‘aquifer injection and augmentation design principles’)?</td>
<td>Chapter 2</td>
</tr>
<tr>
<td>3. What are the legal mechanisms that govern aquifer injection of CSG produced water in the PRB, Wyoming, USA, and the Surat CMA, Queensland, Australia?</td>
<td>Chapter 3 (Wyoming) and Chapter 5 (Queensland)</td>
</tr>
<tr>
<td>4. What does the empirical data suggest about the relative success or ‘not success’, in terms of sustainability, of the governance framework relating to:</td>
<td>Chapter 3 (Wyoming) and Chapter 5 (Queensland)</td>
</tr>
<tr>
<td>a. the overall groundwater system;</td>
<td></td>
</tr>
<tr>
<td>b. extraction of groundwater in the CSG context; and</td>
<td></td>
</tr>
<tr>
<td>c. injection of groundwater.</td>
<td></td>
</tr>
<tr>
<td>5. Have the regulatory frameworks in each jurisdiction adopted the AIA design principles? If so, how?</td>
<td>Chapter 4 (Wyoming) and Chapter 6 (Queensland)</td>
</tr>
<tr>
<td>6. Did success (or ‘not success’) of the overall governance framework for groundwater and for extraction of CSG and injection correlate with the adoption (or absence) of the AIA design principles?</td>
<td>Chapter 4 (Wyoming) and Chapter 6 (Queensland)</td>
</tr>
<tr>
<td>7. What does the analysis suggest about the importance of the various aquifer injection and augmentation design principles for groundwater governance, and the separate operational phases of aquifer injection using CSG produced water?</td>
<td>Chapter 7</td>
</tr>
<tr>
<td>8. What features of a governance framework can enable or, alternatively, hinder aquifer injection and augmentation using CSG produced water?</td>
<td>Chapter 7</td>
</tr>
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</table>
CHAPTER 2: MAPPING THE THEORETICAL FOUNDATIONS

As previously mentioned, aquifer injection appears to be one solution to the practical problem of the production of CSG produced water, depending on geography, source water and groundwater quality, and resident demand for the water. Yet, as demonstrated in this thesis, the governance arrangements of both CSG extraction and aquifer injection, or MAR, have been widely criticised as ineffective or absent. Thus, an evaluation of the specific governance arrangements relating to aquifer injection of CSG produced water appears warranted.

To conduct this evaluation, I need an appropriate yard stick (what I have termed in Chapter 1 as the ‘AIA design principles’). To formulate this yard stick, an understanding is required of the goal of the relevant governance frameworks (that is, what we hope to achieve). It is also sensible to start with what steps or design criteria other learned scholars have recommended for effective governance of groundwater and managed aquifer recharge. This requires a broad analysis. The concepts and literature relevant to the management of aquifer injection and groundwater more generally, is extensive. This chapter and the corresponding AIA design principles would be deficient without an examination of sustainability, adaptive management and adaptive governance, as well as common pool resources and MAR. No other scholar has analysed MAR or indeed groundwater governance within the context of CSG development in this way. Yet, doing so enables a fulsome evaluation of the governance arrangements in place. Fortitude on the part of the reader at this stage is therefore necessary. It will pay dividends in terms of understanding the reasons behind the choice of the specific AIA design principles and their subsequent application in the regulatory and empirical analysis conducted later in this thesis.

This chapter adopts ‘sustainable development’ as the overarching regulatory objective and determines what measures of that goal are appropriate for aquifer injection and augmentation in the CSG context. After a discussion of the relevant principles of sustainability, I consider adaptive management, adaptive governance, common pool resources and MAR to determine what regulatory features are considered ideal. The synthesis of overall scholarly recommendations is presented in a table. This collation is termed the ‘aquifer injection and augmentation principles’ (AIA design principles). In addition, I have developed a unique diagnostic tool in the form of a ‘heat map’ based on this collation of design principles. Both the table of AIA design principles and

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193 Refer to chapter 1, section 1(c), p 15 and 2(b), above p 21.
194 A ‘heat map’ presents data in a diagram where colours are used (in this case, green, amber and red) to reflect the relative presence or absence of particular criteria or design principles.
corresponding heat map provide a helpful framework for analysis, or a yardstick against which the specific governance arrangements in the Surat CMA and PRB can be measured later in this thesis.

1. The objective of sustainable development

As mentioned, this research adopts ‘sustainable development’ as the main goal for the regulatory frameworks governing water and other natural resources in both Queensland and Wyoming. In Queensland, ‘sustainable development’ is expressly adopted in the legislation.\(^{195}\) For Wyoming, the objective is implied. An express legislative governance objective of sustainability is generally lacking for natural resources in the USA federally\(^{196}\) and in most of the states, including Wyoming.\(^ {197}\) Nonetheless, ‘sustainability’ has been an implicit dominant objective by many American scholars as well as having been overtly adopted in the USA on a policy or informal level.\(^ {198}\)

\(^{195}\) A strategic policy of sustainability by the Commonwealth, States and Territories for natural resources and the environment was adopted in the Intergovernmental Agreement on the Environment 1992; Commonwealth of Australia et al, Intergovernmental Agreement on the Environment (1992) [http://www.environment.gov.au/about-us/esd/publications/intergovernmental-agreement] and the National Strategy for Ecologically Sustainable Development 1992 [http://www.environment.gov.au/about-us/esd/publications/national-esd-strategy]. In Queensland, the planning, allocation and use of water is to be managed sustainably in accordance with the principles of ecologically sustainable development, see: Water Act 2000 (Qld), s2, which states that the ‘main purposes of this Act are to provide a framework for the following – (a) the sustainable management of Queensland’s water resources …’ For environmental protection, ‘ecologically sustainable development’ is the object of any regulatory powers under the Environmental Protection Act 1994 (Qld). Even though the regulator must only ‘have regard to the need for ecologically sustainable development’ when managing the State’s petroleum resources (see s 3(1)(a)(i) Petroleum and Gas (Production and Safety) Act 2004 (Qld)), because an operator cannot extract petroleum resources without a permit (EA) under the EP Act, the objective of ecologically sustainable development remains the guiding principle for regulation of that activity.

\(^{196}\) There are some notable exceptions but they do not relate to water or the environment generally, for example: the federal armament retooling and manufacturing support initiative: 10 USC § 7553 (formerly cited as 10 USC § 4553), the shipyard modernisation and improvement initiative: 46 USCA § 53733 (formerly cited as 46 App USC §1279e; 46 App USC §1280a), programs to promote sustainable development of the resources of Indian Tribes: 25 USCA § 4301, and the design and construction of new facilities on real property by federal agencies: 41 CFR § 102.55. There are other exceptions but they are all extra-territorial in application: for example, the US Energy Policy Act of 1992, which provides that it ‘is the goal of the United States in carrying out energy supply and energy conservation research and development … to foster international cooperation by … transferring environmentally sound, advanced energy systems to developing countries to promote sustainable development’: 42 USC § 13401(5).

\(^{197}\) There are no Wyoming statutes that include the term ‘sustainable development’.

Asserting that sustainable development is the dominant objective of the relevant regulatory frameworks in both jurisdictions does not mean that there are not also other objectives. Certainly, there are other (additional) objectives to be found in legislation governing natural resources, such as oil and gas. For example, the oil and gas leasing program encourages domestic oil and gas development to reduce US dependence on foreign sources of energy. Yet, there are now emerging concerns that water availability will impact energy reliability in the USA. Water security underpins energy security, but also health and food security, and economic development. Its critical importance is highlighted in the human right to water and sanitation. It is also now seen as impacting civil conflict and the migration of peoples in other jurisdictions. As explained below, sustainable development seeks a balance between social, economic and environmental outcomes, both now and with future generations in mind. ‘Sustainability’ is a broad concept and the balancing exercise required to meet it requires that these other objectives and concerns are also considered. As developed nations, it is incumbent on us to seek to strike a balance between economic progress and the resulting environmental and social impacts. We know that the need for water underpins all activities, including our very survival as well as that of future generations. Where water is concerned, it is deeply hazardous to place economic development above the health and resilience of the overall resource. Furthermore, we are now arguably at the stage where our thirst for global economic growth is reaching the limits of our natural world. Therefore, sustainable development is the most important objective for the protection of our environment generally and most importantly for our water resources. This is consequently adopted as the goal of the relevant regulatory frameworks for this research.


203 InterAction Council, above n 201.

a) What is ‘sustainable development’ in the groundwater context?

Broadly, sustainable development ensures that ‘development ... meets the needs of the present without compromising the ability of future generations to meet their own needs.’

The notion of sustainable development has advanced as environmental regulation expanded from focussing on the remediation of harm to encompassing the prevention of harm. The concepts of social and economic development are coupled with environmental protection ‘so as to ensure that the economy, the society and the environment are maintained as far as possible in their present state for not only present but also future generations.’ The fundamental concept of sustainable development was encapsulated in the Rio Declaration on Environment and Development, produced by the United Nations’ Conference on Environment and Development in 1992. The Declaration adopted 27 principles, defining the rights and responsibilities of the States for assisting in the implementation of economy-wide approaches to sustainable development.

The polluter pays principle was adopted (as principle 16) which states that the polluter should, in principle, bear the cost of pollution. In the groundwater context this principle implies that groundwater users will meet the full cost of the impact of their individual extraction on the environment. The cost of the impact must be measured in terms of not just the rate of extraction, but the impact of that extraction on the surrounding environment (including other users). For example, the cost of extracting groundwater in the vicinity of a highly sensitive groundwater dependent ecosystem ought to include the impacts to that system. Similarly, the cost of impacts of new groundwater users that create disproportionate impacts in addition to historic and existing collective use, ought to include this disproportionate impact.

The other two key principles that are relevant to this research, and are discussed below, are principle of inter-generational equity and the precautionary principle.

(i) Inter-generational equity and groundwater development

The principle of inter-generational equity included in the 1992 Rio Declaration states that ‘the right to development must be fulfilled so as to equitably meet [the] developmental and environmental needs of present and future generations.’ This requires that one generation does not severely degrade the environment: ‘each generation [must] leave the planet in no worse condition than it received it, and provide succeeding generations equitable access to its resources and benefits.’

A corresponding concept, involving the equitable access among existing generations, is known as ‘intra-generational equity’.

Inter-generational equity involving groundwater translates to ensuring that withdrawals from a groundwater basin do not impact the future use of that basin, at least, unless and until alternatives are developed and available for the future on a sustainable basis. For extractions to be sustainable, they must not cause continued declining and deteriorating water levels, deteriorating water quality or negative impacts on the basin’s ability to hold water through, for example, compaction. These outcomes will impact the ability of future generations to access that resource.

A key issue for Australia has also been avoiding water levels deteriorating to a point where groundwater-dependent species are impacted. In the management of groundwater resources, the (contested) term ‘safe yield’ is used to reflect the amount that extractors can withdraw without compromising water levels; this usually equates to a percentage of the basin’s natural recharge. Success in terms of resource sustainability (and inter-generational equity), therefore, can be measured against this type of ecological deterioration.

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210 There will always be some impact to groundwater levels when groundwater is extracted from the system.
212 The Land Court decision by CAC McDonald highlights how conditions were drafted for the Carmichael mine in the Galilee Basin to protect groundwater-dependent ecosystems from groundwater drawdown, due to the proposed open-cut coal mine: Adani Mining Pty Ltd v Land Services of Coast and Country Inc [2015] QLC 48 (15 December 2015).
214 Zhou, above n 211; Jac van der Gun and Annukka Lipponen, ‘Reconciling Groundwater Storage Depletion Due to Pumping with Sustainability’ (2010) 2 Sustainability 3418. This was one of the measures of success adopted by Jacopo A Baggio et al, ‘Explaining Success and Failure in the Commons: The Configural Nature of Ostrom’s Institutional Design Principles’ (2016) 10(2) International Journal of Commons 417.
Inter- and intra-generational considerations for groundwater sustainability also require more than simply a consideration of the physical status of the groundwater resource. Water governance is fundamentally socio-economic and political in nature. A balancing exercise between environmental, social and economic factors is also necessary. Where development of ‘fossil’ groundwater resources occurs, there should be: improvements in wellbeing, enhancement in social capital and opportunities for younger generations (that may provide technological breakthroughs). That is, there must be clear improvements in social wellbeing: short-term socio-economic benefits must pay dividends for the future and outweigh the longer term ‘negative impacts.’ There must also be an ‘exit’ strategy, which considers what to do once the aquifer shows signs of serious depletion. Van der Gun and Lipponen argue that:

as long as groundwater pumping does not threaten to exhaust the aquifer and society considers the benefits from pumping to outweigh the associated negative impacts – both integrated over a prolonged period of time, one may speak of sustainable groundwater development.

Where the extraction involves a “fossil aquifer”, robust political processes which engender trust and manage conflict will therefore be paramount in ensuring that the appropriate trade-offs (for the inevitable reduced aquifer levels) occur. They will also ensure consideration of local unintended consequences. Hence, the measure of sustainability for groundwater development, which includes both a lack of deterioration of the resource as well as a lack of conflict and trust
issues,222 is extremely important when evaluating governance frameworks.223 This is the measure of sustainability that will be adopted in this research.224

(ii) The precautionary principle applied to groundwater development

The second relevant principle is the precautionary principle, which is a pillar of environmental law225 both internationally and in Australia. This is enshrined in Queensland’s environmental legislation226 and has been applied in numerous Queensland decisions.227 It specifically relates to the notion of future uncertainty of harm or risk(s) of harm, which are an inescapable aspect of activities that impact the environment. Relevantly, within the CSG context, it relates to the management of uncertainty associated with future impacts of dewatering coal measures that are also aquifers and, for aquifer injection specifically, the potential impacts to water quality.

A widely accepted international formulation of the precautionary principle (from the 1992 Rio Declaration) states:

222 The term ‘trust’ is used in this context to reflect reliance on and confidence in the integrity of certain actions (such as decision-making by the regulator or actions of other stakeholders): XiaoHu Wang and Montgomery Wan Wart, ‘When Public Participation in Administration Leads to Trust: An Empirical Assessment of Managers’ Perceptions’ (2007) 67(2) Public Administration Review 265; Kaifeng Yang, ‘Public Administrators’ Trust in Citizens: A Missing Link in Citizen Involvement Efforts’ (2005) 65(3) Public Administration Review 273.
223 These were the measures adopted by other scholars relating to the sustainability of groundwater resources: Baggio et al, above n 214; Barnett et al, above n 177; Elicia Ratajczyk et al, ‘Challenges and Opportunities in Coding the Commons: Problems, Procedures, and Potential Solutions in Large-N Comparative Case Studies’ (2016) 10(2) International Journal of the Commons 440.
224 Sustainability can be also analysed through the lens of the ‘resilience’ of the social-ecological system, which can be measured qualitatively and relatively in terms of biological diversity; ecological variability; modularity; and acknowledgment of slow variables, tight feedbacks, social capital, innovation, overlaps in governance and ecosystem services, see: Brian Walker and David Salt, Resilience Thinking: Sustaining Ecosystems and People in a Changing World (Island Press, Washington DC, 2006). However, these system properties are more easily attributable (and measurable) to surface ecosystems such as water basins. For a very brief discussion of ‘resilience theory’ within the development of adaptive governance scholarship, see p 50 below.
225 It was described in Lockheed Martin Corp v US, 35 F Supp 3d 92 (DDC 2014), [56] per Ellen Segal Huvelle, J, as ‘an amorphous pillar of contemporary environmental theory.’
226 The standard criteria that must be considered in environmental assessments and management decisions includes the precautionary principle (as well as the principles of intergenerational equity and biological diversity and ecological integrity included in the Intergovernmental Agreement on the Environment 1992), see eg, ss 58, 143, 175–6 and schedule 4 definition of standard criteria. The principle has also been adopted in various iterations of town planning (or zoning) legislation, see: Integrated Planning Act 1997 (Qld), Sustainable Planning Act 2009 (Qld) and the Planning Act 2017 (Qld).
Aquifer injection in the Coal Seam Gas context: Part A: Chapter 2: Theoretical underpinnings

In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.\(^{228}\)

The wording of this principle, as adopted in Australia in the *Intergovernmental Agreement on the Environment* 1992, includes a postscript (which is underlined below):

> In the application of the precautionary principle, public and private decisions should be guided by:

(i)  careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment; and

(ii) an assessment of the risk-weighted consequences of various options.\(^{229}\)

The precautionary principle applies when there is satisfaction of the following conditions precedent: a threat of serious or irreversible environmental damage, and scientific uncertainty.\(^{230}\)

This principle centres on a decision-maker’s attitudes or beliefs about both the nature of risk and magnitude of environmental damage, and uncertainty about causes and eventuality. The principle can be viewed as part of a decision-making procedure or process, rather than an outcome that requires ‘proof’ of ‘safety’\(^{231}\) or to avoid all (serious) risks.\(^{232}\)

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\(^{228}\) Principle 15; United Nations, above n 207.

\(^{229}\) Agreed between the Commonwealth of Australia, the States (including Queensland) and Territories and the Australian Local Government Association, see: Commonwealth of Australia et al, *Intergovernmental Agreement on the Environment*, above n 195; *National Environmental Protection Council (Qld) Act* 1994 (Qld), sched.

\(^{230}\) Preston CJ in *Telstra Corporation v Hornsby Shire Council* (2006) 67 NSWLR 256 at 269; *Adani Mining Pty Ltd v Land Services of Coast and Country Inc* [2015] QLC 48 (15 December 2015), 17–19 and 67–68 as per MacDonald P; *Hancock Galilee Pty Ltd v Currie* [2017] QLC 35 (4 July 2017), 15; *Lockheed Martin Corp v US*, 35 F Supp 3d 92 (DDC 2014), [56] per Ellen Segal Huvelle J, ‘For applying the precautionary principle as a standard of care requires, at a minimum, a demonstration that some factual basis for the exercise of precaution—ie, knowledge of the potential environmental risk—existed at the time of the relevant disposals.’


\(^{232}\) *Adani Mining Pty Ltd v Land Services of Coast and Country Inc* [2015] QLC 48 (15 December 2015), 18 and the judicial review of the subsequent delegate’s decision for the Carmichael Coal Mine *Land Services of Coast and Country Inc v Chief Executive, Department of Environment and Heritage Protection* (2016) 222 LGERA 122; *Hancock Galilee Pty Ltd v Currie* [2017] QLC 35 (4 July 2017), 17. Once the condition precedents are triggered, the precautionary principle is activated, and the decision-maker must assume that there will be serious or irreversible impacts in the exercise of his/her decision-making function. This then reverses the onus of proof so that the proponent must adduce evidence of likely impacts, scientific evidence and proposed management plans to assist the decision-maker (or Court) in the decision-making process, see: *Telstra Corporation v Hornsby Shire Council* (2006) 67 NSWLR 256, 273.
Because the principle has been specifically adopted in environmental legislation in Queensland and Australia,\textsuperscript{233} it has been considered in many cases, most relevantly to this research in the coal mining context.\textsuperscript{234} The cases provide useful judicial commentary on the ambit and function of the principle in Australia. Relevantly, the principle must embrace proportionality: the measures must not go beyond what is appropriate.\textsuperscript{235} Furthermore, the principle does not necessarily prohibit development where there are environmental impacts; the principle is but one of the considerations for the relevant decision-maker and not the overriding factor.\textsuperscript{236} The additional sub-clauses to the principle in the Intergovernmental Agreement recognise that, sometimes, environmental damage will be unavoidable and irreversible, particularly where mining is involved, which necessarily will always involve some negative environmental impacts.\textsuperscript{237} Despite this, the principle has been applied in various jurisdictions in many circumstances (including mining) to prohibit development.\textsuperscript{238}

The measure of scientific uncertainty required will vary but, usually, the greater the threat of anticipated environmental harm; the lower will be the threshold for uncertainty.\textsuperscript{239} Preston CJ of the New South Wales Land and Environment Court stresses that there must be ‘reasonable scientific plausibility’ rather than pure speculation or unsupported opinion.\textsuperscript{240} In contrast, academic scholars caution that, in some circumstances, such as with novel technologies, the adequacy of that information may be completely lacking.\textsuperscript{241} No evidence for cause for concern may be insufficient

\textsuperscript{233} For cases where the principle was incorporated into administrative instruments in the USA, such as in a departmental management plan, see: Defenders of Wildlife v Salazar, 877 F Supp 2d 1271 (MDFla, 2012); National Parks Conservation v Department of Interior, 46 F Supp 3d 1254 (MDFla, 2014).

\textsuperscript{234} Adani Mining Pty Ltd v Land Services of Coast and Country Inc [2015] QLC 48 (15 December 2015); Hancock Galilee Pty Ltd v Currie [2017] QLC 35 (4 July 2017).

\textsuperscript{235} Adani Mining Pty Ltd v Land Services of Coast and Country Inc [2015] QLC 48 (15 December 2015), 18; Hancock Galilee Pty Ltd v Currie [2017] QLC 35 (4 July 2017), 17.

\textsuperscript{236} Adani Mining Pty Ltd v Land Services of Coast and Country Inc [2015] QLC 48 (15 December 2015), 19; Hancock Galilee Pty Ltd v Currie [2017] QLC 35 (4 July 2017), 17.

\textsuperscript{237} Hancock Galilee Pty Ltd v Currie [2017] QLC 35 (4 July 2017), 19.


\textsuperscript{239} Preston, above n 238, 131.

\textsuperscript{240} Ibid.

\textsuperscript{241} Peel, above n 231, 74. This is reflective of Donald Rumsfeld’s statement: ‘we don’t know [what] we don’t know’: Hart Seely (Ed), Pieces of Intelligence: The Existential Poetry of Donald H. Rumsfeld (Simon & Schuster Ltd, 2003), 2.
An important application of the principle occurs when present understandings of ecological processes break down; that is, with respect to the ‘unknown’ and perhaps the ‘unknowable’. The precautionary principle, as well as the broader requirements of sustainable development, are applied by decision-makers during environmental impact assessments and decision-making at the front end of development: the application and permitting stage. Yet, uncertainty does not disappear once development is authorised. Usually, there is an ongoing issue relating to how to manage uncertainty as the development progresses. There needs to be an approach to decision-making that provides an ability to respond to changing understandings about a resource and changed circumstances as development progresses. The regulators, especially in Queensland, have sought to rely on what is known as an ‘adaptive management’ approach to respond to ongoing uncertainty in the pursuit of sustainable development.

2. Adaptive Management

In 2004, a broad policy of adaptive management (AM) was adopted across Australia for water allocation and planning. In 2009, AM was expressly adopted in Queensland in relation to the governance of CSG activities. Since 2008, the US Department of the Interior has required all bureaus to apply an AM approach in the NEPA process where possible. As mentioned, it is applied by decision-makers at various levels and in various ways to address ongoing uncertainty in development. The approach has developed since the 1970s: relevant notable scholars include

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242 Peel, above n 231, 100 (for fisheries management), and 126 (for the health risks of mobile phone towers).
243 Ibid, 54.
245 Gunderson, Holling and Light note that sustainable development requires ‘flexible, diverse, and redundant regulation; monitoring that leads to corrective responses; and experimental probing of the continually changing reality of the external world’; LH Gunderson, CS Holling and Stephen S Light, Barriers and Bridges to the Renewal of Ecosystem and Institutions (Columbia University Press, 1995), 32.
Holling, Walters and Lee. Their contributions, along with other scholarship, are discussed after a brief explanation of the approach and the context in which it was developed.

a) What is AM?

First generation natural resource management was implemented through a ‘command and control’ approach. It is still the preferred approach of stakeholders and decision-makers because it is decisive and assumes certainty; it relies on best-available technology requirements to control specific environmental problems (such as pollution) or crises (such as ozone depletion) and aims to maintain the status quo. Command and control regulatory frameworks tend to feature technical norms and legal prescriptions, which then dictate decision-making. The laws apply a classical paradigm of science and engineering: problems are definable, separable and may have solutions that are findable. This kind of framework typically involves information that has been defined by technical experts and is not always shared; stakeholder engagement is mainly through passive channels. The main data collection and monitoring focuses on the state of the environment rather than other impacts. Large-scale infrastructure is utilised; therefore, the large sunk costs inhibit changing objectives. All of these characteristics result in a system that is difficult to change and that relies on the assumption that a resource system is ‘knowable’. Specific flaws in the ‘command and control’ approach include token consideration of socio-economic dynamics; overly conservative research; falsely assuming systems are linear, predictable and controllable;
decoupling of humans and natural systems,\textsuperscript{263} and increased vulnerability in the whole system (such as with major droughts and floods).\textsuperscript{264}

AM was developed in response to these flaws; it entails systematically learning through the management process and is both proactive and reactive. A key feature of the approach is the requirement for a built-in feedback loop so that monitoring data can allow for reassessment of management actions.\textsuperscript{265} Due to this reassessment, changes in management direction or objectives are possible and even the status quo may be questioned. A further key aspect of AM is the framing of management as an experiment.\textsuperscript{266} The process is distinguishable from trial-and-error approaches or ad hoc decision-making, which do not feature strategic planning in the first case, nor a reassessment of actions or objectives to reduce uncertainty.\textsuperscript{267}

b) Development of AM – a changing approach

AM has attracted its adherents as well as its critics, due in part to the development of the theory and therefore its changing definition as well as the concept’s inherent flexibility.\textsuperscript{268} From at least the 1970s, the approach developed within the natural resources’ literature, most notably from Holling’s seminal 1978 text, \textit{Adaptive Environmental Assessment and Management}.\textsuperscript{269} In 1986, Walters developed a more technical approach, involving mathematical modelling to pinpoint uncertainties.\textsuperscript{270}

In 1993, Lee explored the social and political dimensions impacting large-scale ecosystem management, by canvassing the role of ‘social learning’.\textsuperscript{271} Lee describes social learning by reference to understanding how to ‘achieve an environmentally sustainable economy’ and defines social learning as ‘the combination of adaptive management and political change’.\textsuperscript{272} Lee highlights the challenges and criticisms of AM. Appendix 9 lists some of these challenges sourced from literature on AM.

\textsuperscript{263} Folke et al, Resilience, above n 262.
\textsuperscript{264} F Moberg and V Galaz, \textit{Going from Conventional to Adaptive Freshwater Management for Human and Ecosystem Capability} (Stockholm International Water Institute, 2005), 5.
\textsuperscript{266} Holling, above n 250; Walters, above n 251; Halbert, above n 265, 263.
\textsuperscript{268} Allen et al, above n 267, 1342; Halbert, above n 265, 267–268. Other criticisms highlight practical challenges for AM that can be divided into theoretical, institutional and management, scientific as well as social challenges. Appendix 9 lists some of these challenges sourced from literature on AM.
\textsuperscript{269} Holling, above n 250.
\textsuperscript{270} Walters, above n 251.
\textsuperscript{271} Lee, above n 204.
\textsuperscript{272} Ibid, 8.
interaction between science and politics. He distinguishes the scientific- or resource-centred
application of AM, which he termed the ‘compass’, from the human dimension involving conflict,
which he termed the ‘gyroscope’. He explained that the compass, AM, ‘is an idealistic application of
science to policy that can produce reliable knowledge from unavoidable errors.’ The gyroscope, or
‘bounded conflict’, ‘is a pragmatic application of politics that protects the adaptive process by
disciplining the discord of unavoidable error.’ Lee highlighted that, in order to facilitate learning
from the AM method, bounded conflict was necessary. What that entails is maintaining a ‘level of
institutional cooperation and stability capable of planning, implementing, and monitoring activities
over the length and breadth of large ecosystems, and … [persevering] for biologically relevant
periods.’ He argued that both the compass and the gyroscope (that is, both AM and ‘bounded
conflict’) are essential for social learning, which can transition from unsustainability to a durable
social order.

Learning is the engine that drives the AM process, but ‘social learning’ (the combination of
AM and political change) can transform governance. Just as Lee drew heavily on theories of public
policymaking, Pahl-Wostl has drawn from organisational learning to describe social learning as
either single-loop, double-loop or triple-loop learning. Pahl-Wostl explains that:

- single-loop learning refers to an incremental improvement of action strategies without questioning
  the underlying assumptions ...
- double-loop learning refers to a revisiting of assumptions within a
  value-normative framework. In triple-loop learning, one starts to reconsider underlying values and
  beliefs, world views, if assumptions within a world view do not hold anymore.

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272 Ibid, 11.
273 Lee, above n 204, 11.
274 Ibid, who equates bounded conflict with politics and argues that ‘unbounded conflict’ leads to strife and
poverty, and above all, extremely limited learning about the relevant ecosystems. He argues that ‘unbounded
conflict destroys the long-term cooperation that is essential to sustainability’ (10). ‘Conflict is necessary to
detect error and force corrections’ (p10) but ‘severe conflict can undermine the error-correcting capability
itself’ (114).
275 Ibid, 11.
276 Ibid, 114.
277 Lee, above n 204, 11.
278 Ibid, ch 4 (such as John Dewey, The Public and its Problems (Alan Swollow, 1954); Anthony Downs, ‘Up and
Down with Ecology—The Issue—Attention Cycle’ (1972) 28 The Public Interest 38; and John W Kingdon,
279 Chris Argyris and Donald A Schöns Theory in Practice: Increasing Professional Effectiveness (Jossey-Bass
Publishers, 1st ed, 1974); Chris Argyris, On Organizational Learning (Blackwell Publishers, 1993); Robert A
Hargrove, Masterful Coaching (Jossey-Bass, 3rd ed, 2008); Lee, in addition to single- and double-loop learning,
also describes ‘task-based learning’ at the local level, where an operator learns how to carry out a task more
efficiently, and ‘system level learning’, which develops in the centralised areas of planning and where different
kinds of projects are compared and evaluated: Lee, above n 204, 114.
Figure 6 below illustrates this multiple loop learning framework and helps to explain transitions from one type of water resources framework to another, perhaps more adaptive, framework. It also provides an example of the different levels of learning that are associated with AM.

![Learning Framework Diagram]

Figure 6. The sequence of learning cycles

The AM approach has continued to be refined through an increase in published literature since 2000. Different ‘schools of thought’ have been acknowledged, focusing on the different ways that the approach has been applied by decision-makers to address uncertainty and to promote learning: either through focusing on ecosystem resilience or structured decision-making. In

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282 Ibid.
283 Ibid, Hiller and Tyre, above n 265.
285 The Decision-Theoretic AM School is exemplified by Hugh Possingham, Australian Conservation Foundation and Earthwatch Institute, *The Business of Biodiversity: Applying Decision Theory Principles to Nature Conservation* (Australian Conservation Foundation, 2001); US Department of the Interior’s *Technical Guide on Adaptive Management*, Williams, Szaro and Shapiro, above n 249 (which recognises the need for double-loop learning, 37). This approach does not rely heavily on experimentation and simple ecological models are developed, which are largely process based. Rather than experimentation, a trade-off analysis occurs. If anything, in Queensland, where AM has been sought to be applied, an approach akin to the Decision-Theoretic AM School has been adopted, with mixed results. Similarly, the US Department of the Interior’s *Technical Guide*, applied by the US Bureau of Land Management, has also been described as falling within this AM approach because it provides an aid to decision-making. This is discussed further in Chapter 7.
addition, since at least 2005, Adaptive Co-Management, 286 Integrated AM 287 and Adaptive Governance 288 have evolved as another (broadly similar) approach, which focusses on stakeholder collaboration (both formal and informal) throughout the entire process. This broader interpretation of AM is relevant even where key decisions about the system are made centrally by an overarching government. Case studies have revealed that there are many other stakeholders who do, in fact, influence decision-making through less formal mechanisms, for better or for worse. 289

In this context, wide stakeholder participation has been promoted as beneficial. 290 The logic is that more effective participation will result in improvements to governance as expressed in, for example, Arnstein’s ladder of participation. 291 Research in respect of effective participation in environmental decision-making is nascent; however, key principles for effective public participation involve ensuring that all relevant stakeholders are included in ‘collaborative problem formulation and process design, transparency of the process and good faith communication’. 292 Where there is

286 Moberg and Galaz, above n 264, 6.
289 Such was the case with respect to the spruce budworm management in eastern Canada, as discussed in Rebecca J McLain and Robert G Lee, ‘Adaptive Management: Promises and Pitfalls’ (1996) 20(4) Environmental Management 437, 440; Gunderson notes that, in cases of successful AM, there is almost always an informal network of stakeholders who emerge, see; Gunderson, above n 284; LH Gunderson and Stephen S Light, ‘Adaptive Management and Adaptive Governance in the Everglades Ecosystem’ (2006) 39 Policy Sciences 323. There are always numerous and often changing government agencies, non-government organisations, and associations and individuals that are sometimes cooperative and other times competitive in watershed governance, see: Edella Schlager and William Blumquist, Embracing Watershed Politics (University Press of Colorado, 2008).
scientific uncertainty, transparency of information relating to decision-making (including facts, assumptions and uncertainties), along with providing opportunities for independent review, and reconsideration of decision-making, are also important procedural processes. 293

There is growing research for when public or stakeholder participation is helpful, and when it can be detrimental to governance. 294 Two-way communication can be costly, unpredictable and can erode existing power bases. 295 Conversely, existing vested interests and power inequalities may be reinforced by ineffective participatory measures. 296 Broad engagement will no doubt increase decision-making costs but it can ultimately decrease the costs of implementation of policy. 297 Contextual factors such as the rationales for participation, 298 the social or cultural context, 299 and the existing institutional framework are important in determining the degree of participation that will be effective. 300 However, higher levels of participation have been shown to impact levels of trust positively, 301 and have had positive outcomes in respect of groundwater governance. 302

1. Stakeholder participation needs to be underpinned by a philosophy that emphasises empowerment, equity, trust and learning; 2. Where relevant, stakeholder participation should be considered as early as possible and throughout the process; 3. Relevant stakeholders need to be analysed and represented systematically; 4. Clear objectives for the participatory process need to be agreed among stakeholders at the outset; 5. Methods should be selected and tailored to the decision-making context, considering the objectives, types of participants etc; 6. Highly skilled facilitation is essential; 7. Local and scientific knowledge should be integrated; 8. Participation needs to be institutionalised.

293 National Research Council, Public Participation, above n 292, 234
295 Hurlbert and Gupta, above n 291; Baker and Chapin, above n 294.
296 Akamani, above n 294, 12.
297 Schlager and Blomquist, above n 289, ch4.
298 For example, as an aid to policy development and implementation, or as a normative goal; Glucker et al, ‘Public Participation in Environmental Impact Assessment: Why, Who and How?’ (2013) 43 Environmental Impact Assessment Review 104.
299 For example, whether there are social inequities.
300 Baker and Chapin, above n 294.
Aquifer injection in the Coal Seam Gas context: Part A: Chapter 2: Theoretical underpinnings

It is worth noting that the ability of the governance framework and the social-ecological system (SES) to adapt is connected with the development of the concept of the ‘resilience’ of a system within adaptive governance scholarship.\textsuperscript{303} Resilience is a measure of the amount of perturbation or disturbance a system can withstand without crossing a critical threshold.\textsuperscript{304} An analysis of the ‘resilience’ of a given SES is an alternative lens through which to view and manage sustainable development. However, resilience is often considered within the context of climate change and with respect to surface ecosystems (such as river basins) rather than groundwater.\textsuperscript{305}

c) Common legal pitfalls in the application of AM

There has been much criticism of AM (and adaptive governance) due to its difficulty in being applied in the ‘real world.’\textsuperscript{306} AM has developed largely through the work of scientists; Ruhl notes that the jump from theory, to policy and to the law has proven to be difficult.\textsuperscript{307} It should be remembered that any form of governance usually involves government agencies (whether centralised or polycentric). Scientists and others may overlook that these organisations are creatures of statute, which have defined legislative powers: there are limits to how often and how broadly they can change decisions. This was overlooked in the early days, but legal constraints to AM are now acknowledged as important.\textsuperscript{308}


\textsuperscript{305} Lebel et al, above n 302; Walker et al, above n 303; Walker and Salt, above n 224; Cosens and Gunderson, above n 29; for a critical analysis of the approach, see: Lennart Olsson, Anne Jerneck, Henrik Thoren, Johannes Persson and David O’Byrne, ‘Why Resilience Is Unappealing to Social Science: Theoretical and Empirical Investigations of Scientific Use of Resilience’ (2015) 1(4) Science Advances e1400217.

\textsuperscript{306} Walters notes that he had participated in 25 planning exercises and only 7 resulted in relatively large-scale management experiments; of those, only 2 would have been considered well planned in terms of statistical design: see: Walters, above n 284; see also Appendix 9.


Aquifer injection in the Coal Seam Gas context: Part A: Chapter 2: Theoretical underpinnings

The essential difficulty in applying an AM approach within the confines of the law is that the AM approach, and (public) administrative law, have at their core two competing paradigms. As mentioned above, the AM approach expressly acknowledges and addresses uncertainty. The approach accepts that uncertainty is something that needs to be managed over time. Administrative law is the ‘law relating to government power,’ and has developed to govern how administrative agencies exercise delegated authority. Administrative law seeks to provide, among other things, finality and certainty. The rigidity of legal thinking in this regard, therefore, does not usually lend itself to experimentation. Thus, ‘the legal system and the natural sciences system serve two different masters.’

In environmental law, administrative decision-making has developed in a two-step process. The first step usually involves an environmental assessment that is publicly available for comment and facilitates public participation and judicial review. This process developed alongside the notion that it was possible to predict all consequences prior to a decision being made. The second step is the decision by the administrative officer authorising (or refusing) the proposed development. This decision is required to be made according to the ‘rule of law’, which requires certainty and ought to be final. Administrative action must either authorise the development, or

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Ruhl, Regulation by Adaptive Management, above n 308.
Ruhl and Fischman, above n 308, 437; Allen et al, above n 267, 1343.
Locke, above n 311; at ch4 § 22, where the author states ‘freedom of men under government is, to have a standing rule to live by, common to every one of that society, and made by the legislative power erected in it; a liberty to follow my own will in all things, where the rule prescribes not; and not to be subject to the inconstant, uncertain, unknown, arbitrary will of another man: as freedom of nature is, to be under no other restraint but the law of nature’ [emphasis added].
not. Where AM is applied at an operational level in development,\textsuperscript{317} such as for a mine, the decision to approve the development will often be on the condition that it be managed adaptively.\textsuperscript{318} Therefore, in this context, AM is put into practice at the ‘back end’ of the process, after a decision has been made by the regulator.\textsuperscript{319} This opens the door for otherwise authorised development to be continually reassessed as time progresses: an outcome contrary to the expectations that decision-making should be final and certain. Nonetheless, it also allows development to be approved that would otherwise have been refused, on the condition that various operational issues will be managed adaptively.

It has been argued that a true AM approach is not possible within the current administrative law framework. Ruhl argues that neither the legislatures empowering the bureaucracy, the courts interpreting bureaucratic power nor the public are supportive of such broad administrative powers.\textsuperscript{320} Scholars have noted that, in the US, the form of AM that has actually been implemented in practice is what has been called ‘AM-lite’.\textsuperscript{321} This form of AM often lacks some of the essential steps described in AM theory for iterative learning. Ruhl further explains that ‘AM-lite ... in its extreme form is open ended contingency planning or ‘on the fly’ management ... [and] may slip into ‘basic trial and error learning’’.\textsuperscript{322} ‘AM-lite’ often suffers from not having clear objectives and processes for monitoring, a lack of decision-making thresholds in monitoring and a lack of specific actions triggered by those thresholds.\textsuperscript{323}

The Australian caselaw has followed the US approach in that the Courts acknowledge the necessity for the various steps in AM, especially regarding adequate monitoring. Where impacts to groundwater are sought to be managed, monitoring of those impacts by reference to agreed indicators is essential. However, it is less clear how stringent the Courts will be in the detail around the decision thresholds in monitoring, and the actions to be triggered at those threshold points. The Australian cases reveal that there is more room for flexibility (on an administrative law basis) for AM in this jurisdiction.

\textsuperscript{317} As opposed to where AM has been applied by regulatory bodies in their own management of a resource, such as with respect to land use (in the case of the US BLM) or fisheries.
\textsuperscript{318} For example, that adaptive management steps, which include monitoring, evaluation and compliance, should be applied to reduce uncertainty relating to certain impacts as the development proceeds.
\textsuperscript{319} For example, that adaptive management steps, which include monitoring, evaluation and compliance, should be applied to reduce uncertainty relating to certain impacts as the development proceeds.
\textsuperscript{320} Ruhl, Regulation by Adaptive Management, above n 308, 30.
\textsuperscript{321} Allen et al, above n 267, 1343; Ruhl and Fischman, above n 308.
\textsuperscript{322} Ruhl and Fischman, above n 308.
Aquifer injection in the Coal Seam Gas context: Part A: Chapter 2: Theoretical underpinnings

The courts in Australia have been reluctant to strike down administrative decisions that impose an AM approach. In *Telstra Corporation v Hornsby Shire Council*,\(^{324}\) concerns were raised as to the health implications of the emissions of electromagnetic energy relating to the installation of a mobile phone tower. Preston CJ outlined, in allowing the appeal and granting consent for the tower, that AM may involve the following core elements:

- monitoring impacts of management or decisions based on agreed indicators;
- promoting research to reduce key uncertainties;
- ensuring periodic evaluation of the outcomes of implementation, drawing lessons, and review or adjustment, as necessary, of the measures or decisions adopted; and
- establishing an efficient and effective compliance system.\(^{325}\)

In *Ulan Coal Mines Limited v Minister for Planning*,\(^{326}\) a judicial review relating to a coal mine project, the approval required monitoring and adaptive management relating to the supply of water. Preston CJ upheld the approval, applying the requirements from the earlier *Telstra* case, stating that the ‘test for invalidating an exercise of administrative power on the ground of manifest unreasonableness is stringent.’\(^{327}\) Similarly, the adoption of an AM approach has been upheld in various cases, where the existence of monitoring requirements was central to the satisfaction of the Courts.\(^{328}\)

A draft approval for a coal mine, which contained conditions that required an AM framework, was relatively recently considered in *Adani Mining Pty Ltd v Land Services of Coast and Country & Ors*.\(^{329}\) McDonald P found that the AM required for the potential groundwater drawdown\(^{330}\) was satisfactory, even though it did not explain how mitigation would occur. It had been argued that the conditions of the permit did not include a timeframe for when the objectives were to be achieved, the groundwater management and monitoring plan lacked clarity, and the requirements were aspirational and non-specific. McDonald P held that the requirement for the

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\(^{324}\) (2006) 67 NSWLR 256, 276 [164].


\(^{327}\) (2008) 160 LGERA 20, [100].

\(^{328}\) For example, *Environmental Protection Authority v Ballina Shire Council* (2006) 148 LGERA 278, [74]; *Port Stephens Pearls Pty Ltd v Minister for Infrastructure & Planning* [2005] NSWLEC 426; *Hancock Galilee Pty Ltd v Currie* [2017] QLC 35 (4 July 2017), 17. For the rejection of the argument that a proposal was uncertain, because the approval was conditional on the subsequent approval of an environmental management plan (for CSG wastewater ponds): *Golder v Maranoa Shire Council* [2015] QPELR 292, [33]. Robertson DCJ held that the subsequent approval of the plan would not significantly alter the nature of the development, nor did it leave for a later decision an important aspect of the development.


\(^{330}\) Or a decline in groundwater pressure due to development.
regulator to approve the groundwater management and mitigation plan would ensure that adequate monitoring and mitigation would occur at that later point.  

This somewhat follows the approach that had been adopted in 2000 by Doyle CJ of the South Australian Supreme Court, in *Tuna Boat Owners Association of South Australia v Development Assessment Commission*. This case involved an appeal from a decision of the Environment Resources and Development Court (South Australia), which rejected a proposal for a tuna farm because there was no assurance that the proposed adaptive management approach could or would be implemented. Whether the approach was applied depended on an agency policy of issuing licences for only 1 year rather than the maximum 10. If agency policy changed, and a 10-year licence was granted, there were no powers under the relevant legislation to change conditions after the issuance of the licence. Thus, the adaptive approach would then be unavailable (if a 10-year licence was granted). Doyle CJ stated that ‘it is not appropriate to assume that the Minister would act in this manner, at least and until there is evidence indicating that he might well do so.’ Therefore, in Australia, agencies appear to hold the confidence of the judiciary: it is presumed that agencies will apply an authentic AM approach in future administrative action.

There is a tension between the precautionary principle, which would otherwise prohibit an activity until further information is obtained, and the adoption of AM, which allows an activity to proceed while information is collected. The New Zealand Supreme Court in *Sustain Our Sounds Inc v The New Zealand King Salmon Co Ltd (Sustain our Sounds case)* highlighted that the overarching issue is to first determine whether the AM regime is consistent with a precautionary approach. While that case involved fishing in another jurisdiction (New Zealand), and not groundwater, it is nonetheless instructive. The Full Court established that the factors to be considered when deciding whether AM is a legitimate approach to adopt, rather than prohibiting an activity, are the:

- extent of the environmental risk (including the gravity of the consequences if the risk is realised);

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331 The Groundwater Management and Monitoring plan was finally approved by the Minister for the Commonwealth Department of Environment in April 2019, and by the Minister for the Queensland Department of Environment and Science in June 2019 (following an independent report jointly authored by CSIRO and Geoscience Australia) see chapter 8 below p 271–272. This approach is discussed in chapters 7 and 8.


333 (2000) 77 SASR 369; 110 LGERA 1 [54].

334 AM can operate to ‘water down regulatory requirements, reduce public scrutiny of planning and development approval processes, and accord preferential treatment to favoured industries’ Godden and Peel, above n 231, 287.

335 [2014] 1 NZLR 673, [129]; *Friends of Leadbeater’s Possum Inc v VicForests (No 3)* (2018) 231 LGERA 75
importance of the activity (which could in some circumstances be an activity it is hoped will protect the environment); 

• degree of uncertainty; and 

• extent to which an adaptive management approach will sufficiently diminish the risk and uncertainty.\textsuperscript{336}

More recently, New Zealand case law has highlighted that whether an AM approach is appropriate depends on a number of factors, which centre on ‘the extent of risk and uncertainty remaining and the gravity of the consequences if the risk is realised’.\textsuperscript{337}

In terms of the question as to whether an AM approach will sufficiently diminish risk and uncertainty, the \textit{Sustain our Sounds} case relied on various factors. The AM regime in that case was upheld as consistent with a precautionary approach due to findings that: baseline information about the environment could be obtained prior to development; there was an effective monitoring regime proposed, which included appropriate thresholds (and would be peer reviewed); and remedial actions were capable of being instituted if adverse impacts occurred.\textsuperscript{338} The above discussion provides the low bar that must at least be met for an AM approach to be valid in Australia: monitoring, research, evaluation and compliance. That is, administrative validity at law is not the same as ‘effectiveness’. While it is clearly necessary to understand where the line is drawn between valid administrative decisions adopting AM and ones that are ultra vires,\textsuperscript{339} it is also the point of this chapter to determine what is theoretically ideal.

Arguably, there must be:

an adequate evidential foundation to have reasonable assurance that the adaptive management approach will achieve its goals of sufficiently reducing uncertainty and adequately managing any remaining risk.\textsuperscript{340}

\textsuperscript{336} Ibid; \textit{Davidson Family Trust v Marlborough District Council} [2017] NZHC 52 (31 January 2017).

\textsuperscript{337} \textit{Davidson Family Trust v Marlborough District Council} [2017] NZHC 52 (31 January 2017), [53].

\textsuperscript{338} [135]–[140].

\textsuperscript{339} There are no cases in Australia, where government application of an AM approach has been found to be ultra vires, but there have been in the USA. Fischman and Ruhl note that, in 53 judicial opinions applying the law to some aspect of administrative action involving AM, 45% overturned the administrative decisions as being ‘arbitrary and capricious’, see: Fischman and Ruhl, above n 323, 271.

There is great uncertainty about groundwater.\textsuperscript{341} Groundwater is fugitive and largely unseen, and extraction can occur in relative secrecy. Responses in groundwater systems are not usually immediately apparent or predictable. Moreover, historic approaches to groundwater extraction that previously did not place limits on the activity based on impacts to the resource,\textsuperscript{342} can compound resistance to changing governance measures. The combination of uncertainty relating to the ecological system as well as the impacts caused by the existing social system can create difficulties for sustainable development.\textsuperscript{343} In this context, there is arguably a greater need for the hallmarks of genuine AM: transparent monitoring, learning, evaluation and compliance.\textsuperscript{344} There is also clearly the need to address the social and political dimensions that impact the management of the resource:\textsuperscript{345} a hallmark of adaptive governance.

Uncertainty and the social dimension of an ecological system are both addressed in the theories relating to common pool resources, which accommodate adaptive governance in that specific context.\textsuperscript{346} Therefore, the governance of common pool resources is the subject of the next section in this chapter.

3. **Groundwater as a Common Pool Resource**

The criticisms of the governance frameworks relating to CSG impacts on groundwater, particularly in Queensland, are suggestive of problems balancing competing interests in the resource. That is, the current conflicts are suggestive of a common pool resource (CPR) problem. CPRs are a type of resource that suffer governance or management issues due to the difficulty in excluding other users from accessing the resource and the use of the resource, which reduces the overall quantum of the resource that is available to other users.\textsuperscript{347} Common examples of CPRs are fisheries, forests, pastureland and, of course, water resources.\textsuperscript{348} Overuse or even destruction of the


\textsuperscript{342} Such as the common-law rules relating to groundwater, whereby extraction was not curtailed by notions of ‘reasonable use’, see: *Acton v Blundell* (1843) 12 M & W 324; 152 ER 1223; *Chasemore v Richards* (1859) 7 HL Cas 349; 11 ER 140; *Bradford v Pickles* [1895] AC 587, 601.

\textsuperscript{343} Particularly in large ecosystems, ‘social constructs can be difficult to alter, and the boundaries between competing claimants to a natural resource have often produced stalemate rather than problem solving’: Lee, above n 204, 12. In these circumstances, Lee argues that an adaptive approach can ‘loosen the deadlock with surprising outcomes’ (Lee, above n 204, 12).

\textsuperscript{344} Varady et al, above n 215.

\textsuperscript{345} Ibid, where the authors note that groundwater governance ‘should be decentralised and must involve local communities’.

\textsuperscript{346} Dietz, Ostrom and Stern, above n 288; Cosens and Gunderson, above n 29, 6.

\textsuperscript{347} Ostrom, *Governing the Commons*, above n 145, 30–32.

resource system can easily occur through mismanagement.\textsuperscript{349} They are distinct from ‘public goods’, such as street lighting and public radio stations where, even though exclusion of users is not possible, the use of the resource does not subtract from the available system.\textsuperscript{350} CPRs are notoriously challenging to govern due to their features of ‘non-exclusivity’ and ‘subtractability’. It is the management of these qualities or characteristics that ultimately determines the success of a CPR governance framework.

Various scholars highlight the difficulties of encouraging people to work together for a common good, such as managing a resource sustainably. Coase argued that the key to resolving pollution, and other negative environmental impacts of development, is via the bargaining that occurs when there are well-defined property rights and transaction costs are minimal.\textsuperscript{351} However, in 1965, Mancur Olson challenged the idea that individuals with a common interest would voluntarily act to further that communal interest.\textsuperscript{352} He highlighted that there is little incentive to contribute to a collective good because, regardless of the number of contributors, the end result is shared by the collective. This is known as the ‘free-rider’ problem. He argued that:

\begin{quote}
unless the number of individuals is quite small, or unless there is coercion or some other special device to make individuals act in their common interest, rational, self-interested individuals will not act to achieve their common or group interests.\textsuperscript{353}
\end{quote}

In 1968, Garrett Hardin explained, in his essay ‘The Tragedy of the Commons’, this dilemma by reference to a common pasture, free to all, where herders graze cattle.\textsuperscript{354} He argued that herders are locked into a strategy of over-grazing through self-interest. Because the herders have free access to the pasture and do not bear the cost of over-grazing immediately or directly, each herder has an incentive to increase their short-term gains through increasing their herd to the detriment of other herders and, ultimately, themselves.\textsuperscript{355} Hardin argued that the solution was to either convert CPRs

\textsuperscript{349} Ostrom, \textit{Governing the Commons}, above n 145.
\textsuperscript{350} Ibid, 32.
\textsuperscript{353} Olson, above n 352, 2. Earlier, where a market exists, Coase had explained why firms (or a collection of individuals organised by an entrepreneur) are established in order to avoid transaction costs not otherwise reflected in price signals; RH Coase, ‘The Nature of the Firm’ (1937) 4(16) \textit{Economica} 386.
\textsuperscript{354} Garrett Hardin, ‘The Tragedy of the Commons’ (1968) 162((3859)) \textit{Science} 1243.
\textsuperscript{355} Ibid, 1244.
to private property and ‘sell them off’, or to keep them as public property ‘but allocate the right to enter them.’

Hardin’s essay and the ‘prisoner’s dilemma’ game suggest that there are two ways to govern CPRs: a free market, or a central governing state ‘command and control’ model. There have been challenges to these presumptions, however. The prisoner’s dilemma game does not distinguish between an open-access CPR, where it is almost impossible to exclude other resource users, and a limited-access CPR, in which a well-defined group of resource users rely jointly on a CPR. Moreover, Hardin’s predictions, using game theory and the ‘prisoner’s dilemma’ game, only hold true for one-shot conditions where there is no communication between players, as well as no capacity to change the external variables affecting them. The problem of successfully managing CPRs can now be understood as a coordination issue between resource users and the provision of collective benefits rather than a ‘dilemma’ per se.

Neither state control nor markets have proved to be particularly effective for governing CPRs. By at least 1990, case-study research, where common property arrangements had been replaced by state-controlled frameworks, often revealed deteriorating governance of the resources because of difficulties in monitoring, enforcement of rules of access and even corruption. Similarly, the use of markets to address deterioration of a resource has been questioned in the groundwater context. This is because benefits from markets are maximised when the environmental impact and access to the traded property right are universal. These circumstances do not exist for discreet aquifers: extracting from one aquifer in one location does not have the same environmental impact as extracting from another aquifer in another location. Moreover, the

356 Ibid, 1245.
357 Elinor Ostrom describes the prisoner’s dilemma game as ‘a non-cooperative game in which all players possess complete information. In non-cooperative games, communication among the players is forbidden or impossible or simply irrelevant as long as it is not explicitly modelled as part of the game’, see: Ostrom, Governing the Commons, above n 145, 4.
358 Ibid, 8–12.
359 Ibid, 48.
362 Ostrom, Governing the Commons, above n 145, 42–43.
364 Ostrom, Governing the Commons, above n 145, 23.
365 Esteban and Albiac, above n 363.
optimal allocation of resources, which is supposed to occur in a market, is difficult to achieve with respect to groundwater because there is usually asymmetric information and power between a multiplicity of parties, and there are always significant transaction costs. At the very least, sinking a bore or well is not instantaneous; the water is not always present or of a quality that can be used, and it is an expensive exercise.

There is now growing international recognition of the importance of community mechanisms to balance both market and state powers in society generally. As early as 1990, Nobel laureate Elinor Ostrom had proposed that there was a third option for sustainable governance of a CPR: collective governance by the users of the resource. Building on research undertaken by the US National Research Council, and after extensive empirical research involving a wide array of real-world examples of managing CPRs, Ostrom and other scholars concluded that, in some circumstances, CPRs could be managed successfully by collective arrangements rather than either the state or the market. Ostrom defined successful CPR governance by referring to the long-term sustainability of the resource system as well as the institutions that govern them. In 1990, Ostrom compiled a set of design principles (Table 2, below), or broad institutional regularities or ‘best practices’ which, she posited, was conducive to successful CPR governance. When these design principles are present in a governance system for a CPR, the opportunity for ‘free-riders’ benefitting at the expense of the other users is reduced. The design principles ‘explain under what conditions

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370 Costs vary depending on the depth, but wells are often 1000 meters deep. In Australia, in 2018, an average cost for a 150-mm-diameter bore was A$150 per meter (plus GST); for example, see: Centre State Drilling, Water Bore Drilling Cost per Mt No Water No Charge <http://www.centrestatedrilling.com.au/water-bore-drilling-cost-per/>. The efficacy of markets in the groundwater context are discussed further in chapter 8 section 3, below p 300.
372 Ostrom, Governing the Commons, above n 145; David Sloan Wilson, Elinor Ostrom and Michael E Cox, ‘Generalizing the Core Design Principles for the Efficacy of Groups’ (2013) 90 Journal of Economic Behavior & Organisation S21, S22. Ostrom relied upon the model of the individual as being ‘fallible, norm-adopting individuals who pursue contingent strategies in complex and uncertain situations, and that ‘the decisions and actions of CPR appropriators to appropriate from and provide a CPR are those of broadly rational individuals’, see: Ostrom, Governing the Commons, above n 145, 33 and 185. Ostrom’s work focuses on the utilitarian calculations of the resource users, rather than the role of culture and norms, see: Oran R Young, The Institutional Dimensions of Environmental Change: Fit, Interplay, and Scale (MIT Press, 2002).
374 The background to Ostrom’s later work is described in Ostrom, Beyond Markets and States, above n 361, p649ff.
375 Ostrom, Governing the Commons, above n 145, 58–60.
376 Wilson, Ostrom and Cox, above n 372, 526.
trust and reciprocity can be built and maintained to sustain collective action in the face of social
dilemmas posed by CPRs.\footnote{377}

The core design principles (DPs) for CPRs are as follows:\footnote{378}

**DP 1: Clearly defined boundaries**

(a) Clearly defined social boundaries (users)
(b) Clearly defined biophysical boundaries (the shared resource)

**DP 2: Local rules and proportional equivalence between benefits and costs**

(a) congruence between local conditions and rules
(b) investment/extraction proportionality

**DP 3: Collective-choice arrangements** – the users of the resource help tailor the rules of use and the application of the rules

**DP 4: Monitoring**

(a) monitoring the resource
(b) monitoring the monitors- where there is some capacity for the users to assess the activities of monitors

**DP 5: Graduated sanctions** – the violation of the operational rules attracts graduated sanctions (depending on severity) by either the users or officials, who are accountable to the users

**DP 6: Conflict resolution mechanisms** – users and officials have rapid access to low-cost, local arenas to resolve conflicts

**DP 7: Minimal recognition of rights to organise** – the rights of the users to devise (some of) their own frameworks for governance, which are not challenged by external governmental authorities

**DP 8: Nested enterprises** – for groups that are part of larger social systems, there is appropriate coordination among relevant parties so that allocation, provision, monitoring, enforcement, conflict resolution and governance are organised in multiple layers of

\footnote{378 Ostrom, Governing the Commons, above n 145, ch 3; Elinor Ostrom, ‘Design Principles in Long-Enduring Irrigation Institutions’ (1993) 29(7) Water Resources Research 1907; Wilson, Ostrom and Cox, above n 372; Cox, Arnold and Villamayor Tomas, above n 377; Baggio et al, above n 214.}
enterprises. Smaller, local-scale agencies or organisational units are coordinated with each other and are ‘nested’ within ever larger agencies or organisations.

Ostrom’s design principles apply to both the making of rules or laws relating to a CPR as well as the administration of those rules or laws. Often both the laws and the administration of the laws will be relevant to an evaluation. For example, in theory there may be conflict resolution mechanisms within the legal framework, but in practice they may be problematic and the administration of the legal rules is therefore relevant in any evaluation of the governance framework. For some of the design principles, such as the existence of monitoring of the physical resource or the existence of graduated sanctions, what actually happens as evidenced by reports and publicly available data will be what is most relevant.

In 2010, Cox et al undertook a literature review of more than 100 CPR case studies in order to evaluate Ostrom’s design principles. Success or failure (measured by reference to long-term effective environmental management) was matched against the occurrence of design principles present in the governance of the various resource systems. Cox et al concluded that Ostrom’s design principles are well supported empirically, that robust resource systems are characterised by most of the design principles whereas the failures are not, and that they form a sound basis for future research.379

Ostrom’s design principles, like Hardin’s recommendation of state or market models, are not a panacea for CPR governance.380 The attributes of the resource and resource system (scale, renewability, stability and mobility); resource users (heterogeneity, discount rates, scale and number); practicality of monitoring and enforcement measures; and the macro-political institutions, culture and economic environment are key factors in determining effective governance arrangements.381 For example, the following attributes are conducive to an increased likelihood that the resource users will organise themselves collectively where: the resource attributes can be feasibly improved; there are cheap, reliable and valid indicators of the resource condition; the behaviour of the resource is predictable, sufficiently small and extremely important to resource users’ welfare; there is a common shared understanding of how the resource operates; there are

379 Cox, Arnold and Villamayor Tomas, above n 377.
shared discount rates in respect of future benefits; there is trust and reciprocity; the users have autonomy to create access rules; and there is local leadership and organisational experience.\textsuperscript{382} CPRs are complex social-ecological systems (SES) and panaceas such as advocating either state, market or communal control fail to acknowledge the diversity of factors that impact sustainable governance.\textsuperscript{383} Because each SES is unique, not every variable will be relevant in every study.\textsuperscript{384} For example, monitoring of the monitors in a groundwater context, may justify expert interpretation prior to or in addition to public availability of data. Furthermore, the interactions of these factors may change over time; there is thus a need for governance arrangements to be flexible and adaptive.\textsuperscript{385} In short, Ostrom noted that there is no cure-all or blueprint approach that works in all settings over time.\textsuperscript{386} Rather than a single-policy solution, hybrid systems combining aspects of state, market and communal arrangements are now seen as preferable.\textsuperscript{387} Furthermore, such arrangements ought not to be considered a ‘one-shot’ effort; instead, they should be able to be adapted and revised over time to address dynamic situations.\textsuperscript{388}

Ostrom’s design principles are helpful in that they can provide a framework for evaluating water governance arrangements. They have, in fact, been put to the test for different jurisdictions worldwide.\textsuperscript{389} The usefulness of the design principles for such an analysis has been recognised even

\begin{footnotes}
\item[382] Elinor Ostrom, \textit{Understanding Institutional Diversity} (Princeton University Press, 2005), 244.
\item[383] Ostrom, Janssen and Anderies, above n 380.
\item[384] Ostrom, A Diagnostic Approach, above n 360, 15182.
\item[385] Ibid; Ostrom, \textit{Understanding Institutional Diversity}, above n 382, 255.
\item[386] Ostrom, Janssen and Anderies, above n 380; Ostrom, A Diagnostic Approach, above n 360, 15186.
\end{footnotes}
in jurisdictions that feature primarily State ownership or control of water. As a theory rooted in the utilitarian decision-making of singular actors, it would seem highly applicable to groundwater, where the majority of users are either separate landholders or corporations (or institutions) that have a largely economic decision-making focus. Current research supports the notion that an historic lack of recognition of the groundwater resource as a CPR has, at times, led to its deterioration, and that the design principles are generally conducive to success. Research has confirmed that the characteristics of successful water governance arrangements posited on the basis of small-scale ecologies and institutions are relevant for the larger water system. Where the groundwater system is large and complex, collaborative efforts between the users and regional and national government agencies have been seen as important. Furthermore, greater success is achievable when entitlements are clearly defined. Specific challenges for large groundwater systems have been found to relate to the remote impacts of groundwater pumping, user heterogeneity, cross-scale coordination and collaboration, as well as monitoring and enforcement. While collective management strategies have been seen to be successful, they still require the support of a strong and clear regulatory regime.

One final piece of research ought to be considered in this thesis, even though it did not involve groundwater resources. Ostrom’s design principles were the foundation for a large case-study analysis of irrigation (involving surface water), fishery and forestry activities by Baggio et al published in 2016. Baggio et al confirmed that no particular design principle on its own leads to

References:


For example, for Australia and the USA; Baldwin above n 389; Sarker, Baldwin and Rossa, above n 389; Ross and Martinez-Santos, above n 219; Schlager and Heikila, above n 389; Heikila, Schlager and Davis, above n 389; Babbitt, Burbach and Pennisi, above n 177; Shalsi, above n 302.


Sarker, Baldwin and Rossa, above n 389, 610.

Ibid; Ross and Martinez-Santos, above n 219; Babbitt, Burbach and Pennisi, above n 177; Boone and Fragaszy, above n 389.

Babbitt, Burbach and Pennisi, above n 177.

Schlager, above n 388; Ross and Martinez-Santos, above n 219;

Ross and Martinez-Santos, above n 219. The importance of collaboration between the state and self-governing users groups was confirmed in Wester, Sandoval Minero and Hoogesteger van Dijk, above n 302.

Ross and Martinez-Santos, above n 219.

Lopez-Gun and Cortina, above n 389; Schlager, Community Management of Groundwater, above n 388; Baldwin, above n 389; Ross and Martinez-Santos, above n 219; Theesfeld, above n 348; Wester, Sandoval Minero and Hoogesteger van Dijk, above n 302;

Baggio et al, above n 214.
success but the more that are present, the better in terms of outcomes.\textsuperscript{400} Furthermore, success in managing a CPR was found to depend on clusters of design principles (with certain clusters better in certain situations), and that at least 5 or 6 design principles out of 11 (which includes the sub-design principles in DP 1, DP 2 and DP 4) are necessary to ensure success.\textsuperscript{401} They found that the absence of any particular design principle meant very little in itself.\textsuperscript{402} Alternatively, where congruence between local conditions and rules, investment/extraction proportionality (DP 2), accountability of the monitors (DP 4) and graduated sanctions (DP 5) are missing, this greatly increases the odds of non-successful CPR systems.\textsuperscript{403}

Ostrom’s design principles are a useful starting point in any evaluation of the governance arrangements for activities that impact the groundwater resource in the Surat CMA and PRB.\textsuperscript{404} Examining the congruence of a governance system or framework with the design principles helps to identify underlying weaknesses (or strengths) in the regime.\textsuperscript{405} Aquifer injection and augmentation using CSG produced water is an activity that intrinsically impacts a groundwater system. In the first place, the extraction of the CSG produced water is an activity that is part of the overall groundwater allocation framework. Subsequent injection obviously also fundamentally impacts the groundwater resource. The rules associated with these two operational phases sit within the broader topic of groundwater governance in the two jurisdictions. Therefore, it is logical that the governance of these two operational phases can also be considered through the lens of Ostrom’s design principles. Consequently, Ostrom’s design principles form the basis of my evaluation.

**AM, adaptive governance and Ostrom’s design criteria for CPRs**

AM, adaptive governance and Ostrom’s principles can operate to reinforce each other.\textsuperscript{406} For example, encouraging collaborative problem-solving, garnering social acceptance and commitment, and cultivating a culture of trust and tolerance for change and uncertainty are the three cooperative dilemmas that must be overcome to achieve authentic adaptive governance.\textsuperscript{407} Arguably, Ostrom’s criteria of collective choice arrangements (DP 3), transparent monitoring where the monitors

\textsuperscript{400} Ibid, 424, 431.
\textsuperscript{401} Ibid, 428.
\textsuperscript{402} Ibid.
\textsuperscript{403} Ibid, 428–429.
\textsuperscript{404} This method was suggested by Ostrom following research undertaken in relation to the governance of activities impacting forests in Honduras in Ostrom, *Understanding Institutional Diversity*, above n 382, 270, citing Catherine Tucker, ‘Common Property Design Principles and Development in a Honduran Community’ (1999) 15 *Praxis: The Fletcher Journal of Developmental Studies* 47.
\textsuperscript{405} Ostrom, *Understanding Institutional Diversity*, above n 382, 270.
\textsuperscript{406} Dietz, Ostrom and Stern, above n 288; Cosens and Gunderson, above n 29.
themselves are monitored (DP 4) and the existence of the right to organise (DP 7) would therefore contribute to adaptive governance. Similarly, Ostrom’s criteria for nested organisational structures (DP 8) can tighten feedback loops between resource changes and response, and increase the proximity between knowledge of the resource, response capacity and decision-making.\(^{408}\) This also enables adaptive governance of the resource to occur. In research involving a diverse set of case studies, Lebel et al confirmed the connection between adaptive governance and Ostrom’s design principles (and managing resilience).\(^{409}\) The authors found that adaptive governance, and the capacity to manage resilience, requires attributes of good governance such as participation and deliberation, polycentric and multi-layered institutions, and accountable and just authority.\(^{410}\)

AM, adaptive governance and the theories related to CPRs are highly contextual.\(^{411}\) There are implications for these approaches depending on the circumstances. In this case, the context is a large groundwater system with heterogenous extractors (pastoralists, gas corporations, feedlots, irrigated agriculture and towns) which is a unique CPR setting. As already mentioned, different clusters of Ostrom’s design principles are important for certain types of resources and groundwater is no exception.

A recently implemented program involving groundwater conducted in India (called the MARVI program) has highlighted that issues around monitoring (DP 4), collective choice arrangements (DP 3) and rights to organise (DP 7) can be addressed through encouraging participation at the local level.\(^{412}\) In that study, local groundwater champions were trained in measuring both water levels and water quality using inexpensive devices. The data provided by these groundwater champions revealed the status and connectivity of the groundwater resources and was uploaded by them using smartphones. This then changed the views held by extractors, convincing them that it was a collective resource that required cooperative management.\(^{413}\) The increased knowledge of recharge rates enabled local rules (DP 2) to be developed relating to extraction, recharge activities and groundwater productivity that had buy-in by the local community.\(^{414}\)


\(^{409}\) Lebel et al, above n 301; Cosens and Gunderson, above n 29.

\(^{410}\) Lebel et al, above n 301; Cosens and Gunderson, above n 29.

\(^{411}\) Cosens and Gunderson, above n 29.

\(^{412}\) Jadeja et al, above n 389.

\(^{413}\) Ibid.

\(^{414}\) Ibid.
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This emphasis on knowledge building as an intrinsic aspect of governance has also been supported by research relating to coastal governance in the Netherlands.\(^{415}\) Finding a balance between using and conserving a resource can be enabled by interactive and flexible governance arrangements, which complement centralised governance, and which provide for joint knowledge production and exchange.\(^{416}\) Both the MARVI program and Van der Molen’s research in the Netherlands found that there was still a need for mechanisms and funding to sustain the local champions over time.\(^{417}\) The MARVI researchers also concluded that there was a need to promote the acceptance of this participation by the scientific community, policy-makers and regulators.\(^{418}\)

For AM to occur, there must be a commitment for openness and transparency so that continued political support for the approach endures over the relevant timeframes. For groundwater, the relevant timeframe is hydrogeological and, therefore, involves extremely long time periods. AM always has high information requirements but, in the groundwater context, these are heightened because of the relative invisibility and size of the resource, and the timeframes involved. Unfortunately, in the groundwater context, reliable information often requires significant investment by scientists to determine aquifer boundaries, connectivity and flow. Ostrom’s requirements of monitoring both the resource and the monitors (and perhaps others) (DP 4) will be essential, because there is no certainty in the likely impacts. It will also provide clarity around the extent of the resource (DP 1). Transparency in terms of the rules and entitlements to extract; levels of extraction; changes in the resource (DP 1) and any individual learning occurring by the operators, other users and the regulator; and changing management actions and the reasons for these will be essential in fostering cooperation for the management of the resource as well as social learning.

AM can occur within the context of just the operator and the regulator; this process can still be genuine, even if it is not transparent. Nevertheless, without making the process known to stakeholders and the public, the other users of the resource will not share in that learning process. This will be at odds with managing the CPR, which depends on coordination between users. The overall success of the AM approach relating to the wider management of the resource will then be impacted along with any collective action. As mentioned, the development of rules governing a CPR should not be considered as one-shot exercises. We can never know in advance all the factors that may incentivise users, or those which may impact the resource. An AM approach is necessary,

\(^{416}\) Franke van der Molen, above n 415.
\(^{418}\) Jadeja et al, above n 389.
therefore, in the development of rules, preferably with some input by the users, so that they are perceived as legitimate and fair, and can respond to changes. This points to a need for the collaborative style of AM known as adaptive governance. The relationship between these factors will be discussed against the empirical findings in Chapter 7.

In summary, the design principles posited for CPRs are a useful tool to use in analysing governance frameworks relating to groundwater. But the presence of an AM approach, and arguably adaptive governance, is also a positive indication of the strength of a groundwater governance framework.

4. **Recommended characteristics for MAR governance**

Various scholars, some from a legal background and others from an economic and scientific background, have made specific recommendations for the governance of managed aquifer recharge (MAR) projects. These general recommendations were made considering MAR projects involving excess surface water and were not necessarily developed within the context of AM and Ostrom’s CPR literature or with CSG development in mind. Because MAR intrinsically involves groundwater, a CPR, the recommendations appear to overlap with some of the recommendations already posited for CPRs.

a) **A unified approach to assessment**

A unified approach to assessments, including State-based MAR guidelines and policy, has been viewed as necessary for MAR projects. A unified approach to assessment will provide operators with some certainty in terms of the approvals process. This recommendation overlaps Ostrom’s design principle relating to clearly defined social boundaries for the resource users (that is, the administrative rules relating to accessing and injecting into groundwater (DP 1)). If injection rules are clear and applied uniformly, this will satisfy DP 1. Furthermore, where the same activity is assessed in a similar way, regardless of location or jurisdiction, there will often be a nested organisational structure of decision-makers (DP 8). For example, where a federal requirement is applied uniformly at State or local levels, this can be an indication of a nested organisational structure. Therefore, this recommendation will most likely be satisfied where Ostrom’s DP 1 and DP 8 are present.

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b) Clear economic incentives

Clear economic incentives such as a business case for MAR projects, especially aquifer injection, must be present if the process is going to be adopted at all.\textsuperscript{421} Aquifer injection is a capital-intensive process: bores must be drilled, injection pumps operated and often (but not always) costly water treatment precedes injection. These activities are over and above the default discharge-to-surface option. There must be some benefit to outweigh this extra cost, in the absence of regulatory compulsion. Regulatory arrangements that avoid unnecessarily increasing the costs of the process will also provide some positive incentives. Again, Ostrom’s design principles overlap this issue. Economic incentives for the process ought to be present where there is congruence between local conditions and costs and benefits borne by resource users (DP 2). If the rules for injection recognise local aquifer water quality and allow for injection without expensive water treatment (an example of local rules for the activity reflecting local geographic characteristics), this may reduce costs and provide positive incentives. Equally, if the benefits of injecting into a depleted aquifer are accrued to the injector (an example of benefits to the locality from the activity accruing to the operator or resource user), this also would provide a positive incentive for the process. Without satisfaction of Ostrom’s DP 2 relating to congruence between costs and benefits, and rules and local conditions, there are unlikely to be economic incentives for the process.

c) MAR included in integrated catchment management strategies

Many scholars suggest that MAR, and aquifer injection, ought to be part of an integrated catchment management strategy,\textsuperscript{422} which governs both water quality and quantity issues.\textsuperscript{423} Integrated water resources management (IWRM) is a broad concept that recognises:

- water as an economic good and attempts to simultaneously take into account both qualitative and quantitative aspects, short and long-term perspectives, and surface and ground waters as well.\textsuperscript{424}

\textsuperscript{421} Maliva, above n 163, 1258; Arshad, Guillaume and Ross, above n 163; Bloetscher, Muniz and Witt, above n 130, 12; Pyne, above n 139, 376; Vanderzalm et al, above n 163; Ticehurst and Curtis, above n 162; Ross and Hasnain, above n 163; Dillon et al, Sixty Years of Global Progress, above n 123, 22.

\textsuperscript{422} Otherwise, MAR may become another technical solution that reinforces the status quo and existing groundwater governance, and may not address demand management, see: Audrey Richard-Ferroudji, TP Raghunath and G Venkatasubramanian, ‘Managed Aquifer Recharge in India: Consensual Policy but Controversial Implementation’ (2018) 11(3) Water Alternatives 749. See also: Dillon et al, Managed Aquifer Recharge: An Introduction, above n 124, X; Ross, above n 115.

\textsuperscript{423} Ward and Dillon, Robust Design of Managed Aquifer Recharge Policy in Australia (CSIRO, 2009), above n 161, iv; Bennett, Gardner and Vincent, above n 158, 13; Page et al, above n 161.

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All sources and aspects of water, all users and uses across all times scales ought to be governed holistically. IWRM requires consideration of environmental, economic and social principles, administrative integration between different agencies (State/State, State/Federal, planning/environment/industries), participation or input from all water users (government/industry/community), and between physical interrelationships between surface and groundwater quality and quantity.\(^\text{425}\) IWRM is very difficult to achieve.\(^\text{426}\) For example, one issue in the application of IWRM is how to establish and manage the boundaries in water management.\(^\text{427}\) One may think that a truly integrated water management regime may require the regulation of all water related activities to be concentrated within one unwieldy (and vulnerable) centralised management institution.\(^\text{428}\) This reflects the view that governance arrangements ought to ‘simplify, integrate and centralise so that externalities, spill-over effects, commons dilemmas, and public goods that emerge from the human uses of a watershed may be traded off and balanced against each other.’\(^\text{429}\) But if the activities impacting water resources are coordinated within a nested polycentric organisational structure, which features redundancies (that is, adopting Ostrom’s DP 8 for nested enterprises), there is a good chance that IWRM will take place.\(^\text{430}\)

Other design principles posited by Ostrom can also facilitate IWRM. Where all water users (both extractors and injectors) in a locale have an opportunity and right to influence the rules for the activities, Ostrom’s DP 3 and DP 7, this implies that they are integrated within that framework. Furthermore, the presence of collective decision-making can facilitate conjunctive management of different water resources within the same locale. Groundwater extractors have an inherent demand for water. Injectors (particularly in the CSG context) have an available supply (of which they would like to dispose as economically as possible). Both sets of parties have an incentive to cooperate with each other, if the rules governing the water allow them to do so. If both sets of parties can have an input in the rules, this can facilitate rules that provide for these two needs to be met concurrently, within the same framework. In contrast, where there is fragmented regulation that lacks coordination, groundwater extractors and CSG activities are often regulated according to different

\(^{426}\) Schlager and Blomquist, above n 289.  
\(^{429}\) Schlager and Blomquist, above n 289, 151–152, where the authors note that, in practice, centralised integrated organisational arrangements rarely occur: 133.  
\(^{430}\) Schlager and Blomquist, above n 289.
rules. Different rules for the same type of activity depending on the type of extractor/operator may arise, because neither set of rules take into consideration the needs of or impacts on the other users. This can be seen in Queensland, where water extracted by the CSG industry is treated as a ‘waste’ even though it is identical to the water extracted by groundwater users targeting the same aquifer: the Walloon Coal Measures. The CSG ‘waste’ water is not accounted for or integrated within the same regulatory framework. Subsequent injection is regulated under the environmental protection statutes rather than the water legislation. If the users, who are keen to access more water, could have some influence on rule-making for injection, this would facilitate an integration between these different activities (and needs) impacting the same groundwater resource. Where Ostrom’s DP 3 and DP 7 are present, this facilitates IWRM.

Similarly, where there is congruence between rules and local conditions (Ostrom’s DP 2) all water users and uses (as ‘communities of interest’) ought to be considered because they are part of the same local context. In this situation, water extracted from an aquifer, regardless of the reason for the extraction (agriculture or CSG), would be coordinated or accounted for within the same legislative framework. Where there is congruence between rules to access the resource and local conditions (DP 2), this should consider all physical aspects of the resource, such as connections between surface water and groundwater. It may also imply that all water resources and all water users are governed collectively in a coordinated way at a basin level, depending on the definition of ‘local’.

To the extent that these design principles are present (that is, DP2, DP3, DP7 and DP 8), the recommendation that MAR should be part of an integrated catchment management strategy can be satisfied.

d) Certainty of entitlements

Finally, many have argued that there is a need for certainty of entitlements for the separate operational phases of a MAR project: to access water for recharge; aquifer recharge and storage; recovery of stored water; and rights to transfer the recovered water. Where there is a clear...
entitlement, this will often correspond with clear limits as to who can appropriate the groundwater as well as certainty regarding the resource (DP 1). Therefore, this recommendation is also satisfied by Ostrom’s design principles.

Implicit in many of the recommendations for clear entitlements is the additional assumption or logical ‘leap’ that the entitlements ought to be ‘proprietary’ in nature.433 The scholarship recommending ‘clear entitlements’ for the separate operational phases of a MAR project,434 such as by Ward and Dillon;435 Bennett, Gardner and Vincent436 and the Australian Productivity Commission,437 are based on the historic reforms in Australia that culminated in the National Water Initiative (NWI) in 2004.438 The NWI was agreed to by all States and Territories with a view to reforming water governance in Australia. The NWI reforms recommended the unbundling of water instruments from land ownership, statutory water plans for basins/catchments, the creation of separate instruments for access to water (through entitlements to a share of the common pool, allocations of a quantum of water for each share, as well as end-use obligations) and the creation of a water market. However, in principle, the NWI requires systems to be restored to environmental sustainability before perpetual water extractive rights are allocated.439

Whether water entitlements (that is, individual rights to the resource unit either pre-NWI licences or NWI entitlements) are ‘property rights’ in a legal sense is a ‘controversial issue’.440 The tradable access entitlements envisioned by the NWI have been described as ‘proprietary’ in

Productivity Commission, above n 161; Bloetscher, Muniz and Witt, above n 130, 12; Ticehurst and Curtis, above n 162.

433 Ward and Dillon, Robust Policy Design for Managed Aquifer Recharge (2011), above n 129, 7, where the authors discuss ‘property rights’ in water; see also: Vincent and Gardner, above n 162, who highlight shortcomings in current property rights in alternative water sources used in MAR in Western Australia; Productivity Commission, above n 432, 93–95, which discusses ‘property right’ arrangements for alternative water sources and suggests that there is a need for clear rights for MAR operational phases; Tim Clune and Lin Crase, ‘Groundwater Property Rights: A Key to Climate Resilient Communities in Victoria’ (2017) 26(2) Australian Property Law Journal 195.

434 That is, an entitlement to access the source water, an entitlement to inject or recharge the aquifer, an entitlement to recover the recharged water and an entitlement to use that recovered water.

435 Ward and Dillon, Robust Design of Managed Aquifer Recharge Policy in Australia (CSIRO, 2009), above n 161; Ward and Dillon, Robust Policy Design for Managed Aquifer Recharge (2011), above n 129; Ward and Dillon, Principles to Coordinate Managed Aquifer Recharge, above n 125.

436 Bennett, Gardner and Vincent, above n 158; Vincent and Gardner, above n 162.

437 Productivity Commission, above n 432.


nature.441 The NWI did not require the exact nature of the right to be specified in the legislative frameworks.442 Outside of South Australia and Tasmania, where the legislatures have declared water entitlements (licences) to be the personal property of the licensee, this is not settled law in Australia.443 Rights under the first legislation, which introduced the permit-based system of governance, the Rights in Water and Water Conservation and Utilization Act 1910, were intended to be ‘use’ and not proprietary rights, in contrast to Wyoming.444 The legislation was supported in Parliament by a report by Dr Elwood Mead,445 the former Territorial and State Engineer of Wyoming and founding author of Wyoming’s water laws.446 Mead visited various parts of Queensland and reviewed water supplies; he argued for State control over water and cautioned against the establishment of rights other than ‘use’ rights, which should be limited in time rather than perpetual.447


443 *ICM Agriculture Pty Ltd v Commonwealth* (2009) 240 CLR 140, which admittedly concerned pre-NWI water licences rather than NWI entitlements, where French CJ, Gummow and Crennan JJ found that it was unnecessary to determine the proprietary character of bore licences but also that the groundwater was not the subject of ‘private rights’, at [74]-[86], in contrast, in obiter dictum; Hayne, Kiefel and Bell JJ considered the relevant old-style bore licences a ‘species of property’ due to their ability to be traded and be used as security, at [147]. and Heydon J, dissenting, found that the licences were property due to the licences being definable, identifiable by third parties, transferable and having some degree of permanence or stability, at [194]-[215]. See also: Clune and Crase, above n 433, 196; Janice Gray and Louise Lee, ‘National Water Initiative Styled Water Entitlements As Property: Legal and Practical Perspectives’ (2016) 33 *Environmental and Planning Law Journal* 284; Vincent and Gardner, above n 162, 39; Gray and Lee, ‘Water Entitlements as Property: A Work in Progress or Watertight Now?’, above n 442, 111–114; DE Fisher, ‘Property: An Instrumental Institution for Environmental Governance’ (2012) 24(6) *Environmental Law and Management* 263; Samantha Hepburn, ‘Statutory Verification of Water Rights: The “Insuperable” Difficulties of Propertising Water Entitlements’ (2010) 19 *Australian Property Law Journal* 1.

444 See chapter 3, section 3(b)(ii), below p 102.


There have been indications that the future judicial direction, absent legislative change, might be towards categorising water entitlements as some type of property right. For example, the minority judgement in *ICM Agriculture Pty Ltd v Commonwealth*, stated that pre-NWI water licences were a ‘species of property’. But the minority judgement also highlighted:

- the replaceable and fugitive nature of groundwater;
- that the licences in issue are a creature of statute and inherently fragile;
- that groundwater has not hitherto been thought to be a subject of property; and
- that the rights vested in the State are statutory rights for the purpose of controlling access to a *public resource*. [Emphasis added]  

Six of the Justices in the *ICM Agriculture* case based their findings on the reasoning that the groundwater system is essentially a ‘common resource or common property’, from the perspectives of both the common-law and ‘public domain regime created by legislation’.

The *ICM Agriculture* case was concerned about protections (and compensation) afforded to access to the resource unit (groundwater). The High Court of Australia found that, whatever the categorisation of the access right, there had been no ‘acquisition’ (because no advantage was derived by the Commonwealth or the State) and, therefore, the conversion of the licences (to allocations) was outside of the Australian constitutional ‘compulsory acquisition’ clause (*Australian Constitution*, s.51(xxxi)). That issue is now settled. Adjustments by the regulator to the quantum of water made available under water licences are not an ‘acquisition’ and, therefore, do not trigger compensation under the *Australian Constitution*, s 51(xxxi). Whether there are other benefits that would ensue, such as with respect to succession law, taxation or the efficacy of a market, if licences or NWI-styled water allocations were considered ‘private property’ remains uncertain.

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448 *ICM Agriculture Pty Ltd v Commonwealth* (2009) 240 CLR 140, [142]–[154], as per Hayne, Kiefel and Bell JJ.  
449 (2009) 240 CLR 140, [147]. Heydon J found that the licences were property; [194]–[215]. In contrast, French CJ, Gummow and Crennan JJ held that it was unnecessary to resolve the proprietary character of the bore licences; [74]:[80].  
450 (2009) 240 CLR 140, [149].  
452 Where the licences had been converted to aquifer access licences, resulting in a reduction of the quantum of groundwater available to the plaintiffs.  
453 (2009) 240 CLR 140, [87]–[89], [155]–[157].  
454 Fisher, above n 440, 93.  
455 This may be different with respect to NWI-styled water allocations; however, of relevance to this research are the entitlements afforded groundwater users in the Surat CMA which are primarily pre-NWI water licences.  
456 See Gray and Lee, National Water Initiative Styled Water Entitlements as Property: Legal and Practical Perspectives, above n 443.
However, there is an international trend ‘to treat groundwater as a public [resource] and no longer as [a] private good attached to land rights.’

Economists have argued that it is necessary to treat tradeable permits as a secure property right in order to secure investment, and for efficient use of resources and a reduction of pollution. In order to obtain the benefits of a market, at the very least, the property rights must be such as to induce lasting husbandry of the resource. But the meaning of the word ‘property’ is not uniformly adopted in all contexts. What may be loosely described as ‘property’ in an economic sense may not necessarily translate to ‘property’ in a legal sense. In some jurisdictions, which have introduced tradeable permits for environmental management, attempts are made to give ‘adequate’ protection rather than complete security to permit holders. Protection of investment can be fostered without giving up ultimate control of the resource unit and by retaining the ability to change control requirements when the need arises. There is now developing commentary in Australia, as well as the USA, that questions the necessity and efficacy of defining water access entitlements as ‘private property’ in a legal and constitutional sense. For example, individual property rights are enforceable against the world at large, subject to general restrictions relating to environmental protection and impacts on neighbours. If the legal framework is inadequate in terms

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458 Tom Tietenberg, ‘The Tradeable Permits Approach to Protecting the Commons: What Have We Learned?’, in Ostrom et al, Drama of the Commons, above n 381, 205; Clune and Crase, above n 433, 204.


460 Lee, above n 204, 193.


462 In particular, within the ambit of the Australian constitutional ‘compulsory acquisition’ clause (Australian Constitution, s 51(.xxxi), see: National Water Commission, above n 441, 50; Edwyna Harris, ‘State Administration versus Private Innovation: The Evolution of Property Rights to Water in Victoria’ in Jeff Bennett (Ed), The Evolution of Markets for Water: Theory and Practice in Australia (Edward Elgar, 2005), 52; Connell, above n 369, 35–40; Jennifer McKay, ‘The Legal Frameworks of Australian Water: Progression from Common Law Rights to Sustainable Shares’ in Lin Crase (Ed), Water Policy in Australia: The Impact of Change and Uncertainty (Routledge, 2008), 55; Hepburn, above n 443.

463 Tietenberg, above n 458.

464 Tietenberg gives the example of the US Clean Air Act governing the sulfur allowance program, which provides the limited authorisation to emit sulfur dioxide, but the allowance is expressly noted as not being a property right, see: Tietenberg, above n 458.

of the protections of the resource system, the environment or impacts on others, protection of individual rights comes at the expense of these latter interests.466

In addition, the theories relating to CPRs highlight that it is unnecessary to categorise the legal status of the resource system (and user rights) to either private or state property: commons institutions ‘straddle the public and private spheres’.467 Furthermore, as noted by Ostrom and other scholars, there are in fact many different types of ‘property’ rights: public, state, private, communal and common.468 Schlager and Ostrom further identified five distinct basic bundles of rights, corresponding to rights of access, withdrawal, management, exclusion and alienation.469 As Ostrom notes, ‘most resource economists admit that technical difficulties prevent the creation of private property rights to fugitive resources such as groundwater.’470 The question of whether the MAR entitlement (to access the water, recharge the water, recover the water and, finally, use the recovered water) should be ‘private property’ or some other type of property, and the extent of that right (whether it extends from mere access to rights of alienation) has not been established. It is enough at this stage to note that, at the very least, a clear entitlement is required for each of the operational stages of aquifer injection.471 This will be satisfied where Ostrom’s DP 1 is present.

5. Enumeration and illustration of the theoretical foundations

a) Measures of sustainability

I can now answer the first research sub-question:

What are the measures of sustainability used to measure the outcomes of the groundwater systems in this study?

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466 David Grinlinton, above n 458, 391–395.
467 Alice Ingold, ‘Commons and Environmental Regulation in History: The Water Commons Beyond Property and Sovereignty’ (2018) 19(2) Theoretical Inquiries in Law 425, 430.
469 Edella Schlager and Elinor Ostrom, ‘Property-Rights Regimes and Natural Resources: A Conceptual Analysis’ (1992) 68(3) Land Economics 249; Sikor, He and Guillaume Lestrelin have extended this classification to 8 types of property right, see: Thomas Sikor, Jun He and Guillaume Lestrelin, ‘Property Rights Regimes and Natural Resources: A Conceptual Analysis Revisited’ (2017) 93 World Development 337; see also: Gray and Lee, ‘Water Entitlements as Property: A Work in Progress or Watertight Now?’ above n 442. Fisher describes the criteria as ‘the capacity of the right to be legally protected, the definition of the substance of the right, the identification of the holder of the right, the exclusive use and control of the right by the holder, the capacity of the right to be transferred and the permanence, stability and security of the right’, see: Fisher, above n 440, 92.
470 Ostrom, Governing the Commons, above n 145, 60.
471 This issue is discussed further in chapter 8, section 3, below p 300.
Each of the case-study jurisdictions have adopted (either expressly or implicitly) a general objective of sustainable development in terms of groundwater resources. The traditionally adopted measures of sustainability (for inter-generational equity as well as success in terms of the management of CPRs), which I also adopt in this study, are:

- a lack of continuing resource deterioration where water levels, water quality and the basin’s ability to hold water are maintained. This may include increasing groundwater levels and maintaining water quality through recharge; and
- a lack of conflict and trust issues.

These measures ought to be considered collectively and considered as indications of success rather than binary outcomes. I will use the term ‘relative’ in terms of findings on ‘success’ to reflect this necessarily inexact measurement. Moreover, a ‘lack of continuing resource deterioration’ ought to be considered over longer timeframes for example, 50 or 60 years or more), as groundwater systems respond in geological timeframes. Current indicators for a groundwater system may not be a true indicator of current governance frameworks as the consequences of previous governance practices may still be evident in the system. Considering merely the physical status of the response will tell us very little. It is important to consider the measures collectively, particularly noting evident conflict and trust issues in order to gain an indication of the relative success of any governance framework.

In addition, where the empirical data suggests that a case-study jurisdiction has not met either of these measures, I have adopted the term ‘not-success’ in this thesis rather than the term ‘failure’. This is because a regulatory framework may not be successful on some measures but nonetheless, it may be successful in other ways or contexts. To use the term ‘failure’ would not acknowledge this complexity.

**b) Aquifer injection and augmentation design principles**

I can now also answer the second research sub-question:

What design principles are recommended for aquifer injection and augmentation using CSG produced water?

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472 See discussion at chapter 2, section 1(a)(i), above p 38–40.
473 Ostrom, *Governing the Commons*, above n 145; Baggio et al, above n 214
474 The term ‘groundwater levels’ equates with the water pressure in an aquifer.
Governance of aquifer injection in the two case-study jurisdictions involves governance of two separate operational stages: extraction of the groundwater during CSG development and subsequent re-injection. It would not be enough to consider governance of reinjection without considering governance arrangements relating to accessing the source water. The two operational phases are inextricably linked: without being able to extract the groundwater in the first place, there would be no aquifer injection. Consequently, the research considers the governance of a specific activity (aquifer injection) within the governance of a wider resource system (groundwater). Failings relating to the groundwater system may impact governance of the specific activity of aquifer injection. Conversely, mechanisms governing the activities of accessing or injecting CSG produced water may either address or compound wider governance issues relating to the groundwater resource system.

In the application of the precautionary principle, AM has been adopted in Queensland. It has been applied to the mechanisms governing CSG extraction, as well as relating to water resources. AM requires, at the very least: monitoring, research (to reduce key uncertainties), periodic evaluation of the outcomes, and an efficient and effective compliance system. Also, the AM approach ought to provide an assurance of reducing uncertainty and managing remaining risks. It has been applied to the administrative arrangements relating to CSG projects in Queensland, specifically relating to the management of CSG produced water and knowledge about the groundwater resource. The application of the AM approach in this context will be evaluated against these requirements.

Because aquifer injection of CSG produced water fundamentally involves a CPR, the governance arrangements for the activity, as well as the broad governance of the groundwater system, are analysed in this research through the lens of Ostrom’s design principles for CPRs. As discussed already, the specific recommendations for the process of aquifer injection, or MAR generally, overlap various design principles posited by Ostrom. Consequently, they are addressed within the context of Ostrom’s design principles and do not require specific attention.

Some of these main design principles have been divided by scholars: clarity of boundaries (DP 1), congruence between rules and local conditions (DP 2), and monitoring (DP 4) have been divided by further research. These additional categories are listed in the second column of Table 3, below. I have added to Ostrom’s general design principles by distinguishing aspects specific to the relevant operational phases. This means that the governance arrangements for each activity (the

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475 Ostrom, Governing the Commons, above n 145, ch 3; Ostrom, Design Principles in Long-Enduring Irrigation Institutions, above n 378; Wilson, Ostrom and Cox, above n 372; Cox, Arnold and Villamayor Tomas, above n 377; Baggio et al, above n 214.
access to groundwater and subsequent injection) can also be considered separately. For example, Ostrom’s design principle relating to collective choice arrangements (DP 3) is considered for the extraction of CSG produced water, as well as the injection process. Similarly, sanctions (DP 5) is divided into sanctions relating to extraction as well as injection activities. This creates a much longer and more detailed list of design principles. But without this level of detail, it would be difficult to determine whether there are strengths or weaknesses that specifically relate to an operational phase: either the extraction of groundwater in the first place or the subsequent injection. It is possible that the governance framework may be (more or less) successful for either phase.

The overall governance frameworks in place in each jurisdiction can be measured against these more detailed AIA design principles: this is the ‘yard stick’ used in this analysis. There are 21 design principles (shown in the third column of Table 3, below) that are relevant to governing the groundwater system when the aquifer injection of CSG produced water occurs:
### AIA design principles

<table>
<thead>
<tr>
<th>Ostrom et al’s design principles</th>
<th>Governance arrangements for groundwater where CSG extraction takes place, and the aquifer injection of CSG produced water</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Clearly defined boundaries of the resource</td>
<td>a) Social boundaries</td>
</tr>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) Biophysical boundaries</td>
</tr>
<tr>
<td>2. Congruence between appropriation and provision rules and local conditions, including benefits and costs</td>
<td>a) Congruence between local conditions and rules</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) Investment/extraction proportionality</td>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Collective choice arrangements</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Monitoring of the resource as well as the monitors</td>
<td>a) Monitoring of the resource</td>
</tr>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) Monitoring the monitors</td>
</tr>
<tr>
<td>5. Graduated sanctions</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Conflict resolution mechanisms</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>7. Minimal rights to organise</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>8. Nested enterprises</td>
<td></td>
</tr>
</tbody>
</table>

*Table 3. AIA design principles for groundwater systems*
Additionally, as mentioned, because the separate operational phases are part of the overall governance framework, it is logical that they can also be considered separately to determine whether there are governance vulnerabilities or strengths in either operational phase: the extraction phase or subsequent injection phase. For example, by focussing exclusively on the AIA design principles that relate to the governance of the extraction of CSG produced water, 13 out of the 21 AIA design principles are relevant (shown in the second column in Table 4 below).476 Similarly, for the activity of injection, 13 out of the 21 AIA design principles are relevant (third column in Table 4, below).477 Five of the AIA design principles are common to both the process of extraction and injection; these are shaded grey in Table 4, below.

476 This is because the other 8 AIA design principles relate to specifically to injection: clarity of rules for injection (AIA DP 1a(iii)), rules for injection that reflect local conditions (AIA DP 2(a)(iii)), economic cost/benefit of injection is appropriate (AIA DP 2(b)(ii)), collective choice arrangements relating to injection (AIA DP 3(iii)), monitoring of injection (AIA DP 4(a)(ii)), graduated sanctions relating to injection (AIA DP 5(iii)), conflict resolution mechanisms relating to injection (AIA DP6(ii)) and rights to organise relating to injection (AIA DP 7(ii)).

477 This is because the other 8 AIA design principles specifically relate to extraction: clarity of rules for extraction (AIA DP 1a(iii)), rules for extraction that reflect local conditions (AIA DP 2(a)(i)), appropriators pay the appropriate proportion for water extracted (AIA DP 2(b)(i)), collective choice arrangements relating to extraction (AIA DP 3(i)), monitoring of extraction (AIA DP 4(a)(i)), graduated sanctions relating to extraction (AIA DP 5(i)), conflict resolution mechanisms relating to extraction (AIA DP6(i)) and rights to organise relating to extraction (AIA DP 7(i)).
### AIA design principles for extraction and injection

<table>
<thead>
<tr>
<th>Ostrom et al’s design principles</th>
<th>AIA design principles relating to extraction in the CSG context</th>
<th>AIA design principles relating to injection of CSG produced water</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Clearly defined boundaries of the resource</td>
<td>(a) Social boundaries Identity of groundwater users</td>
<td>Identity of groundwater users</td>
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<td></td>
<td>Clarity of administrative boundaries to access the groundwater</td>
<td>Clarity of administrative boundaries for injection</td>
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<tr>
<td></td>
<td>(b) Biophysical boundaries Physical boundaries of the groundwater resource</td>
<td>Physical boundaries of the groundwater resource</td>
</tr>
<tr>
<td>2. Congruence between appropriation and provision rules and local conditions, including benefits and costs</td>
<td>(a) Congruence between local conditions and rules Appropriation rules that reflect local conditions for water extraction</td>
<td>Rules for injection that reflect local conditions</td>
</tr>
<tr>
<td></td>
<td>(b) Investment/extraction proportionality Appropriators pay for the appropriate proportion of water extracted</td>
<td>Economic benefit/costs of injection</td>
</tr>
<tr>
<td>3. Collective choice arrangements</td>
<td>Collective choice arrangements relating to extraction</td>
<td>Collective choice arrangements relating to injection</td>
</tr>
<tr>
<td>4. Monitoring of the resource as well as the monitors</td>
<td>(a) Monitoring of the resource Monitoring of extraction</td>
<td>Monitoring of injection</td>
</tr>
<tr>
<td></td>
<td>Monitoring of the resident groundwater resource</td>
<td>Monitoring of the resident groundwater resource</td>
</tr>
<tr>
<td></td>
<td>(b) Monitoring the monitors Monitoring the monitors</td>
<td>Monitoring the monitors</td>
</tr>
<tr>
<td>5. Graduated sanctions</td>
<td>Sanctions relating to extraction</td>
<td>Sanctions relating to injection</td>
</tr>
<tr>
<td>6. Conflict resolution mechanisms</td>
<td>Conflict resolution relating to extraction</td>
<td>Conflict resolution relating to injection</td>
</tr>
<tr>
<td>7. Minimal rights to organise</td>
<td>Rights to organise relating to extraction</td>
<td>Rights to organise relating to injection</td>
</tr>
<tr>
<td>8. Nested enterprises</td>
<td>Nested enterprises involving each of the regulators</td>
<td>Nested enterprises involving each of the regulators</td>
</tr>
</tbody>
</table>

*Table 4. AIA design principles relating to both extraction and injection*
The AIA design principles presented in this fashion are, admittedly, very detailed. At this point, what seems to be missing in much of the CPR literature, and with the AIA design principles presented here, is a way to present the information so that an overall impression can be gained immediately. What would be helpful is a tool that could be used by policy analysts to present this information simply, at a glance, say in a snatched meeting with a Departmental Head or group of landholders. The development of a tool that can be used for any context, no matter how detailed the framework, would be extremely useful.

By displaying the information in the table in a circular chart, a ‘heat map’ can be produced. The resulting ‘heat map’ can be used in either very basic or quite detailed analyses. A shading can be attributed to each aspect of the design principles in the chart, reflecting whether the design principle is present (green), somewhat present (amber) or absent (red). This would provide a summary of the relevant governance framework for analysis. The resulting heat map would clearly show whether the design principles are present or absent, where weaknesses or strengths may lie. This would provide an overall picture for the jurisdiction at a glance. Moreover, a circular chart highlights the notion that each design principle works in conjunction with the others rather than being important on its own or as part of a ‘shopping list’. The research by Baggio et al on ‘clusters’ of design principles can be readily considered if a circular ‘heat map’ is produced.

To produce a circular chart that represents the AIA design principles, each of the original 8 design principles by Ostrom have been given equal weighting in a primary chart (Figure 7, below). The equal weighting is given, despite the relatively recent research that some of the design principles can be seen to have more of an impact than others. No research has yet determined how much more important these particular variables are in the different contexts. For the present, until that research can be conducted, the relative importance of each of Ostrom’s original 8 design principles are allocated equal weighting.

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478 Baggio et al, above n 214.
Aquifer injection in the Coal Seam Gas context: Part A: Chapter 2: Theoretical underpinnings

However, as mentioned above, some of these original 8 design principles have been divided by scholars. In addition, there are more than one set of governance arrangements that are relevant to each of these key design principles for both the PRB and Surat CMA (as detailed in Table 3, column 3, above p 78). A more detailed chart is needed, therefore, to reflect the additional aspects relating to each design principle. This chart (Figure 8, below) divides each of the 8 general design principles into these further detailed aspects to more fully represent the AIA design principles.

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479 Refer to authorities in above n 475.
Aquifer injection in the Coal Seam Gas context: Part A: Chapter 2: Theoretical underpinnings

Figure 8. Heat map base for AIA design principles
This chart can produce a more detailed ‘heat map’ when each separate segment of the chart is shaded green, amber or red. (The same method can be used for simpler, less-detailed analyses, which involve the original 8 design principles.) Attributing a grading may be difficult at times because there will often be some elements of a design principle present (or absent). Each governance framework will have its own strengths and weaknesses. Only using three colours has the advantage of highlighting areas where the design principles are largely absent or largely present, leaving amber for the cases where design principles are partially present or partially absent. Where not enough information can be retrieved, a segment can be either left blank or a coloured question mark (green, amber or red) can suggest the likely finding in the absence of further data. The resulting ‘heat map’ will then highlight areas of weakness and strength, in terms of Ostrom’s design principles, at a glance.480

Moreover, if an AM approach has been adopted for any particular aspect of a design principle (for example, for monitoring or rules to access the resource), it can be noted specifically on the chart adjacent to that sub-design principle. An example of this will be seen in the analysis of the Surat CMA governance framework in Chapter 6, below.

The respective heat maps for each jurisdiction can then also be compared to the outcomes of the governance frameworks. This will provide the opportunity to consider what aspects of the governance framework may have contributed to the outcomes.

Prior to undertaking that analysis, however, I need to canvass the relevant governance arrangements in each jurisdiction, then conclude to what extent they have been successful and the extent to which the AIA design principles are present. Parts B and Parts C provide that detail: Part B presents the governance arrangements and the findings relating to the PRB, and Part C relates to the Surat CMA.

480 Ostrom, *Understanding Institutional Diversity*, above n 382, 270.
PART B: AQUIFER INJECTION OF CSG PRODUCED WATER IN THE POWDER RIVER BASIN, WYOMING

This Part presents the formal laws and policies that govern aquifer injection of CSG produced water within the PRB, Wyoming, USA, as well as the empirical data from permits, documents, reports and semi-structured interviews.

In Chapter 3, I detail the geographic setting and the regulatory framework in place, and I conclude as to the relative success of that framework, based on various known outcomes. In Chapter 4, I attribute a grading to each of the AIA design principles, based on the regulatory frameworks and empirical data, and correlate those findings against my conclusion relating to the success of the governance framework from Chapter 3.

Figure 9. Author’s photograph of the western PRB, rolling pastures south of Sheridan, Wyoming, with the Bighorn Mountains in the background
CHAPTER 3: REGULATORY FRAMEWORK IN WYOMING

This chapter addresses the third and fourth research sub-questions, regarding the relevant regulatory mechanisms in place in the PRB and the overall success of the governance framework. After a description of the PRB setting, this chapter demonstrates that the relevant legislative mechanisms for the two phases of aquifer injection of CSG produced water in the PRB are a permit for the CSG well through the Wyoming State Engineer’s Office (WSEO), and an underground injection control permit from the Wyoming Department of Environmental Quality (WDEQ) for the injection well. These legislative mechanisms are granted within the context of the CSG project permitting arrangements; this context is also important for the later analysis in Chapter 4 against the AIA design principles. Therefore, any apparent digression exploring the wider governance framework at this stage will nonetheless provide necessary colour and context for the later analysis in Chapter 4, and later discussion in Chapter 7. Regardless, I have sought to present only the slice of the overall governance framework relevant to aquifer injection of CSG produced water.

This chapter concludes by arguing that the governance arrangements for groundwater generally and for the extraction of CSG produced water have been and are relatively successful. I conclude that the governance of aquifer injection of coal seam-gas produced water has been and is successful.

1. Geographical, geological and hydrological description of the Powder River Basin

The PRB is an area in north-east Wyoming (extending north into south-east Montana). The basin is in the High Plains surrounded by mountain ranges: the Bighorn Mountains in the west, the Casper-Arch Laramie Mountains in the south to south-west, the Hartville Uplift in the south-east, the Black Hills in the east and Miles City Arch in the north-east in Montana (see Figure 10, below). River systems such as the Powder, Little Powder, Tongue and Belle Fourche rivers flow to the north, north-east towards Montana. The area is semi-arid with annual rainfall ranging from 10 to 26 inches (or approximately 25 to 66 cm). It is known for its treeless rolling grassland, which was once the home of buffalo herds. Wyoming has a long history of energy resource extraction: coal mining and

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conventional oil production at the Salt Creek Oil Field. Early settlement of Wyoming featured cattle and sheep ranches. Summers are warm with cool nights, but winters are cold with snow and fierce winds that blow across the plains. Relatively low humidity, a high percentage of sunshine and winds result in high evaporation rates.

The coal basins in the Rocky Mountain States developed during the Late Cretaceous, early Tertiary periods during the Laramide Orogeny, a period where mountains were formed in North-Western America due to the subduction of tectonic plates under the North American tectonic plate. The PRB ‘is an elongated, north-northwest-trending sedimentary and structural basin that forms a broad asymmetric syncline (depression) with a gently dipping east limb and a steeply dipping west limb’. Jones explains that the ‘coal-bearing Tongue River Member is the upper-most member of the early Tertiary (Paleocene) Fort Union Formation’ in Wyoming’s PRB. The PRB is composed of fluvial, lacustrine and mire deposits, consisting of interbedded shale, mudstone, claystone, siltstone and sandstone, alternating with carbonaceous shale and coal. The CSG is generally extracted from the Upper Fort Union Formation throughout the basin. Figure 10, below, shows the geography of the PRB, along with the location of the outcrops of the overlying Wasatch Formation, the Upper and Lower Fort Union formations, and the location of CSG development.

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482 Bills, Walsh and Haggerty, above n 152.
485 Luppens et al, above n 37.
486 Jones, above n 37.
487 Mire is the generic term for wetlands: swamps, marshes and bogs.
488 Jones, above n 37.
489 Further detail about the geology and hydrogeology of the PRB is presented in Appendix 2(a).
2. **Current status of groundwater systems**

While more than 36,000 CSG wells were drilled in the PRB during peak production in 2008, only 24,000 wells were producing gas.\(^{491}\) Since peak production declined, approximately 11,000 gas wells have been converted to regular water wells, mostly for stock use.\(^{492}\) There are approximately

\(^{490}\) Flores, above n 54, 11.
\(^{492}\) Ibid.
14,000 non-CSG water wells, which are permitted to extract approximately 5,021 million gallons per day (or approximately 19 GL) but are actually estimated to withdraw only 541 million gallons per day (or approximately 2 GL).\textsuperscript{493} The Wasatch and Fort Union Formations are the most widely utilised source of groundwater in the PRB.\textsuperscript{494} The coal seam aquifers in the Wasatch and Fort Union Formations in parts of the PRB were documented by the US BLM as having fallen by more than 600 feet (or approximately 183 m) following gas extraction.\textsuperscript{495}

A 2017 report by the Wyoming Geological Survey (WGS) notes that, since CSG development has declined after 2009/2010, there has been some recovery of aquifers.\textsuperscript{496} The average rate of groundwater level recovery has been measured in the non-CSG producing zones at 1.2 feet/year (or approximately 0.4 m) since CSG development has ceased. The study also concluded that the sandstone units located at depths of more than 600 feet (approximately 183 m) and within 200 feet (61 m) of a producing coal seam were most likely to be impacted by more than 200-foot (61 m) groundwater level declines.\textsuperscript{497} The report also highlighted that groundwater level responses are unpredictable once water production from CSG development ceases in an area: some wells experienced modest recoveries but others continued to suffer declines.\textsuperscript{498} The WGS noted that the extraction of groundwater for stock and domestic uses was unlikely to have impacted groundwater levels.\textsuperscript{499} Mine dewatering was noted as perhaps contributing in part to the continued groundwater declines in the Wyodak Coal monitoring wells.\textsuperscript{500}

3. Regulatory Framework

The separate governance mechanisms for the extraction of CSG produced water and subsequent aquifer injection both sit within a broad framework relating to CSG projects generally. To understand their context, I must explain CSG extraction permitting in general. This detailed context becomes relevant in the subsequent analysis against the AIA design principles in Chapter 4. It is thus

\textsuperscript{493} Taboga, \textit{Wyoming’s Groundwater Resource: Summary Report}, above n 41, 2
\textsuperscript{494} In addition, the Lance and Fox Hills Sandstone formations supply groundwater at the margins of the basin, see: Taboga, Stafford and Rodgers, \textit{Groundwater Response in the Sandstones of the Wasatch and Fort Union Formations, Powder River Basin, Wyoming} (2017), above n 40.
\textsuperscript{498} Ibid.
\textsuperscript{499} Ibid.
\textsuperscript{500} Ibid.
worth persevering with this detail. Nevertheless, it should be remembered that any presentation of a governance framework must necessarily be partial. I will do my best to explain the legislative mechanisms that are directly relevant to aquifer injection of CSG produced water.

The regulatory mechanisms required for a CSG project in Wyoming are numerous. Due to the history of settlement in Wyoming, where it was a US territory prior to becoming a State,\(^\text{501}\) large areas of land remain federally controlled.\(^\text{502}\) Therefore, federal regulation relating to resource extraction and use is relevant. Where the CSG is federally owned, an aquifer injection project involving CSG produced water will need:

- a federal lease for the CSG through the federal Bureau of Land Management (US BLM);
- federal drilling permits (an application for permit to drill (APD) and Plans of Development (POD)) outlining water disposal options, such as through underground injection wells, through the US BLM;
- APDs through the Wyoming Oil and Gas Conservation Commission (WOGCC) in combination with the federal APD for the extraction well;\(^\text{503}\)
- a water permit for the extraction well for the production of the CSG produced water from the Wyoming State Engineer’s Office (WSEO); and
- an UIC permit for the injection well under the US Safe Drinking Water Act 1974\(^\text{504}\) through the Wyoming Department of Environmental Quality (WDEQ).\(^\text{505}\)

I explain in detail these regulatory mechanisms in the following sections of this chapter. Figure 11, below, shows where the entitlements to extract groundwater and for aquifer injection sit (circled in red), within the project-wide framework.

\(^{501}\) Irvine v Marshall 61 US 558 (1857); Wyoming became a Territory in 1868, see MacDonnell, above n 446.


\(^{503}\) If the resource is owned privately or by the State, an APD is required to be obtained only through the WOGCC.

\(^{504}\) 42 USC §300f et seq (42 USC Ch 6A Subch XII) (2017).

\(^{505}\) Because this research concerns good-quality produced water, the relevant UIC permit is a class V permit administered through the WDEQ. The alternative UIC permit used by CSG operators, class II permits, are administered by the WOGCC and involve disposal of poorer-quality produced water requiring an aquifer exemption, so that the target formation is excluded from being an underground drinking-water source.
Local counties cannot restrict the use of land for extraction or production of mineral resources in Wyoming.506 There are many other permits that are required for CSG projects. Prior to injection, the CSG produced water may be contained in off-channel impoundments, which also require permits both at federal and state levels. To streamline this analysis, I have excluded an explanation of the permits and usual conditions for these impoundments (such as construction and monitoring requirements). Other permits that are usually necessary, but not considered in this analysis, are helpfully listed in Chapter 1 of the 2003 Final Environmental Impact Statement for the PRB.507

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506 W S 1977 § 18-5-201; this restriction does not limit regulation of how minerals are extracted and thus minimises undesirable land use impacts, as long as the regulation does not prevent activities reasonably necessary for the extraction; Alan Romero, ‘Local Regulation of Mineral Development in Wyoming’ (2009) 10(2) Wyoming Law Review 463, 478.

Aquifer injection in the coal seam gas context: Part B: Chapter 3: Wyoming regulatory framework

There are no mechanisms that govern entitlements to the aquifer space or recovery of the recharge water in Wyoming. End use obligations are found in the National Primary Drinking Water Regulations.\textsuperscript{508}

\textbf{a) Federal instruments}

Because the federal government owns the mineral estate in 11 of the 12 million acres (approximately 45,000 out of 48,600 km\textsuperscript{2}) of split estates lands,\textsuperscript{509} and holds almost half of the surface ownership (30 million surface acres out of 62.34 million acres or 121,400 out of 252300 km\textsuperscript{2}),\textsuperscript{510} the federal requirements relating to extraction of CSG will apply in many cases. Federal requirements governing access to federal minerals or land are in addition to the state permitting arrangements.\textsuperscript{511} Where the resource is not federally owned and does not involve federally owned land, only the state requirements are necessary.

\textbf{(i) Federal controls on CSG extraction on federal lands}

The US Secretary of the Interior is responsible for managing and overseeing mineral development on public lands in a manner that ‘safeguard[s] … the public welfare’,\textsuperscript{512} under the Mineral Leasing Act 1920.\textsuperscript{513} The US BLM is the branch of the United States Department of Interior (US DOI) responsible for overseeing the operation of coal, oil and gas leases on federal lands under the Federal Land Policy and Management Act 1976 (FLPMA),\textsuperscript{514} and the onshore oil and gas operating regulations contained in Title 43 Code of Federal Regulations (CFR) (Subtitle B, Chapter II, Subchapter C, Part 3160). Within the PRB, the Buffalo Field Office administers the US BLM land

\textsuperscript{508} 40 CFR ch 1, subch D, pt 141, §§ 141.1–141.861 (2018), which sets out the maximum contaminant levels of various organic, inorganic and microbiological contaminants, as well as maximum residual disinfectant levels; National Secondary Drinking Water Regulations 40 CFR ch 1, subch D, pt 143, §§ 143.1–143.5 (2018), which sets recommended rather than enforceable limits for 15 contaminants for aesthetic reasons (taste, colour and odour).

\textsuperscript{509} Micheli, above n 502, for the meaning of the term, see above n 182.

\textsuperscript{510} Petroleum Association Wyoming, above n 502.

\textsuperscript{511} These permits are in addition to the State permits required, see Wyoming v US DOI, 136 F Supp 3d 1317, 1350 (Skavdahl J) (D Wyo, 2016): ‘[a]ll state laws apply on federal lands’. However, the Ending Duplicative Permitting Act of 2019, FD HB 1650 (NS), 116th Congress (2019), was introduced into the House of Representatives and referred to the House Committee on Natural Resources and Subcommittee on Energy and Mineral Resources in March 2019. The Act amends 30 USC § 226 so that the US BLM will not require permits for oil and gas activities on non-federal surface lands where the sub-surface mineral estate is less than 50% federally owned.

\textsuperscript{512} 30 USC § 187 (2017).

\textsuperscript{513} 30 USC §§ 181–287 (2017).

\textsuperscript{514} 43 USC §§ 1701–1787 (2017).
portions of Campbell, Johnson and Sheridan counties and the Casper Field Office administers the US BLM lands in the northern portion of Converse County.\textsuperscript{515}

The first stage of oil and gas activities on federal land involves a planning stage: the development of a resource management plan by the US BLM under FLPMA.\textsuperscript{516} The resource management plan broadly describes the allowable uses, goals for future condition of the land and specific next steps, such as which areas will be open to oil and gas leasing, and under what conditions.\textsuperscript{517}

As part of the planning process, the National Environmental Policy Act (NEPA)\textsuperscript{518} requires ‘federal agencies [to] ... take a “hard look” at the environmental consequences of the proposed courses of action’.\textsuperscript{519} This is known as the ‘hard look doctrine’.\textsuperscript{520} Under the NEPA, federal agencies, such as the US BLM, must prepare environmental impact statements (EISs) for proposed major federal actions (such as CSG leasing and permitting, and the preparation of resource management plans) that significantly affect the quality of the human environment.\textsuperscript{521} As mentioned in Chapter 2, the AM approach has been adopted by the US DOI, and consequently by the US BLM.\textsuperscript{522} But AM generally only applies at this regional planning level, rather than with respect to separate projects.\textsuperscript{523}

The Council of Environmental Quality’s regulations governing the NEPA process are in Title 40 (Chapter V Parts 1500–1508) of the Code of Federal Regulations.\textsuperscript{524} They provide for the use of draft, final and supplemental EISs (DEISs, FEISs and SEISs, respectively) and the use of ‘tiering’ to avoid repetitive coverage of material.\textsuperscript{525} Preliminary assessment of the need for an EIS is undertaken through an environmental assessment involving public consultation, which considers the need for the proposed action/development and any possible alternatives.\textsuperscript{526} If the agency considers that no significant impacts will affect the environment, it will issue a ‘Finding of No Significant Impact’.

\textsuperscript{515} Buffalo Field Office, Final Environmental Impact Statement and Proposed Plan Amendment for the Powder River Basin Oil and Gas Project (2003), above n 199, 5-1.
\textsuperscript{516} 43 USC ch 35; 43 USC § 1712 (2017); 43 CFR § 1601.0–5(n) (2018).
\textsuperscript{518} The NEPA is contained in 42 USC §§ 4321–4370m-12 (2017) and 43 CFR §§ 46.10–46.450 (2018).
\textsuperscript{519} Pennaco Energy v United States Department of Interior 377 F 3d 1147 (10th Cir, 2004).
\textsuperscript{521} 42 USC § 4332 (2)(c) (2017); 40 CFR § 1502.3 (2018).
\textsuperscript{522} Refer to chapter 2, section 2, above p 44.
\textsuperscript{524} See 40 CFR §§ 1500.1–1508.28 (2018).
\textsuperscript{525} 40 CFR §§ 1502.9, 1502.20 and 1508.28 (2018); see Reitze Jr, above n 520, 290.
\textsuperscript{526} 40 CFR § 1501.4 (b)–(c) (2018).
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('FONSI'), which is made publicly available.\textsuperscript{527} The draft EIS is made available to the public as well as to other federal agencies with special expertise or jurisdiction, and to relevant State and local agencies for comment. The EIS must consider the context and intensity of the proposed action including beneficial and adverse impacts; impacts to public health or safety; unique characteristics of the locality; the degree to which the impacts on the human environment will be controversial; whether it would establish a precedent; cumulative effects; any potential impacts on endangered or threatened species, or their habitat; and whether the action violates federal, state or local laws.\textsuperscript{528} The agency must prepare a concise public record of decision (‘ROD’), which states what the decision was as well as identifying the alternatives and whether all practicable means of avoiding or minimising environmental harm have been adopted, and if not, why not.\textsuperscript{529} Once the US BLM issues the resource management plan, subsequent more detailed or specific planning and permitting must conform to it.\textsuperscript{530}

The second stage of oil and gas development is the leasing stage. The US BLM issues CSG leases consistent with the resource management plan and, under the \textit{Federal Onshore Oil and Gas Leasing Reform Act 1987},\textsuperscript{531} through a competitive bidding process.\textsuperscript{532} CSG operators must ‘comply with applicable laws and regulations; with the lease terms; Onshore Oil and Gas Orders;\textsuperscript{533} Notices to Lessees; and with other orders and instructions of the US BLM’.\textsuperscript{534}

\textbf{(ii) Requirements of the Buffalo Resource Management Plan 2015}

In the late 1990s, approximately 40,000 new CSG wells were proposed to be drilled in the PRB over the following 10 years by a group of oil and gas companies.\textsuperscript{535} The proposed project

\begin{itemize}
  \item \textsuperscript{527} 40 CFR §§ 1501.4 (1), 1506.6 (2018).
  \item \textsuperscript{528} 40 CFR § 1508.27 (2018).
  \item \textsuperscript{529} 40 CFR § 1505.2 (2018).
  \item \textsuperscript{530} 43 CFR § 1610.5-3(a) (2018).
  \item \textsuperscript{531} Federal Onshore Oil and Gas Leasing Reform Act 1987, 30 USC. §§ 181–287 (2017).
  \item \textsuperscript{532} 30 USC § 226 (2017); CSG is part of the oil and gas estate rather than the mineral estate: \textit{Amoco Production Co v Southern Ute Tribe}, 526 U S 865 (1999).
  \item \textsuperscript{533} The BLM has issued seven Onshore Oil and Gas Orders: 1) approval of operations, 2) drilling requirements, 3) site security, 4) measurement of oil, 5) measurement of gas, 6) hydrogen sulfide operations, and 7) Disposal of produced waters. Onshore Oil and Gas Order 7 states that produced water disposal requires an approval and sets out the informational and procedural requirements for such applications. Injection is the generally preferred method of disposal.
  \item \textsuperscript{534} 43 CFR § 3162.1(a) (2018). Records, including source records, that are relevant to determining the quality, quantity, disposition and verification of production attributable to the Federal lease must be kept for at least 7 years and produced upon request as may be required by regulation, written order, Onshore Order, Notice to Lessee or conditions of approval; 43 CFR § 3170.7 (2018). If reported to the US BLM, these records are not automatically made available to the public on the BLM’s website, but they may be made available; 43 CFR § 3100.4 (2018).
  \item \textsuperscript{535} Lance Oil and Gas [Western Gas Company], Barrett Resources Corporation [Williams], Devon Energy Corporation, Yates Petroleum Corporation, Pennaco Energy [Marathon Oil Corporation], and CMS Oil and Gas [Perenco SA], collectively known as the Powder River Basin Companies (Companies), see: Buffalo Field Office,
coverage would include some 8 million acres (or approximately 32,400 km\(^2\)) of federal, State and Medicine Bow National Forest land.\(^{536}\) The companies already held valid oil leases for the project area, and had contractual and private rights to develop the resources. There had already been several environmental assessments conducted by the US BLM addressing CSG development in the area, but they had underestimated, to a significant degree, the number of wells anticipated by these companies.\(^{537}\)

Following the NEPA process, a Record of Decision and Resource Management Plan Amendments for the PRB Oil and Gas Project was issued in April 2003 (following the 2003 Final EIS for the PRB).\(^{538}\) In 2015, the Buffalo Resource Management Plan replaced the 2003 amendments in order to incorporate management actions to conserve the Greater Sage-Grouse on US BLM lands.\(^{539}\) The revised resource management plan incorporates the requirements for CSG development imposed by the earlier 2003 amendments.

The third stage of oil and gas development involves permitting of the gas wells (after valid leases are obtained). This process involves lessees applying for permits to drill (APDs), which must comply with the relevant resource management plan,\(^{540}\) and undertaking additional NEPA analysis for the relevant wells.\(^{541}\) The site-specific NEPA analyses, ‘tiered’ under the earlier broader EIS, must precede approvals.\(^{542}\)

The APD is required to be lodged with the US BLM for CSG wells on federal oil and gas leases. The APD must be accompanied by a drilling plan; a surface use plan of operations; evidence of bond coverage (and that a surface use agreement was offered to the surface owner); an operator certification, as described in Onshore Oil and Gas Order 1 III.D.6; an onsite inspection; and a water management plan for the use and disposal of federal water.\(^{543}\) No surface disturbance may begin on

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\(^{537}\) Three EAs (Gillette North, Lower Prairie Dog Creek and WYODAK drainage) and two EISs (Gillette South and WYODAK) addressed proposed coalbed methane (CBM) development in the area: 65 Fed Reg 38571 (21 June 2000).


\(^{540}\) 43 CFR §1610.5-3 (2018).

\(^{541}\) 43 CFR § 3162.5-1 (2018).


\(^{543}\) 43 CFR § 3162.3–1 (2018); for the Water Management Plan, see: Buffalo Field Office, *Record of Decision and Resource Management Plan Amendments for the Powder River Basin Oil and Gas Project* (2003), above n 538,
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the lease until an APD is obtained. The water management plan must detail how produced water will be handled during testing and production stages, and contain adequate information to enable the site-specific NEPA analysis and to ensure compliance with all State and Federal requirements prior to approval.\textsuperscript{544} The water management plan must contain details of a monitoring plan.\textsuperscript{545} Prior to the APD being filed, a ‘Notice of Staking’ may be filed for approval with the relevant US BLM office, which notifies the US BLM that a proposed well site has been staked and signals the need for a site inspection.\textsuperscript{546} The site inspection team usually includes US BLM, US Forest Service (if construction occurs on Forest Service lands), the lessee and primary drilling contractors as well as, if relevant, the federal grazing lessees or surface owner.\textsuperscript{547} This inspection enables the identification of sensitive areas, the environmental consequences of the development and possible mitigation strategies. The APD can be amended to include conditions that address these issues post-inspection.

CSG projects must be submitted as Plans of Development (POD), which relate to a group of wells and their ancillary supporting infrastructure for a geographic area or watershed so that development can proceed in a ‘logical, economical, environmentally sound’ way.\textsuperscript{548} US BLM is responsible for conducting the environmental analysis on federal lands; preparing the documentation; specifying mitigation measures; and approving the drilling program, protection of groundwater (and other subsurface resources) and final approval of the APD.\textsuperscript{549} The APD must conform with the lease stipulations,\textsuperscript{550} onshore oil and gas orders, and applicable regulations and laws. Relevantly, the US BLM Onshore Oil and Gas Order No. 7 states that:

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\textsuperscript{544} Buffalo Field Office, \textit{Record of Decision and Resource Management Plan Amendments for the Powder River Basin Oil and Gas Project (2003)}, above n 538, 8; see Appendix D for details on water management plans and Buffalo Field Office, \textit{Approved Resource Management Plan}, above n 523, Appendix N, 565 and 590.

\textsuperscript{545} Buffalo Field Office, \textit{Record of Decision and Resource Management Plan Amendments for the Powder River Basin Oil and Gas Project (2003)}, above n 538, 8; see Appendix D for details on water management plans and Buffalo Field Office, \textit{Approved Resource Management Plan}, above n 523, Appendix N, 565 and 590.

\textsuperscript{546} Ibib, 21; Buffalo Field Office, \textit{Approved Resource Management Plan}, above n 523, Appendix O, 605.


\textsuperscript{550} Lease stipulations imposed by the BLM (or Forest Service) may relate to for example, surface disturbance, surface occupancy, limited surface use, timing (or seasonal restrictions), mitigation measures and measures to prevent conflict with coal extraction; see Buffalo Field Office, \textit{Final Environmental Impact Statement and Proposed Plan Amendment for the Powder River Basin Oil and Gas Project (2003)}, above n 199, 3-243.
Injection is generally the preferred method of disposal. Operators are encouraged to contact the appropriate authorized officer before filing an application for disposal of produced water so that the operator may be apprised of any existing agreements outlining cooperative procedures between the Bureau of Land Management and either the State/Indian Tribe or the Environmental Protection Agency concerning Underground Injection Control permits for injection wells, and of any potentially significant adverse effects on surface and/or subsurface resources. The approval of the Environmental Protection Agency or a State/Tribe shall not be considered as granting approval to dispose of produced water from leased Federal or Indian lands until and unless BLM approval is obtained. If the approval for a disposal facility, e.g., commercial pit or class II injection well, is revoked or suspended by the permitting agencies such as the Environmental Protection Agency or the primacy State, the BLM water disposal approval is immediately terminated and the operator is required to propose an alternative disposal method.\textsuperscript{551}

To obtain approval from the US BLM for disposal of water into injection wells, either on-lease or off-lease, or on State or privately owned lands, the operator must file a Sundry Notice, Form 3160-5, along with the information submitted in support of obtaining an Underground Injection Control (UIC) permit and, if off-lease or on State or private land, the UIC permit (unless the well is authorised by a general permit (discussed further below)).\textsuperscript{552} The US BLM is responsible for protecting water quality in federally owned lands under the FLPMA.\textsuperscript{553} US BLM statutory responsibilities for the approval of disposal via injection include drilling safety, down hole integrity, and protection of the mineral and surface resources.\textsuperscript{554} The operator must comply with the procedural and informational requirements for the APD and Sundry Notice in the Onshore Oil and Gas Order No. 1.\textsuperscript{555} The design and drilling requirements for the injection wells are found in the Onshore Oil and Gas Order No. 2, as well as the Underground Injection Control permit.\textsuperscript{556}

\textsuperscript{551} Onshore Oil and Gas Order 7, 58 Fed Reg 47361, 47362 (8 September 1993).
\textsuperscript{552} Under 40 CFR pt 144 (2018).
\textsuperscript{553} 43 USC § 1701 (a)(8) (2018).
\textsuperscript{554} Onshore Oil and Gas Order 7, 58 Fed Reg 47361, 47362 (8 September 1993).
\textsuperscript{555} Ibid.
\textsuperscript{556} Ibid.
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(iii) Federal control of water within Wyoming

Federal jurisdiction over water resources relies on broad-ranging powers\(^557\) but, unless there is a specific congressional intent, there is a presumption that federal Congress will defer to State laws for water allocation.\(^558\)

(iv) Federal environmental protection of water

The environmental movement of the 1960s led to the expansion of federal powers to the protection of surface waters through the enactment of the *Clean Water Act of 1972* (CWA).\(^559\) The CWA only applies to releases to ‘navigable waters’ of the United States. Courts are expanding the meaning of ‘navigable waters’ to increasingly smaller streams and associated groundwater (as well as lagoons, lakes and wetlands).\(^560\) However, its provisions are not triggered with respect to injection of the produced water into aquifers entirely unconnected with surface waters.

Injection (either to augment potable water sources or for disposal) is governed by the federal *Safe Drinking Water Act 1974* (SDWA)\(^561\) through the Underground Injection Control Program (UIC).\(^562\) The UIC program has been used predominantly for the disposal of fluids\(^563\) but it equally applies to injection or recharge where the purpose is to augment groundwater resources, for example, in ASR projects where both water quantity and quality are managed. The purpose of the SDWA is to ensure ‘that the water supply systems serving the public meet minimum national standards for the protection of public health.’\(^564\) These provisions and the program are administered by either the US EPA or the State, if that State is approved by the EPA. Wyoming has been delegated authority by the US EPA\(^565\) and the WDEQ is responsible for administering the relevant classes of UIC


\(^{559}\) 33 USC § 1251–1388 (2017). Surface disposal of produced water that meets threshold quality trigger parameters will require a National Pollutant Discharge Elimination System (NPDES) permit from the Environmental Protection Agency (EPA), or a State with a delegated program.

\(^{560}\) See Tarlock and Robison, above n 557, §9:9.

\(^{561}\) 42 USC §300f et seq (42 USC Ch 6A Subch XII) (2017).

\(^{562}\) 42 USC §300h-1 et seq (2017).

\(^{563}\) This would fall into the category of ‘unmanaged recharge’, according to the distinguishing examples of groundwater recharge by Dillon et al, *Sixty Years of Global Progress*, above n 123, 4.

\(^{564}\) HR Rep No 93-1185 (93rd Cong) (10 July, 15 Aug, 1974).

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wells. Both the federal and Wyoming regulations are discussed together below, beginning under heading 3(b)(iii), p 105.

b) Wyoming instruments

Each CSG well must be permitted as both a gas well and a water well, and at least three permits are required at the State level: an application for permit to drill (APD) through the WOGCC, a water permit through the WSEO, and a water discharge or injection permit from the WDEQ.

Figure 12. Author’s photograph of the CSG facilities at Midwest, near Casper, Wyoming

(i) Wyoming CSG extractive rights

The WOGCC regulates oil and gas extraction under Wyo. Stat. §30-5-100, et seq. (2018), and subsequent rules and regulations promulgated by the Commission. An APD must be made to the WOGCC in anticipation of drilling any well on free, patented, state, or federal lands. The APD must be in form 1 and be accompanied by a fee of US$500. The form is to be accompanied by details of the proposed drilling, including depths, type of drilling tools to be used, identification of all water sources, depth geology and hydrology of ground waters, proposed casing programs for wells, description of the cementing program and anticipated completion, and stimulation programs, as well as a statement of compliance with the Split Estates Act.

566 WY Rules and Regulations 055.0001.3 § 8 (2018).
568 Ibid § 8 (c) (d) (2018); Wyoming Split Estate Act 2005, WS §§ 30-5-401 to 30-5-410 (2018). The Wyoming Split Estates Act was passed in order to adjust the common law rights of oil and gas estate owners so as to require payment of compensation to surface landholders for damages incurred due to extractive activities. The provisions apply to any land where the surface owners differ from the oil and gas estate. New requirements
monitoring plan must be submitted along with the APD. A surety bond to guarantee remediation can also be required. Production data (of both water and gas) is reported to and disclosed on the WOGCC website for each well.

(ii) Wyoming water rights

The ‘value, importance and significance of water to the people of Wyoming’ is entrenched in the Wyoming Constitution, which provides that water is the property of the State. Article 1 § 31 provides for the control of water:

> Water being essential to industrial prosperity, of limited amount, and easy of diversion from its natural channels, its control must be in the state, which, in providing for its use, shall equally guard all the various interests involved.

Furthermore, Article 8, § 1 states:

> the water of all natural streams, springs, lakes or other collections of still water, within the boundaries of the state, are hereby declared to be the property of the state.

Four geographic water divisions within the State are regulated for water appropriation, distribution and diversions by the Board of Control, which is composed of the WSEO and superintendents. In times of water shortage, it is the Board of Control that is responsible for the division and distribution, in priority, of water resources. The WSEO oversees allocation, but it is the Board of Control that approves adjudication and any changes to water rights.

The Doctrine of Prior Appropriation for surface waters was adopted in the Wyoming Constitution at the outset. Article 8 § 3 provides that:

> priority of appropriation for beneficial uses shall give the better right. No appropriation shall be denied except when such denial is demanded by the public interests.
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Groundwater is not specifically referred to in the Wyoming Constitution. In contrast to surface water rights, Wyoming water law originally adopted the rule of absolute ownership for groundwater: the overlying landholder had an unfettered right to extract the groundwater under his or her property. In 1945, the first groundwater statute established the prior appropriation system and required registration of groundwater use. The legislation was rewritten in 1957 with the addition of a permit requirement. The relevant Wyoming regulatory instrument is Wyoming Statutes Title 41. Underground water is the subject of chapter 3, article 9 in Title 41.

‘Underground water’ is defined as meaning:

any water, including hot water and geothermal steam, under the surface of the land or the bed of any stream, lake, reservoir, or other body of surface water, including water that has been exposed to the surface by an excavation such as a pit.

The concept of ‘beneficial use’ is a cornerstone of the prior appropriation doctrine and is embedded with respect to groundwater in Wyoming Statute § 41-3-931, which states:

an application for a permit for a well in any areas not designated as a critical area shall be granted as a matter of course, if the proposed use is beneficial and, if the state engineer finds that the proposed means of diversion and construction are adequate.

MacKinnon and Fox explain that the concept of ‘beneficial use’ limits rights of extraction to that which is reasonably necessary for the beneficial purpose in order to discourage waste. Categories of groundwater use that are considered as standard beneficial uses by the WSEO are: domestic, stock watering, irrigation, industrial, municipal and a miscellaneous category. Since 2004, the production of water during CSG extraction has also been designated a beneficial use.

579 Gary Bryner and Elizabeth Purcell, Groundwater Law Source Book of the Western United States (Natural Resources Law Center, University of Colorado School of Law, 2003); Wolfe and Hager, above n 578, 43; MacDonnell, above n 446; 1945 Wyo Sess Laws 166, Underground Water Act of 1945, Bill Number SF0074, Enrolled Act No SEA 0069, § 3 (1945): ‘Reasonable economic beneficial use shall be the basis, the measure and limit of the right to use underground water at all times.’
580 Bryner and Purcell, above n 501.
581 WS § 41-3-901(a)(ii)(2018).
582 As opposed to the notion of beneficial ‘re-use’, noted in Queensland’s CSG Water Policy 2012, mentioned in chapter 1, section 1(b), above p 12.
583 WS § 41-3-931 (2018).
584 MacKinnon and Fox, above n118, 376–377.
585 This includes commercial agriculture such as feedlots, mine dewatering, large-scale landscape or lawn watering (greater than 1 acre) and other uses.
Since 1969, domestic use of water or use for stock watering requires permits, but they are deemed to be preferred uses over all other appropriations, regardless of their dates of priority. In Wyoming, a water right is ‘a property right of high order possessing none of the characteristics of personal property, and is considered real property. It can be sold and conveyed separate to the land to which it was applied, unless the sale injuriously affects the rights of other water users. Transfers of water rights must be approved by the Board of Control. The right to sell such property is the right to sell the use rights, not the actual water resource, with such use rights being measured by the prior appropriation for beneficial purposes, so that the burden of use on others is the same. Wolfe and Hager explain that ‘it is a valuable property right that is protected against interference but the state exercises control over the amount and location of use’. Because the WSEO has designated the extraction of water as part of CSG production as a ‘beneficial use’ of water, each CSG well requires a permit to appropriate the groundwater just like any other uses. An ‘Application for Permit to Appropriate Groundwater’ Form U.W.5 is required to be submitted.

587 Domestic use is defined as ‘household use and the watering of lawns and gardens for non-commercial family use where the area to be irrigated does not exceed one (1) acre, where the yield or flow does not exceed 0.056 cubic feet per second or twenty-five (25) gallons per minute’: WS § 41-3-907 (2018).

588 Stock watering was previously noted as being normal livestock watering, including where water is piped to no more than 4 points within 1 mile of a well (5 or more points or use further than 1 mile from the well was considered a miscellaneous use and required adjudication), although now this is merely limited to the flow rate of 25 gallons per minute; see Patrick T Tyrrell, State Engineer, Memorandum, Policy Regarding Groundwater Applications for Stock or Domestic Uses (6 February 2018) <https://sites.google.com/a/wyo.gov/seo/>.

589 Domestic use is defined as ‘household use and the watering of lawns and gardens for non-commercial family use where the area to be irrigated does not exceed one (1) acre, where the yield or flow does not exceed 0.056 cubic feet per second or twenty-five (25) gallons per minute’: WS § 41-3-907 (2018).

590 King v White, 499 P 2d 585 (Wyo, 1972); Budd v Bishop, 543 P 2d 368 (Wyo, 1975); DeWitt v Balben, 718 P 2d 854 (Wyo, 1986). See also: Budd v Bishop, 543 P 2d 368, 372 (Thomas J) (Wyo, 1975), where Thomas J remarked in obiter dictum that the real property right vests at the time the application for appropriation is filed, if the right is adjudicated. Because CSG well water permits are not adjudicated, this may lead to the question as to whether a property right had vested.

591 Johnston v Little Horse Creek Irrigating Co, 79 P 22, 24 (Potter J) (Wyo, 1904).

592 WS § 41-3-104 (2018); State Engineer’s Office, Wyoming, Permitting/Adjudication/Changes (Undated) <http://seo.wyo.gov/ground-water/permitting-adjudication-changes>.

593 Johnston v Little Horse Creek Irrigating Co, 79 P 22, 24 (Potter J) (Wyo, 1904).

594 Wolfe and Hager, above n 578, 45.

595 Darin explains that this was due to the large quantities of water that were produced from the early wells for significant periods of time without producing any gas: Darin, above n 117, 324.

596 State Engineer’s Office, above n 586.
be submitted for each well and approved prior to drilling.\textsuperscript{597} The date of filing the application becomes the priority date of the water right.\textsuperscript{598}

The WSEO may reject a permit if they consider that it is not in the public’s interest.\textsuperscript{599} Since at least 2012, the WSEO has tightened regulation of CSG water permits, which has included amending the conditions attached to each CSG permit to include a self-reporting requirement for the water/gas ratios, beginning in 2013.\textsuperscript{600} This occurred at about the same time as litigation (which failed) brought by aggrieved landholders challenging the WSEO’s application of the public interest test.\textsuperscript{601}

The application for the permit is required prior to the construction and use of water from a well,\textsuperscript{602} and must include:

- the name and post-office address of applicant or applicants,
- a detailed description of the proposed use,
- the location by legal subdivision of the proposed well or other means of obtaining underground water,
- the estimated depth of the proposed well,
- the quantity of water proposed to be withdrawn and beneficially utilized in gallons per minute and acre-feet per calendar year,
- the location by legal subdivision of the area or point of use ...

and such other information as the WSEO may require.\textsuperscript{603}

Minimum construction standards for the wells are authorised under Wyo. Stat. §41-3-909 (and were updated in 2010).\textsuperscript{604} Generally, well permits include the special condition that they will be reviewed within 5 years of the approval, consistent with water wells in established oil and gas fields.

The water well must be completed and put to ‘beneficial’ use before the date specified on the permit (not being more than 3 years after the date of the permit)\textsuperscript{605} and, once completed, notice must be given to the WSEO,\textsuperscript{606} and usually adjudication will follow.\textsuperscript{607} A ‘Proof of Appropriation and Beneficial Use’ form, which includes well location details on a map, must then normally be lodged and the WSEO conducts a field inspection of the works to ensure the accuracy of the map, and the

\textsuperscript{597} WS § 41-3-930 (2018).
\textsuperscript{598} WS § 41-3-936 (2018) (for applications post 31 December 1972); WSEO Regulations and Instructions, 1978, Part II Groundwater Chapter 1, s 12.
\textsuperscript{599} Wyoming Constitution, art 8, § 3; WS §§ 41-3-931 and § 41-4-503 (2018).
\textsuperscript{601} During the carriage of litigation for William F West Ranch, LLC v Tyrrell, 206 P 3d 722 (Wyo, 2009).
\textsuperscript{602} WS § 41-3-905 (2018).
\textsuperscript{603} WS § 41-3-930(a) (2018).
\textsuperscript{605} WS § 41-3-934 (2018), the SEO can extend or cancel the permit if these time limits are not met.
\textsuperscript{606} Via a Statement of Completion Form (UW6).
\textsuperscript{607} WS § 41-3-935 (2018).
yield of the well (among other things). The proof is then advertised in a local paper in the County where the well is situated at least 30 days prior to a regular meeting of the Board of Control. Objections can be made. The Board of Control decides whether the appropriation has been perfected and, if so, a certificate issues and is recorded. Once adjudicated, the water right attaches to the land. Where the use is for stock watering or domestic purposes, adjudication may be initiated by either the WSEO or the water appropriator/user, and it is not necessary to file the map showing location details or have the WSEO inspect. Wells used for CSG water production also have exemptions from adjudication (usually found in the conditions of the permit). The WSEO has established a practice of not taking CSG permits to adjudication because of the shorter timeframe the well will operate as a water-producing well.

Obtaining groundwater permits is generally straightforward. Permits will be granted as a matter of course where the use is ‘beneficial’ and the WSEO finds that the method of diversion and construction is adequate. A wide discretion is granted to the WSEO to issue any permits subject to such conditions as he (or she) may find to be in the public interest. All water permits, the relevant applications, notices and correspondence, including reporting of metering when required, are available on the WSEO website.

The right of a water appropriator does not include the right to have the water level or artesian pressure at the appropriator’s point of diversion maintained at any level or pressure higher than that required for the maximum beneficial use of the water in the source of supply. Where there is growing conflict over groundwater resources, the WSEO can designate ‘Control Areas’ to restrict or slow development. These are underground water districts designated due to the following reasons:

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608 WS § 41-3-935(b) and (c) (2018).
609 WS §§ 41-3-935(c), 41-4-511 (2018).
610 WS § 41-4-511 (2018).
611 WS § 41-4-511 (2018).
612 WS § 41-3-935(c) (2018).
613 MacKinnon and Fox, above n 118, 384. This was confirmed in an interview with the WSEO, see: Interview with Participants W1 and W2 (Cheyenne Wyoming, 10 August 2017). This is a standard condition (9) on all CBM water permits.
615 WS § 41-3-933 (2018).
616 Metering requirements are to be found in the conditions on water permits or imposed by State Engineer’s Order for example for a Control Area: State Engineer’s Office, Wyoming, Metering and Reporting (Undated) <http://seo.wyo.gov/ground-water/metering-and-reporting>. The reporting of monthly extraction figures by CSG wells conditioned on water permits is not usually uploaded; see the e-permits link: <https://sites.google.com/a/wyo.gov/seo/>.
617 WS § 41-3-933 (2018).
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(i) the use of underground water is approaching a use equal to the current recharge rate;

(ii) ground water levels are declining or have declined excessively;

(iii) conflicts between users are occurring or are foreseeable;

(iv) the waste of water is occurring or may occur; or

(v) other conditions exist or may arise that require regulation for the protection of the public interest.618

In these areas, when all water withdrawals are adjudicated, if there is insufficient water to meet all demands, various corrective controls can be applied by the WSEO. These include closing the area to any further appropriation, ceasing or reducing junior water users’ entitlements or specifying a system of rotation of use.619 There are currently three Control Areas designated (Laramie County, Platte County and Prairie Center in the south-eastern corner of the state). Any new wells exceeding 25 gallons per minute (exempting stock and domestic use) will require additional levels of assessment such as public notice and consideration by a 5-member Advisory Board for each area.620

(iii) Wyoming environmental protection

The protection of the environment throughout the State of Wyoming is regulated under the Wyoming Environmental Quality Act, WS §35-11-100 et. seq. The laws are generally administered by the WDEQ,621 and the Water Quality Division governs emissions affecting water resources.

As already mentioned, the federal UIC program delegated to the WDEQ, is intended to protect underground drinking water sources which are defined as a source:

(a)(1) Which supplies any public water system; or

(2) Which contains a sufficient quantity of ground water to supply a public water system; and

(i) Currently supplies drinking water for human consumption; or

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618 WS § 41-3-912 (a) (2018).
619 WS § 41-3-915 (2018).
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(ii) Contains fewer than 10,000 mg/l total dissolved solids; and
(b) Which is not an exempted aquifer.622

There are six types of injection well classifications:

Class I – Industrial and municipal waste disposal wells,
Class II – oil and gas related injection wells,
Class III – solution mining wells,
Class IV – shallow hazardous and radioactive waste injection wells,
Class V – wells that inject non-hazardous fluids into or above underground sources of drinking water,
Class VI – geologic sequestration wells.

CSG produced water can be disposed of via class II wells or class V wells. Class II wells are administered by the WOGCC,623 and generally relate to poorer quality produced water because an aquifer exemption for the formation in which the produced water is to be injected is required.624 They are used for disposal of fluid and therefore fall within the category of groundwater recharge categorised by Dillon et al as ‘unmanaged recharge’.625 In contrast, Class V wells, permitted by the WDEQ,626 do not require an exemption as long as the injection does not alter the general quality of the formation in which it is injected. Aquifer recharge through injection wells and infiltration mechanisms are both regulated via class V permits. Both the quantity of water and quality of injectate and groundwater are specifically regulated, therefore, these types of wells are a form of ‘MAR’ categorised by Dillon et al.627 As this research centres on injection wells (for the comparison with the Queensland projects) only class V injection wells form the basis of this study.

Groundwater is classified in broad categories which contain specific parameters for numerous constituents and characteristics.628 For example, a sample of the categories and the relevant parameters for TDS, pH and SAR (where listed) are:

Class I – domestic – TDS up to 500mg/L, pH of 6.5-8.5 s.u.,

622 40 CFR § 144.3 (2018).
625 Dillon et al, Sixty Years of Global Progress, above n 123, 4.
627 Dillon et al, Sixty Years of Global Progress, above n 123, 4.
628 WY Rules and Regulations 020.0011.8 § 5, Table 1 (2018).
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Special Class A – water for fish and aquatic life – TDS 500–2000 mg/L, pH of 6.5–9.0 s.u.,

Class II – water for agriculture – TDS of 2,000 mg/L, 4.5–9 pH s.u. and SAR of 8,

Class III – water for livestock – TDS up to 5,000 mg/L, pH of 6.5–8.5 s.u.,

Class IV (A) – water for industry – TDS up to 10,000 mg/L

A discharge into a particular class of groundwater must not result in variations to the range of parameters in the standards. But if exceedances can be remedied, they can be excused. Due to the average quality of CSG produced water in the PRB, often only minimal treatment is required where it is injected into class III or class IV aquifers.

There are three types of Class V permits issued: by rule, general or individual permits. Only general or individual permits are applicable to CSG operators. Where a class V facility is permitted by rule, the relevant information is required to be submitted to the department prior to construction and operation and must meet performance standards. Aquifer Recharge Facilities, where water is specifically stored underground to be withdrawn at a later date for beneficial use, are permitted by rule as a class V 5B, as they are considered to pose a minimal threat to groundwater.

CSG operators are specifically excluded from this category of injection well.

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631 ‘Groundwater with estimated TDS levels of 2000-5000 are the most frequently encountered waters in the PRB to depths of less than 5000 feet.’: Karl Taboga, James E Stafford and James R Rodgers, *Groundwater Salinity in the Powder River Basin, Wyoming* (2018) <https://www.wsgs.wyo.gov/products/wsgs-2018-ofr-05.pdf>; Where there are salinity differences (such as for the Smith/Big George, Anderson Rider, Canyon, Cook, Wall, Lower Wall, Pawnee and Moyer which range from 500-3000mg/L, the coal beds are usually less saline in the east and becoming more saline to the west (which are deeper), see Copeland and Ewald, above n 70, 249–268, Figures 4-104 - 4-122.
632 Where an authorisation in the rules does not require either an individual or general permit. The facility must meet all the requirements in WY Rules and Regulations 020.0011.27 (2018); see definition ‘Permit by rule’ in WY Rules and Regulations 020.0011.27 §§ 2 (hh), 11 (2018).
633 “‘General permit’ means a permit issued to a class of operators, all of which inject similar types of fluids for similar purposes. General permits require less information to be submitted by the applicant than individual permits and do not require public notice for a facility to be included under the authorization of a general permit”: Wy Rules and Regulations 020.0011.27 §§ 2 (v), 10 (2018).
634 “‘Individual permit’ means a permit issued for a specific facility operated by an individual operator, company, municipality, or agency. An individual permit may be established as an area permit and include multiple points of discharge that are all operated by the same person’: Wy Rules and Regulations 020.0011.27 §§2 (aa), 7, 9 (2018).
636 Ibid § 11(c)(ii), App C ‘5B2’ (2018). A MAR project that is of a commercial character is classified as a class I well and the requirements for these are more stringent, see Department of Environmental Quality, Wyoming, *CBM-Produced Water Injection Wells: Requirements to Ensure Protection of Ground Water* (2005) <http://sgirt.webfactional.com/filesearch/content/Water%20Quality%20Division/Programs/Groundwater/Sub
injection facilities are permitted as class 5C5 facilities, where the injection of the produced water is into a receiving aquifer containing water of the same or a lower class of use. General 5C5 permits have been issued by the WDEQ for Campbell, Johnson and Sheridan Counties. General permits require application to the WDEQ for coverage. Individual permits are tailored to the specific facilities that cannot meet the general permits. All class 5C5 CSG facilities require metering of water injected into each well and monitoring of the quality of the injectate and include an express condition that the permit is not a property right. Operators report information quarterly, which is uploaded into the WDEQ Gem database (which also includes all administrative decisions and actions).

Public notification of all individual class V permit applications (but not for facilities covered by general permits) is required, including notices in the newspapers in general circulation. Where the facility intends to be covered by a general permit, the operator must notify the relevant surface owners, mineral owners, water rights owners, oil and gas owners and the owners of the coal leases within half a mile of the point of injection. If there is a significant degree of public interest in a draft permit, a public hearing can be held by WDEQ. The permits last for 10 years and at the end of that period the operator must make a new application.

Unfortunately, during the peak CSG production years, the WDEQ only had power to require financial assurance or bonding for class I wells and not class V injection wells. But in March 2018, Senate File 0016 was passed that now requires the WDEQ to promulgate financial assurance requirements for ‘plugging, abandonment, post-closure monitoring, corrective actions and site reclamation’ for both class 1 hazardous waste as well as nonhazardous or class V UIC facilities.

WY Rules and Regulations 020.0011.27 § 21 (2018)
Ibid § 13 (p) (2018). This section also requires the injectate to be metered.
Ibid § 21 (k) (2018) and All Consulting, above n 105.
Ibid § 6(b) (2018).
An AM approach to the operations is not actively applied, even though the permits can be modified at the instigation of either the operator or WDEQ.\textsuperscript{647} The reporting of monitoring data is used by the regulator to enforce permit limits, rather than to reduce uncertainty through learning.

\textbf{(iv) Memorandums of Agreement}

An interagency memorandum of understanding (MOU) between the WOGCC, WDEQ and WSEO helps clarify the overlap of responsibilities between the individual government departments. It states that even though there are overlapping powers of the different government departments to impact water resources:

because protection of the waters of the state is a priority, no construction or action which is not protective of surface and groundwaters of the state shall be authorized by either the Department of Environmental Quality, the Oil and Gas Conservation Commission, or the Office of the State Engineer.\textsuperscript{648}

The MOU includes requirements for the departments to share information on applications and provides opportunities for objections.\textsuperscript{649} In addition, the \textit{Buffalo Resource Management Plan 2015} notes that the US BLM will cooperate with the efforts of the WDEQ to manage groundwater quality.\textsuperscript{650} There was also an historic Powder River Basin Interagency Working Group which was tasked with developing resource-monitoring plans and to measure impacts from oil and gas development and mitigation strategies, to coordinate development and provide a rapid response to surprises.\textsuperscript{651}

\begin{footnotes}

\footnotetext[647]{Most permits include the general term that the WDEQ can modify, suspend or revoke the permit after notice and an opportunity to be heard is given where here has been a violation of the permit, there was misrepresentation of the facts or a failure of the tubing, casing, cement, or confining layers; see also power of WDEQ to modify, revoke, reissue or terminate a permit: WY Rules and Regulations 020.0011.27 § 7(d)(vii) (2018).}

\footnotetext[648]{Wyoming Department of Environmental Quality et al, \textit{Memorandum of Agreement between the Wyoming Department of Environmental Quality, the Wyoming Oil and Gas Conservation Commission and the Wyoming State Engineer’s Office} (5 August 1994), cl 1.}

\footnotetext[649]{There is also a Memorandum of Understanding between the US BLM and the WOGCC for class II UIC permits: US Department of Interior, Bureau of Land Management, et al, \textit{Memorandum of Understanding between the US Department of Interior Bureau of Land Management Wyoming State Office (BLM MOU WY920-94-09-79) and the State of Wyoming, Wyoming Oil and Gas Conservation Commission} (27 September 1994) concerning the day to day oil and gas operations and use of public, State and privately-owned lands for oil and gas production and drilling operations.}

\footnotetext[650]{Buffalo Field Office, \textit{Approved Resource Management Plan}, above n 523, Appendix N.2.3, 592.}


\end{footnotes}
4. Conclusion for regulatory mechanisms

a) Legal mechanisms for aquifer injection of CSG produced water

I can now answer the third research sub-question for the PRB:

What are the legal mechanisms that govern aquifer injection of CSG produced water in the PRB, Wyoming USA?

The Wyoming regulatory framework for aquifer injection of CSG produced water is a traditional ‘command and control’ governance model whereby a polycentric nested framework of multiple regulators, controls the activity through largely static permits. The regulatory agencies have the power to change the permits but do so usually in a reactive way to changing circumstances rather than to reduce uncertainty.

In summary, in the PRB context, a CSG operator will require a federal APD (from the US BLM) if the CSG is federally owned as well as a Wyoming APD (from the WOGCC) for the gas wells which extract the produced water along with the gas. The operator will also have separate permits that relate to the extraction of the CSG produced water and the subsequent recharge. These separate permits are stand-alone permits and do not require the same operator to inject the CSG produced water that extracted it in the first place. The regulatory mechanisms which specifically govern aquifer injection of CSG produced water in the PRB, Wyoming, are:

- For access to the CSG produced water: a water permit (from the WSEO) for the corresponding CSG wells;
- For injection activities involving the CSG produced water: a separate UIC permit from the WDEQ for the injection well(s).

b) Success or not success?

Recall that the measures of sustainability of the regulatory framework adopted in this research are: first, a lack of continued groundwater resource deterioration (which may include augmentation of the groundwater resources); and second, a lack of conflict and trust issues.

In order to determine whether there is success or not, it will be helpful to have distinguished the outcomes relating to the governance of the groundwater system overall, as well as for the separate activities of extraction of CSG produced water and subsequent injection. The governance of one aspect may have been more successful than another. It is also possible that the success or
failure of one aspect may influence the overall outcomes for another aspect. This distinction ought to be kept in mind. Therefore, I have split the question relating to success into three parts:
What does the empirical data suggest about the relative success or ‘not success’, in terms of sustainability, of the governance framework relating to:

a. The overall groundwater system?

b. Extraction of groundwater in the CSG context?

c. Injection of groundwater?

For groundwater governance overall, whether the PRB governance framework has been successful or ‘not successful’ is difficult to say. The preceding discussion of the regulatory framework now becomes helpful in answering this question. The contraction of the industry in the PRB has meant that many pressures did not continue to place a strain on the governance framework. If the CSG industry had continued at the same or a greater rate of development, it is impossible to predict how robust that governance framework would have been. There was no transformation of that regulatory system, but there were changes to how the WSEO exercised its discretion on water permits for CSG wells. The WSEO did require operators to explain excessive water production and did cancel permits for CSG wells following changes of policy.652

The physical status of the resource has recovered, to some extent, since the severe contraction of the CSG industry in Wyoming following 2011.653 Of note, studies have concluded that other groundwater users were unlikely to have impacted groundwater levels.654 Also, recharging groundwater was adopted from early on through the UIC program, through both aquifer injection as well as infiltration methods. At the height of CSG produced water production, 4.3 GL (out of 145.6 GL) of CSG produced water were recharged via injection wells in one year.655 Total quantum injected overall to date is not reported by the WDEQ, but it was an activity that was undertaken from the start of development in the early 2000s (for at least a decade prior to cessation of CSG extractive activities). As already mentioned in chapter 1, analysis of a large sample of permits656 and qualitative data from the WDEQ, suggests that there were few examples of negative environmental impacts to the resident water quality through injection activities.657 These are all positive indications that the framework was effective to some degree.

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652 State Engineer’s Office, above n 600, 33.
654 Ibid.
655 Steinhorst, Fischer and Williams, above n 103, 4 and fig 1, 25; and see chapter 1 section 1(b), above p 14.
656 Noted in Appendix 10.
657 Specific examples are discussed in chapter 4.
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There were undoubtedly conflicts during the peak production years, which can be seen through the litigation, the NEPA process generally, and historic media reports. There is now recent research which has found that some landholders were satisfied with the overall framework governing CSG extraction in Wyoming in retrospect. The conflicts have not persisted, and they related to the extraction of water in the first place and subsequent land-based impacts, rather than for the injection process. From the interviews conducted in 2017 as part of this research, there did not appear to be a lack of trust in the regulators: in four of the five interviews where participants were directly asked, participants reflected positively in terms of the overall trust in the regulatory agencies.

Conflict of itself is not necessarily a bad thing: it can be transformative and is necessary for learning. Without further targeted research involving a large sample of landholders and other stakeholders, it is uncertain as to whether any lack of trust between stakeholders during that time reflected a framework that facilitated ‘unsustainable’ development.

I have come to the tentative conclusion that the governance framework for (all activities that impact) the groundwater system was relatively successful. This finding is admittedly contestable, though it is based on the following findings: the groundwater resource suffered drawdown but has shown rapid recovery in some areas, which indicates a degree of hydrogeological resilience; the allocation framework relating to non-CSG users does not appear to be over allocated (except for the ‘Control Areas’ outside of the PRB); the WSEO did in fact change decision-making during periods of conflict; the many recharge wells that successfully reinjected CSG produced water; and a lack of residual or enduring trust issues. It must be acknowledged that as CSG development contracted rather than continued at the same rate, this finding has a lower degree of confidence.

For the governance of CSG produced water extraction, again, it is not possible to categorically say whether the governance arrangements in the first place were successful or not.

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659 Bills Walsh and Haggerty, above n 152.
660 Participant W3, a representative of a peak organisation representing landholders and ranchers, stated that he was not aware of any conflicts about aquifer reinjection of treated CSG produced water, certainly none that led to litigation: Interview with Participant W3 (Casper, Wyoming, 11 August 2017).
661 Interview with Participant W3 (Casper, Wyoming, 11 August 2017); Interview with Participant W4 (Casper, Wyoming, 11 August 2017); Interview with Participants W5 and W6 (Sheridan, Wyoming, 14 August 2017); Interview with Participants W19 and W20 (Buffalo Wyoming, 22 August 2017); but note that Participant W7 felt that there was a degree of lack of trust with respect to the WSEO although the same participant felt that landholders had an ability to influence the rules: Interview with Participant W7 (Sheridan, Wyoming, 15 August 2017). I did not ask the representatives of the main regulators, the WSEO or the WDEQ, this question about themselves.
662 Lee, above n 204.
successful given the ambiguous impacts to water resources over time. Nevertheless, the absence of residual trust issues and the fact that the WSEO did adjust decision-making suggests that the framework was relatively successful with a medium level of confidence.

For the governance of injection, which continues, it is possible to conclude, with a higher level of confidence, that the governance framework was successful. The process positively contributed to groundwater resources, and there is no evidence that the process involved conflicts between stakeholders or has had detrimental environmental effects. Arguably, the issue relating to the lack of bonding was a post-operative issue, rather than an issue relating to the governance of actual injection.

The findings relating to the success of the governance framework relating to each aspect are presented in Table 5, below:
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<table>
<thead>
<tr>
<th>Aspect of governance</th>
<th>Success or not-success?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater governance overall</td>
<td>Not possible to decisively conclude either way due to truncated operations. There are indications that the framework was relatively successful, mainly due to an absence of residual trust issues and the changes in decision-making that occurred in response to earlier conflicts.</td>
</tr>
<tr>
<td>Governance of extraction of CSG produced water (and groundwater generally)</td>
<td>Not possible to decisively conclude either way due to truncated operations. There are indications that the framework was relatively successful, due to an absence of residual trust issues and the changes in decision-making that occurred in response to earlier conflicts.</td>
</tr>
<tr>
<td>Governance of injection process</td>
<td>Successful due to the ready adoption of the process by many operators, the quantum injected over many years, and the lack of conflict or negative environmental impacts.</td>
</tr>
</tbody>
</table>

*Table 5. Summary table of success/not-success for governance of groundwater, extraction of groundwater and subsequent injection in PRB*

Having made conclusions about the success of the governance framework in the PRB, I must next consider the framework in terms of the AIA design principles. This enables me to determine whether there is a correlation between the findings of relative success (groundwater governance and extraction of CSG produced water) and success (injection), and the governance features present. That is the subject of the following chapter.
CHAPTER 4: WYOMING FRAMEWORK
MEASUREMENT AGAINST THE AIA DESIGN PRINCIPLES

This chapter addresses the fifth and sixth research sub-questions, which require the measurement of the PRB governance arrangements against the AIA design principles and then correlating these results against the finding of relative success and success from Chapter 3.

I have attributed a grading (green/amber/red) to each aspect of the 21 design principles formulated in Chapter 2, based on the data collected for the PRB. Green is attributed where most of the design principle is present in the governance arrangements. Amber is attributed when there are aspects of the design principle present. Red is attributed where the design principle is largely absent. It is relatively straightforward to undertake this analysis where the design principle is either largely present (green) or absent (red). It is acknowledged that where the design principle is partially present/absent, and thus earning an amber grading, this finding may be debateable. A summary of the findings is presented cumulatively in a table as well as with a corresponding heat map, at the end of the chapter.

Each (sub) design principle is discussed below. Some of the design principles are further described to provide clarification of the theoretical underpinnings and then the gradings are attributed and the reasons for that grading are explained. The discussion, table and heat map reveal that some of the theoretically ideal design principles for groundwater and aquifer injection of CSG produced water are present in the PRB. There are also several contexts where the relevant design principles are missing. Nonetheless, the chapter demonstrates that there appears to be a correlation between the general presence of the AIA design principles and the relevant findings of relative success and success for the PRB governance framework.
1. **Clearly defined boundaries**

Scholars have divided this design principle into two aspects: the rules relating to the social boundaries with respect to the resource, and the biophysical boundaries of the resource itself.\(^{663}\) This design principle ensures that resource users are clearly identifiable, so that those entitled to access are identifiable and that sanctions can be meted out if rules are broken. It is also essential for determining the scope of the physical resource. The design principle is important as it limits the potential for free-riders.

   a) **Clarity around the social boundaries relating to the resource:**

   (i) **Identity of resource users**

   The identity of the water users in the PRB is clear. Hence this sub-design principle is graded green. All water users are required to have a water permit.

   The WSEo website through the e-Permits portal\(^{664}\) has search mechanisms as well as a map which indicates the location of water permits and a link to the relevant documents: the water permits, the historic application, notices and any relevant correspondence. All water permits are also listed in terms of seniority on the WSEo website. Due to the influence of the prior appropriation rule, water rights have always depended on seniority vis-à-vis the other water users. Therefore, transparency in terms of who owns water rights and where they are located has been a hallmark of the Wyoming water sharing system. Yet the extraction data for these water users is not readily available because most groundwater use is unmetered. Nevertheless, where there are conflicts due to over-extraction, there are avenues to address this through the well interference provisions (these are discussed below relating to the conflict resolution mechanisms).\(^{665}\) Therefore, these other aspects of the framework compensate, to some extent, the lack of extraction data.

   In terms of CSG produced water extraction, water permits are tied to specific gas wells and the WSEo and WOGCC require extraction details for water as well as gas from each well, and this information is published on the WOGCC website.

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\(^{663}\) Ostrom, *Governing the Commons*, above n 145, ch 3; Ostrom, Design Principles in Long-Enduring Irrigation Institutions, above n 378; Wilson, Ostrom and Cox, above n 372; Cox, Arnold and Villamayor Tomas, above n 377; Baggio et al, above n 214.


\(^{665}\) WS § 41-3-911 (2018), see this chapter (4), section 6(i) below at p 136.
Similarly, the identity of the operators who have used recharge are clear. All UIC permits both past and present are available through the WDEQ website. Correspondence, notices and monitoring reports are all freely available.

(ii) Clarity of the administrative boundaries to access groundwater

This aspect has been shaded green: the rules for accessing groundwater resources in the PRB are very clear and apply equally to all water users.

Participant W3, a representative of pastoralists, stated that the allocation rules were well understood by all, remarking:

Water law in Wyoming is sacred. If there’s any law that you don’t dare change, it’s the water law … Most people in Wyoming are very proud of it and are dedicated to it.666

Similarly, W4, a representative of the CSG industry, explained:

Water law in Wyoming was settled even before it became a State in the late 1800s. These rules were based on the first come, first in priority rule. Everyone knows what they are and there’s no way they are going to change.667

Nevertheless, the rules have not been static. As mentioned in Chapter 3, as CSG development progressed and the impacts on water resources became apparent, the WSEO did impose additional conditions to address these concerns, such as the required water to gas ratio and even required some wells to be shut-in.668

The water permit granted by the WSEO for access to the water during CSG extraction is a clear entitlement which sets out volumetric limits for the quantum of water permitted per calendar year. Separate permits are required for each gas well. The same procedure applies equally to CSG operators as all other groundwater users (and mirror those for surface water users), including for stock and domestic use. One distinction for CSG water wells is that they are not adjudicated, but nor are domestic and stock wells, and CSG wells have additional standard conditions in terms of monitoring and reporting. Standard conditions attaching to CSG water wells include measuring and reporting requirements for water extraction annually and water levels in nearby water wells (agreed by the WSEO) semi-annually (unlike most non-CSG bores).669 Another distinction is the rate at which CSG water wells are permitted to flow. While stock and domestic wells are permitted at a maximum

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666 Interview with Participant W3 (Casper, Wyoming, 11 August 2017).
668 See chapter 3, section 3(b)(ii), (above n 600), above p 103.
669 Standard conditions 2 and 5; for example, see permits for P178555.0 (LX CS Bar Federal#8) and P178705.0 (LX CS Bar Federal#2) for EOG Y Resources.
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rate of extraction of 25 gallons per minute, many CSG water wells extract at 200 gallons per minute. Nonetheless, despite the differences, a unified and generally transparent procedure applies to CSG water extraction and non-CSG water use alike.

The AM approach adopted by the US BLM does not appear to impact the certainty around these entitlements where they occur with respect to federal land or minerals. Recall that the water permit is for the gas well, which also requires an APD from the US BLM. As mentioned in Chapter 2, the US BLM is required to apply an AM approach but it does so by applying AM at the higher regional NEPA assessment stage rather than at the operational levels. Therefore, the hallmark of an AM process, the potential for change or adaptation, does not impact the projects at an operational level from the federal perspective, and certainly not for the US APD. This is partly due to the ‘tiering’ of the environmental assessments. Participant representatives of the US BLM explained:

The [W]DEQ would from time to time change the requirements for surface water quality but not with respect to individual UIC permits. The BLM adopts the adaptive management approach in the NEPA process. As the predicted impacts of the 2003 EIS never eventuated, the NEPA process was not revisited. An EA is conducted for each project, but adaptive management is only ever applied in a forward looking way, rather than changing permits already issued. ...Once a permit is issued, then it is usually left as is.

(iii) Clarity of the administrative boundaries for aquifer injection

The mechanism controlling injection, the UIC permit, is a stand-alone entitlement and therefore this aspect of the recommendations is also graded green. Permits rarely change over time.

The individually tailored permits for specific injection well facilities, like the Salt Creek Midwest facility are separate entitlements. They are readily available on the WDEQ’s website along with relevant application materials and any correspondence. Similarly, application of the general permits issued by the WDEQ for Campbell, Johnson and Sheridan Counties are also clear and transparent, as operators must apply for permit coverage for each injection facility. The WDEQ website also has copies of the application documents and the approvals for coverage. Just like with the CSG extraction wells, some of the UIC wells were converted to water wells for the landowner

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670 For example, P178705 (LX CS Bar Federal#2).
672 Interview with Participants W19–20 (Buffalo Wyoming, 22 August 2017).
673 The reporting of monitoring data is used by the WDEQ to ensure permits are complied with rather than to adaptively management an injection project (for examples of this process see this chapter (4) section 5(ii) below at p 133–135).
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after operations ceased. This was possible because they are stand-alone permits. For example, 6 of the Nance injection wells, operated by JM Huber Corporation, were turned over to the landowner in 2011. 675

Furthermore, the UIC permit is an entitlement, rather than an obligation or condition of development. 676 Depending on the water quality characteristics, geography, hydrogeology and surface demands for the water, operators can choose from injection or surface disposal by way of impoundments or discharge to waterways. It was conceded by the group of Participants representing the WDEQ that the advantages of the UIC program included the ability to have general permits and the option for operators to use class V permits, 677 when it was appropriate. 678 The administrative ease of the general permit was considered to be an incentive for industry. 679 Participants W19 and W20, representatives of the US BLM, considered that what operators had with the Wyoming framework, which provided for various different water disposal entitlements, was ‘options’. 680

The entitlement to inject in Wyoming is independent of the entitlement to the source water: the operator extracting the water and supplying the source water for injection can be different from the UIC operator. For example, Participant W4 explained that the historic facility at Gillette ‘was an example of the use of a large reverse osmosis plant to which several companies supplied CBM [CSG produced] water.’ 681 The project was considered to be successful; the companies treated the water and the local county injected into the formation that supplied the town. 682 As CSG development moved away from the facilities, and it extended and moved across the basin, 683 this became a problem for the plant. 684

675 Letter from Huber Energy to the WDEQ, 24 January 2011, regarding UIC permit for the Nance well UIC 5C5-1 WYS-005-249 available in the WDEQ GEM database: Wyoming Department of Environmental Quality, Login (GEM) <http://deq.wyoming.gov/wqd/underground-injection-control/resources/gem-login/).
676 This is different to the position in Queensland, as discussed below in chapter 6, section 1(a)(iii), p 189.
677 See chapter 3, section 3(b)(iii), above at p 106.
678 The ability to inject like for like water quality into available aquifers was present, see: Interview with Participants W8–18 (Sheridan, Wyoming, 16 August 2017).
679 Interview with Participant W7 (Sheridan, Wyoming, 15 August 2017).
680 Interview with Participants W19 and W20 (Buffalo Sheridan, Wyoming, 22 August 2017); the participants went on to say that ‘the US BLM does not direct any one option.’
682 Ibid.
683 CSG development commenced in the eastern margins of the basin and proceeded westward and south: Interview with Participant W4 (Casper, Wyoming, 11 August 2017).
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The UIC program, which governs many different types of aquifer injection with a wide variety of source waters, also provides a uniform assessment procedure. Wyoming regulations adopted the federal requirements, as well as State-based requirements, in the WDEQ Rules and Regulations, Chapter 27. The federal program has been in place since the 1980s and the class V UIC framework was reviewed extensively by the US EPA in 1999, but not for the more recent CSG activities. This framework provides operators, the regulator and the public with certainty and transparency around the recharge activities.

b) The physical boundaries of the resource

This aspect of the design principle is shaded amber because, while the boundaries of the resource are becoming clearer since the advent of CSG extraction, as a large groundwater system, it is difficult to conclude definitively that the boundaries (and behaviours) of the resource are known. In addition, most users do not report extraction, and this also impacts on the knowledge of the resource. The sub-design principle is not entirely present (green) nor is it absolutely absent (red); it is somewhere in between.

As mentioned, while the quantum of water extracted by CSG operators is easily obtained, the quantum extracted by non-CSG users is more difficult to obtain because most users do not require metering and reporting. There are no publicly available documents that regularly report the actual extraction by non-CSG users. As mentioned above, while permitted extraction in 2015 totalled 5,021 million gallons per day (19 GL per day), only 541 million gallons per day (2 GL per day) was estimated to have been extracted. This reveals that there is significant uncertainty as to the actual water extracted.

Nonetheless, the physical boundaries of the resource are becoming clearer through the extensive work of the US and Wyoming State Geological Surveys. CSG development provided the opportunity for increased knowledge of the stratigraphy of the Fort Union and Wasatch Formations as the data from CSG bore drilling and production became available. Numerous reports and conceptual models have now been published by the US and Wyoming State Geological Surveys

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687 It is unknown how water users consider these arrangements; however, it could be assumed that there is a degree of acceptance and comfort in non-metering because the new arrangements for the Area of Control in Laramie County, which do include metering, have been fought by some members of the Advisory Board: Interview with Participant W1 and W2 (Cheyenne Wyoming, 10 August 2017).
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providing information about the resource. The Wyoming State Geological Survey also has a publicly available interactive groundwater atlas on its website.

2. Congruence between appropriation and provision rules and local conditions, including benefits and costs

This overall design principle is essential for ensuring that rules are considered to be fair by resource users. Relating user impacts to the benefits they obtain is a crucial element in establishing a fair system. Scholars have divided this design principle into first, congruence between the rules and local conditions; and second, congruence between costs and benefits.

a) Congruence of rules and local conditions

(i) Appropriation rules reflect local conditions for water extraction

This aspect of the design principle is shaded green. Admittedly, the same rules for water extraction generally apply across the PRB and there is no separate automatic catchment or basin planning. Yet the required separate application process for water permits and adjudication (where it occurs) ensures that local conditions are considered. Despite the fact that CSG wells are typically not adjudicated, discretion appears to be applied by the WSEO in the application process. Participants W1 and W2, representatives of the WSEO, confirmed that a common-sense approach is


694 Ostrom, Understanding Institutional Diversity, above n 382, ch 3; Ostrom, Design Principles in Long-Enduring Irrigation Institutions, above n 378; Wilson, Ostrom and Cox, above n 372; Cox, Arnold and Villamayor Tomas, above n 377; Baggio et al, above n 214.

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applied to what is reasonable in terms of the particular well. W1 and W2 explained that applications for water permits will be questioned if they seem at odds with the reasonable requirements of the local setting. As already mentioned, CSG operators are conditioned to measure and report water levels in nearby wells. This means that there is integration between the extraction of water by the CSG industry and other water users. There is also conjunctive management: the priority of users is listed in a single schedule of priorities for the entire common water supply (for surface and groundwater).

(ii) Rules for injection reflect local conditions

Each UIC permit application addresses local conditions specific to the target formation and, therefore, this criterion is shaded green.

UIC permits are tailored to meet the specific risks associated with the project. Most injection wells associated with CSG activities in the PRB were (are) fairly simple (see Figure 13, below, which shows a typical UIC well facility). This was because they often involved minimal water treatment before injection because the produced water was in a similar range of quality to the resident target formation. If the classification of the resident water in the target formation is not negatively impacted, the activities are authorised. This means that the authorised activities are dependent on the properties of the CSG produced water, as well as the properties of the local target formation. Expensive remediation efforts to create top-quality produced water are unnecessary where the target formation matches the existing CSG produced water quality. Participants W19 and W20 considered that it was an advantage to have the classifications for the different aquifers, so that CSG produced water of a like quality to a certain aquifer could be reinjected with minimal treatment.

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696 Interview with Participants W1 and W2 (Cheyenne, Wyoming, 10 August 2017).
697 Ibid.
698 See chapter 3, section 3(b)(ii).
699 WS § 41-3-916.
700 For example, a class III aquifer must not be degraded so that it becomes a class IV formation.
701 Interview with Participants W19 and W20 (Buffalo, Wyoming, 22 August 2017).
The importance of developing rules that are appropriate for local conditions was highlighted by Participants W5 and W6, representatives of industry. Participant W6 explained:

In respect of the different treatment options to the water, ... [we] really don’t have to treat the water very much now ... [We] have used all the treatment technologies: reverse osmosis, ion exchange with the Higgins Loop, ... subsurface irrigation. With the ... [subsurface] irrigation, this allowed for alfalfa and hay to be grown. ... the water did have to be treated (with acid) to prevent the pipes and emitting points from clogging. At the start, ... [we] had to treat all the water and the regulators required full containment of the water. When ... [we] treated it, it was then too pure for the environment and had to be mixed with the CBM water to get a balance. ... these extra requirements meant that many wells became non-viable and sent many companies under. Now ... [we] can send it down rivers with very little treatment and use it for agriculture. ... often the only treatment now will be the use of gypsum to remove the sodium to reduce the SAR levels. The gypsum can be dumped in the drainage path and when the water flows through it, the SAR is reduced. ... [We] used to use zeolite rocks from Utah but these were more expensive so [we] converted to gypsum. ... [We] will also use rocks and these will reduce the iron loading of the water. ... The largest expense in the production of the gas is the cost of the water treatment and the early requirements put many companies under when the gas prices fell.\(^{703}\)

b) Congruence between costs and benefits

(i) Appropriators pay for the proportion and impact of water extracted

\(^{702}\) Sourced from the WDEQ GEM database available through: Wyoming Department of Environmental Quality, Login (GEM) <http://deq.wyoming.gov/wqd/underground-injection-control/resources/gem-login/>.

\(^{703}\) Interview with Participants W5 and W6 (Sheridan, Wyoming, 14 August 2017).
Aquifer injection in the coal seam gas context: Part B: Chapter 4: Wyoming’s measurement against the design principles on the local environment. No other charges are levied against groundwater users. Therefore, the people of Wyoming generally fund the governance of the resource through the WSEO (and the WDEQ for water quality).

(ii) Economic benefit/costs of injection for those who undertake injection

This design principle has been shaded red, because economic studies measuring the relative costs of water disposal methods have revealed that shallow reinjection of CSG produced water comes at an overall cost for the operators, while benefits to groundwater resources are enjoyed generally by the people of Wyoming.

In 2006, the US Department of Energy reported on the economics of the PRB CSG development, focussing on the various water disposal alternatives. The costs of surface discharge, infiltration impoundments, shallow reinjection, reverse osmosis and ion exchange were compared. Surface disposal and impoundments of untreated CSG produced water were found to be the cheapest strategies. The study generally quantified shallow injection of untreated CSG produced water as less costly than reverse osmosis, with surface release of treated water and trucking brine and salts to disposal sites; or ion exchange treatment, with surface disposal of treated water and deep injection of wastes. Therefore, an important issue relates to the required level (and associated cost) of water treatment. There are costs associated with the treatment, the injection (obviously) but also with respect to the disposal of the residual brine that is a result of treatment processes.

Participant experiences support this research finding. Industry interview participants preferred disposing untreated CSG produced water into the river, followed by placing the untreated CSG produced water in unlined pits for infiltration, then in lined reservoirs for storage pending.

704 The fee for domestic and stock wells and CSG wells is the same: US$50. The fee for irrigation, municipal, industrial and miscellaneous users is US$75.00, and admittedly, they are also large extraction, see: Wyoming State Engineer, General Agency, Board or Commission Rules, Chapter 1: Fees, <https://2ce3bd20-a-84cef9ff-sites.googlegroups.com/a/wyo.gov/seo-files/Emergency_Rules_Chapter_1_Fees.pdf?attachauth=ANoY7cqOdMT1kJsGhScZK0DVm3B_c3j30KDiDBpHlSsMfjyqdiHh8egOhHyNikdpTmtpRmvVwa5LBO3Ra_SUTKVCiA-1keY94tk3q-jfj88etC-3ShjkszPunwzLjQWaOcvC-LOhVFQh5sVEnluroo4XSvQhssinOKHYu9Nq8ls9kNQds5iV_M2o8UUN3-QNSLakNTWlsZE5GqvAOZu7ykU85gw-nCkOEpyQ5ADO0JlAjbGkpl3D&attredirects=0>.

705 Bank and Kuuska, above n 83.

706 Ion exchange is ‘a reversible chemical reaction between a solid and a solution by means of which ions of similar charge may be exchanged between the two’. Reverse osmosis is ‘a method for the desalination of water, which involves passing the saline water through a permeable membrane (film) under pressure. Relatively pure water passes through the membrane, leaving much of the dissolved salt behind.’ see: Chris Park and Michael Allaby, A Dictionary of Environment and Conservation (Oxford University Press, third edition, 2017).

707 Shallow reinjection had generally lower capital costs and lower costs of operation and maintenance: Bank and Kuuska, above n 83, C-2.
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discharge to the river or used for agriculture, then finally (considered to be the worst option) class V UIC injection.\textsuperscript{708} Participants explained that neither the class V UIC method, direct injection nor subsurface irrigation was ideal where some treatment was necessary to prevent clogging of the injection bores or aquifer.\textsuperscript{709} A representative of landowners explained that “industry didn’t want it [UIC] because it was more expensive than simply dumping the water.”\textsuperscript{710} A representative of the US BLM explained:

Injection evolved out of the situation where the other alternatives for disposal were not available. For example, if the water quality was not appropriate for disposal into the Powder River (because it would affect downstream landowners), and if there was no room for another reservoir, operators would move to injection. Basically, on a cost–benefit analysis, injection was used when it made sense. Reservoirs could be expensive and they required reclamation bonds to be paid, which were not insignificant.\textsuperscript{711}

After the contraction of the industry, the US EPA conducted a further economic study of the CSG industry in the USA in 2013.\textsuperscript{712} This study concluded that a large number of CSG projects were no longer economically viable due to the declining natural gas prices, regardless of the water treatment options applied.\textsuperscript{713} Considering CSG produced water disposal costs, the study also found that underground injection was more expensive for operators than ion exchange.\textsuperscript{714} The US EPA concluded that it would not move forward with additional regulation of wastewater discharges from CSG projects, presumably because the contraction of the industry had resulted in a reduced appetite (and need) to address water issues and heightened regulation would further cripple the already ailing industry.\textsuperscript{715}

An industry participant explained that, even though the class V injection wells were successful at the height of CSG operations in Wyoming, they were not financially viable.\textsuperscript{716} He stated that the Salt Creek Midwest facility ‘is still in operation because it services a whole field of wells where there are no landowner agreements for surface disposal’.\textsuperscript{717}

\begin{thebibliography}{99}
\bibitem{708} Either through wells or using subsurface drip irrigation, see: Interview with Participants W5 and W6 (Sheridan, Wyoming, 14 August 2017).
\bibitem{709} Interview with Participants W5 and W6 (Sheridan, Wyoming, 14 August 2017).
\bibitem{710} Interview with Participant W7 (Sheridan, Wyoming, 15 August 2017).
\bibitem{711} Interview with Participants W19 and W20 (Buffalo, Wyoming, 22 August 2017).
\bibitem{713} Ibid, 35.
\bibitem{714} Ibid, 35.
\bibitem{715} Ibid.
\bibitem{716} Interview with Participants W5 and W6 (Sheridan, Wyoming, 14 August 2017).
\bibitem{717} Ibid.
\end{thebibliography}
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3. **Collective choice arrangements**

   The third design principle posits that, where most of the individuals affected by regulation have an opportunity to tailor and modify the rules, this results in rules that match local conditions, and that are more likely to be considered fair.\(^\text{718}\) The design principle also enables the rules to be changed in response to water users discovering new information about the resource or how the rules operate in practice. It allows for rules to adapt, when resource users perceive new opportunities or threats.\(^\text{719}\) This may increase decision-making costs but, ultimately, it will reduce agency costs,\(^\text{720}\) because the rules are considered legitimate by the users.\(^\text{721}\)

   (i) **Collective choice arrangements relating to extraction**

   This aspect of the design principle is shaded amber because there appears to be mainly indirect avenues for stakeholders to influence rulemaking for water permits. The third design principle posits that, where most of the individuals affected by regulation have an opportunity to tailor and modify the rules, this results in rules that match local conditions, and that are more likely to be considered fair.\(^\text{718}\) The design principle also enables the rules to be changed in response to water users discovering new information about the resource or how the rules operate in practice. It allows for rules to adapt, when resource users perceive new opportunities or threats.\(^\text{719}\) This may increase decision-making costs but, ultimately, it will reduce agency costs,\(^\text{720}\) because the rules are considered legitimate by the users.\(^\text{721}\)

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\(^\text{718}\) Ostrom, *Understanding Institutional Diversity*, above n 382, 263. Where appropriators themselves have defined the ‘rules’ relating to the resource, rather than having them imposed by an external agency, the internal legitimacy of the rules among the appropriators is enhanced, see: Christopher E Morrow and Rebecca Watts Hull, ‘Donor-Initiated Common Pool Resource Institutions: The Case of the Yanesh Forest Cooperative’ (1996) 24(10) *World Development* 1641; Dietz, Ostrom and Stern, above n 288; Ostrom, *Understanding Institutional Diversity*, above n 382, 262.

\(^\text{719}\) Ostrom, Commons, above n 692, 4–5.


\(^\text{721}\) State Engineer’s Office, ‘Guidance: CBM/Ground Water Permits’ (March 2004) <https://2ce3bd20-a-84cef9ff-s-sites.googlegroups.com/a/wyo.gov/seo/seo-files/CBM%20Guidance%2004.pdf?attredirects=ANoY77cOLZ-J0NhgrPrhtsf2kOi8nxXAXPUOYVRkkOwhfwrlcEZrXgf1n1S58fiVCLsDOvAhFcmeLPhwzf2julRpxED9S_73R2aKnyRuiAe79A7uijUwRof1FmzjMpo7kplw3Y08g1YYOtzznJaUWCLNJvih-kv8SZC39p9y2UPlm14cqlr89sUsa0Tr1P_NpNDfN-FMliu3Dub0g4mSgma4Yam-Ptw%3D%3D&attredirects=0>.

\(^\text{722}\) MacKinnon and Fox, above n 118, 384.
Aquifer injection in the coal seam gas context: Part B: Chapter 4: Wyoming’s measurement against the design principles reporting and the cancelling of certain CSG water well permits, concurrently with the litigation.\textsuperscript{724} This points to some influence by landholders on rule-making.

There also appears to be the ability for landholders to influence how CSG development occurs in other indirect ways. The landholder will be part of the well placement discussions as part of the site inspection for the APD.\textsuperscript{725} Recent research has highlighted that there is indirect private participation by landowners in how energy project development enfolds through contractual land leasing negotiations and the negotiation of surface use and damage agreements.\textsuperscript{726} As part of this research, many participants considered that they had some ability to influence the rules, albeit in informal ways.\textsuperscript{727}

The relative inability of stakeholders to directly participate in decision-making for CSG water permitting can be contrasted with other types of water wells. Other wells (not including stock and domestic wells) require adjudication by the Board of Control. Adjudication includes advertising the application and can be contested.\textsuperscript{728} In addition, where the WSEO declares an area to be a Control Area, water users may themselves agree to any method or scheme of control of withdrawals, well spacing, apportionment, rotation or proration of the common supply of underground water.\textsuperscript{729} This second example of public participation involves a partnership in decision-making, as opposed to the mere tokenism that occurs, for example, in the lower levels of participation enumerated by Arnstein.\textsuperscript{730} Where wells are contested, or where a ‘Control Area’ is designated, there are opportunities for the public and other stakeholders to have an input in decision-making, which enables collective choice arrangements.

\textbf{(ii) Collective choice arrangements relating to injection (UIC permit)}

\textbullet{} This sub-criterion is also shaded amber to reflect the presence of informal avenues to influence rule-making. While there are no express collective choice arrangements for UIC permit regulation (the rules for the UIC program are set by the US EPA and WDEQ), there is some indication

\textsuperscript{724} Ranchers complained about the lack of notice given to landholders prior to water permits being issued, among other things: \textit{William F Ranch, LLC v Tyrrell} 206 P 3d 722 (Wyo, 2009).


\textsuperscript{727} Interview with Participants W1 and W2 (Cheyenne, Wyoming, 10 August 2017); Interview with Participant W3 (Casper, Wyoming, 11 August 2017); Interview with Participant W4 (Casper, Wyoming 11 August 2017); Interview with Participants W5 and W6 (Sheridan, Wyoming, 14 August 2017); Interview with Participant W7 (Sheridan, Wyoming, 15 August 2017).

\textsuperscript{728} WS § 41-4-312-315 and 41-4-511.

\textsuperscript{729} WS § 41-3-915(c).

\textsuperscript{730} Arnstein, above n 291.
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from participants that there are informal networks that provide for some influence of the rules in this context.

There is an opportunity for relevant stakeholders to make submissions on class V UIC permits during the public notice period, and there is the opportunity for a public hearing for such applications. However, the WDEQ is the ultimate decision-maker and rule promulgator. Therefore, this type of participation is consultation, rather than the higher levels of participation as enumerated by Arnstein (such as partnership).

Yet, Participants W5 and W6, representatives of industry, argued that industry had had a seat at the table for the general development of some of the rules in place. They explained:

At the start, rules were put forward by the regulators, which were generally at the time seen as being the most environmentally sensible but they really didn’t have the expertise to determine whether they were appropriate. Industry was able to come in and educate the regulators and the rules changed over time. PAW [Petroleum Association of Wyoming] is on the task force and has a say on all new regulation. It ... [allows] all its members to comment.

Despite the obvious influence of industry, Participant W7, a representative of landowners, agreed that there was also some ability for stakeholders to influence the rules. Participant W4, a representative of industry, further explained that the relevant task force included operators, landowners, environmentalists and government representatives. Debate would occur over long periods, the parties coming together to discuss and negotiate relevant limits. As described by the participants, this process is suggestive of a degree of partnership in certain decision-making with state oversight, rather than mere placation, consultation or informing. W4 reflected:

For months on end, the taskforce discussed and negotiated these limits. It took a lot of time but in the end, the limits were set with everyone’s input. Environmentalists didn’t agree with the outcome and tried to sue the [W]DEQ, but their action failed. After all, ... they had been part of the process. ... even though it took time and was painful, it was a good strategy. It meant that when the representatives weren’t yelling at each other, ... [we] did gain an understanding of each other’s perspective. Sometimes, ... [we] were actually able to come to an agreement for some things. The process was not only a means of reaching agreement where that was possible, it was also an exercise in educating

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731 This is also noted in the discussion below relating to DP 8, nested organisational structures, below p 140.
732 Arnstein, above n 291.
733 Interview with Participants W5 and W6 (Sheridan, Wyoming, 14 August 2017).
734 Ibid.
735 Interview with Participant W7 (Sheridan, Wyoming, 15 August 2017).
736 The task force would participate in determining effluent limits for surface disposal of CSG produced water; Interview with Participant W4 (Casper, Wyoming, 11 August 2017).
738 As classified by Arnstein: Arnstein, above n 291, 221.
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other stakeholders. That was helpful. Although, admittedly, where there was a deep philosophical disagreement as to the existence of the industry, in those cases, agreement would never be reached—no negotiations could affect that outcome.739

4. Monitoring

Monitoring is necessary to ensure rules are enforced and to exclude free-riders. This design principle has been divided into two aspects: the monitoring of activities that impact the resource (including the resource itself) and monitoring of the monitors.740

a) Monitoring of activities impacting the resource, and the resource itself:

i) Monitoring of groundwater extraction

This aspect of the design principle is shaded amber because, even though there is extensive transparent monitoring of groundwater extraction by CSG activities, the same cannot be said for other groundwater extraction generally.

As already mentioned, CSG operators who extract CSG produced water must report to the WSE0 annually the total volume of water and CSG extracted from the well during the previous 12-month period, as well as the total cumulative water produced, the annual and cumulative water/gas ratio, and semi-annual groundwater measurements of nearby water wells.741 The water extracted from each well is publicly available on the WOGCC website in connection with the APD. In this way, the cross-reporting between operators and the WSE0 and WOGCC allows for cross-checking and triangulation of data.

Stock and domestic water users generally are not required to report usage and nor are other non-CSG extractors outside of ‘Control Areas’.742 While the licences and associated forms are available on the internet via the Wyoming government’s e-permit website, extraction amounts are not included, except for wells in the ‘Control Areas’. Despite this, the operation of the prior appropriation method of sharing water resources, where priority of users is enforced, the ready

739 Interview with Participant W4 (Casper, Wyoming, 11 August 2017); the role of this type of ‘bounded conflict’ is discussed further in chapter 7, section 2(b), below p 268.
740 Ostrom, Governing the Commons, above n 145, ch 3; Ostrom, Design Principles in Long-Enduring Irrigation Institutions, above n 378; Wilson, Ostrom and Cox, above n 372; Cox, Arnold and Villamayor Tomas, above n 377; Baggio et al, above n 214.
741 That information is not usually uploaded by the WSE0 on the e-permits website – the requirements are found in the standard conditions on the water permit: see chapter 3, section 3(b)(ii), above p 103.
742 See chapter 3, section 3(b)(ii), above p 104, n 616.
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availability of licence information, and the well interference provisions\textsuperscript{743} does provide some comfort in extraction volumes.

(ii) Monitoring of injection

The public availability of the monitoring efforts relating to injection by the WDEQ leads to this aspect of the design principle being attributed a green grading.

UIC permits generally require injection pressures to be continuously monitored to ensure that injection does not exceed the pressure limits in the permits. Monthly injection volumes and the instantaneous pressure rates, as well as the water quality of the injectate, are required to be reported to the WDEQ quarterly and these are publicly available. Class V permits for injection of CSG produced water do not usually require the target formation to be monitored, just the injectate. Representatives of the WDEQ explained that extensive monitoring of the target formation was unnecessary:

in reality, given that the same general quality water is being reinjected into the formation, any unanticipated reactions will be temporary and confined to the zone of injection, and will generally come back to the ambient quality in time. For example, ... if there is some arsenic mobilisation, this is due to the redox reactions, but the ambient water being generally deoxygenated will soon remedy the spike.\textsuperscript{744}

An exception requiring routine monitoring of the target formation occurs where the class V permit involves greater uncertainty, such as where injection is for the purpose of promoting biogenic methane production.\textsuperscript{745}

(iii) Monitoring of the resident groundwater resource

The efforts by the US BLM, WSEO and WDEQ, along with operators, have resulted in extensive monitoring of the groundwater resource. Yet only a small proportion of this data is made

\textsuperscript{743} Through the well interference provisions under WS § 41-3-911 (2018). The water user with the earliest priority has the better right: WS § 41-3-907; these are explained below in this chapter, section 6(i), below p 137.

\textsuperscript{744} Interview with Participants W8–18 (Sheridan, Wyoming, 16 August 2017).

\textsuperscript{745} In 2011, after the decline in CSG production in Wyoming, amendments were made to allow for applications to the WOGCC for an order allowing well and reservoir injections to restore or enhance the microbial conversion of hydrocarbon substrates to methane gas. A class V UIC permit would be required: WS § 30-5-128; see, for example, permits 13-018 and 13-368 for Ciris Energy Incorporated’s Buffalo and Antelope Injection projects, which involve injection of treated CSG produced water that is fortified with various vitamins, minerals and other substances in order to promote biogenic methane production. Both of these permits require the target formation to be monitored and reported, see: UIC permit 13-018 dated 1 May 2014, Condition Hf, 15, and UIC permit 13-268 dated 14 October 2013, Condition Hf, 15.
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available to the public outside of reports and publications. Therefore, this aspect of the criterion is shaded amber.

The US BLM has approximately 60 monitoring wells in the PRB, measuring water levels and water quality and has acknowledged the importance of public access to the data collected in its Water Resource Program Strategy 2015–2020. That data source was but now is no longer freely available on the internet (apart from in the cumulative reports compiled by the WSGS). There is also a series of monitoring wells, all installed by operators, as conditions of their US BLM approvals. These wells collect data on water levels and the data are downloaded by US BLM staff.

There are 112 active groundwater monitoring wells operated by the WSEO throughout Wyoming. Monitoring data from these wells is publicly available on the WSEO’s website. Participant W2, a representative of the WSEO, explained that, in 2016, the WSEO completed extra monitoring wells from which data are now uploaded on the WSEO’s website. Most monitoring wells completed are in heavily used areas. W2 explained that ‘outside these areas, there’s no point because water levels are not changing much.’

Since 2004, the WDEQ has required groundwater monitoring below unlined infiltration impoundments with a view to determining whether the seepage of the CSG produced water was impacting groundwater resources. In 2010, the WDEQ reported on an evaluation of approximately 2,013 impoundments with nearly 2,300 associated water monitoring wells. The report concluded that the water quality of unconfined aquifers below the CSG produced water impoundments was generally stable but some changes in groundwater chemistry were detected in some cases (both negative and positive). Whether this was due to fluctuations in natural recharge or infiltration of CSG produced water was not determined and further research was planned. Despite the data

748 The BLM underwent a website upgrade in 2017 and it is uncertain why that information is no longer included on the new version of the website.
749 Interview with Participants W19 and W20 (Sheridan, Wyoming, 22 August 2017).
750 A proportion of these are in the PRB; State Engineer’s Office, 2017 Annual Report (October 1, 2016 through September 30, 2017) <http://seo.wyo.gov/documents-data/annual-reports-strategic-plans>, 14 and 16.
752 Interview with Participants W1 and W2 (Cheyenne, Wyoming, 10 August 2017).
753 Ibid. The information would likely be available through application to the department.
754 Steinhorst, Fischer and Williams, above n 103, 4.
756 Ibid, 22.
757 Ibid, 22.
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being submitted electronically, it is not generally made available to the public (other than in reports such as the review of data published in 2010).

In summary, Participants W5 and W6, representatives of industry, explained that there are 15,000 wells that have been drilled (mostly by industry) that are providing monitoring data and they are still sampling some wells monthly, bi-monthly, quarterly and annually.\textsuperscript{758} Many of the wells that were regularly checked for groundwater quality and quantity by the regulator and were drilled into multiple layers are now no longer checked as often, and W6 presumed that this was because the department felt it was no longer necessary.\textsuperscript{759} Participant W7, a representative of landholders, also considered that the level of monitoring, particularly of water extraction, is adequate.\textsuperscript{760}

b) Monitors monitored

\begin{itemize}
  \item This sub-design principle has been given an amber rating, because of the lack of availability of the US BLM’s monitoring data and the WDEQ’s impoundment water monitoring, as mentioned above, detracts from the ability to monitor the monitors in Wyoming. Nevertheless, the amber grading also reflects that there is an overall transparency of the WSEOs and the WOGCC data, as well as increased efforts by the WDEQ. The WDEQ is in the process of developing an online data management system that is intended to be accessible by the public.\textsuperscript{761} A significant amount of data is already available through its publicly accessible database.
\end{itemize}

5. Graduated sanctions

This design principle requires the use of ‘graduated sanctions by robust governance arrangements.’\textsuperscript{762} The important aspect of this design principle is that rule-breakers (and free-riders) are discovered and that a punishment is meted out without making first-time breaches a ‘criminal offence’.\textsuperscript{763}

(i) Sanctions relating to extraction

\begin{itemize}
  \item Graduated sanctions exist for non-compliance with water permits, but poor compliance arrangements contribute to this aspect of the criterion being graded red. Participant W7, a representative of landowners, confirmed the lack of compliance activities by describing the WSEO
\end{itemize}

\textsuperscript{758} Interview with Participants W5 and W6 (Sheridan, Wyoming, 14 August 2017).
\textsuperscript{759} Ibid.
\textsuperscript{760} Interview with Participant W7 (Sheridan, Wyoming, 15 August 2017).
\textsuperscript{762} Ostrom, Understanding Institutional Diversity, above n 382, 266.
\textsuperscript{763} Ostrom, Commons, above n 692.
Aquifer injection in the coal seam gas context: Part B: Chapter 4: Wyoming’s measurement against the design principles as a ‘paper tiger’ on sanctions.\textsuperscript{764} Nevertheless, sanctions for non-compliance with water permits or regulations are graduated. Participants W1 and W2 explained:

With respect to sanctions, if someone is in non-compliance, the WSEO must first ‘notice’ them before issuing a formal Order to cease extraction. After that point, if an Order has been issued and the extractor is still in non-compliance, a recommendation is made to the County prosecutor for litigation. Unfortunately, it is only a recommendation, so it is a limited power to prosecute. There is a very poor history of prosecution in the State because the County Prosecutor has other crimes also to deal with. The one case that was prosecuted ultimately settled out of Court with the extractor being required to fund a community center or children’s playground. But the fallout from the prosecution was such that it ruined the company’s initial public listing.\textsuperscript{765}

(ii) Sanctions relating to injection

This sub-design principle has been attributed an amber grading to reflect the practical difficulty of sanctions post-CSG production. The lack of bonding for UIC wells became an issue when CSG production ceased.\textsuperscript{766} This was a significant issue when the industry contracted and operations ceased, but has now been addressed by legislative amendments that were passed March 2018.\textsuperscript{767} Otherwise, a green grading (rather than amber) would have been appropriate because sanctions for UIC violations are clearly graduated and meted out by the WDEQ.

The WDEQ has an Inspection/Compliance Committee that meets monthly to ensure that the department responds appropriately to violations of WQEQ rules and regulations.\textsuperscript{768} A range of actions are implemented by the department from letters of violation to notices of violation and enforcement action, such as permit termination, revocation or modification.\textsuperscript{769} In addition, often the WDEQ officers will remind operators informally of reporting deficiencies before the need for formal notice arises. Any measures undertaken on specific permits (often including these informal reminders) are readily accessible via the WDEQ database.

\textsuperscript{764} Interview with Participant W7 (Sheridan, Wyoming, 15 August 2017).
\textsuperscript{765} Interview with Participants W1 and W2 (Cheyenne, Wyoming, 10 August 2017). ‘Any person who withdraws underground water or who fails to stop or reduce the flow of underground water in violation of any order of the state engineer made pursuant to this act, or any person who does not have a permit, certificate or vested right to appropriate underground water who shall withdraw underground water from any well other than a well for stock or domestic purposes as defined in WS 41-3-907, is guilty of a misdemeanor and upon conviction shall be punished under WS 41-3-916’: WS § 41-3-919 (2018). The misdemeanour is punishable by a fine of not more than US$1,250 and/or imprisonment for 3 months: WS § 41-3-616 (2018).
\textsuperscript{766} Bills, Walsh and Haggerty, above n 152.
\textsuperscript{767} See above n 152.
\textsuperscript{769} WY Rules and Regulations 020.0011.27 § 7 (2018).
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My summary of the review of a large sample of permits is detailed in the text box below. In short, most of the non-compliances with UIC permits involving CSG produced water in the PRB over the peak production years were not issues that could be considered as highly risky for the environment. This is reflected in the very low rates of sanctions issued by the WDEQ during that time, and the relatively standardised approach adopted by the department for the process.

**Summary of analysis of sanctions for non-compliance with UIC permits**

My review of the large sample of UIC permits issued to the leading CSG producers in Wyoming during the peak years, illustrates how sanctions are imposed by the WDEQ. It also highlights the generally low risks to the environment of this process because there were very few instances involving any exceedances that could be considered to have detrimentally affected the groundwater resources. The non-compliances generally related to relatively minor pressure, pH or bacterium exceedances often due to operational issues. Out of a sample of 157 permitted injection facilities (including historic as well as currently authorised wells), involving 272 discreet injection wells over a period of 13 years, only relatively soft administrative sanctions were applied. A total of 57 letters of violation of permit limits were issued by the WDEQ for this sample of permits since 2005; most appeared to have been resolved relatively quickly from my review of documents.

For example, eliminating all bacteria from the injectate was at times difficult for the operators. Standard conditions for UIC permits require the injectate to be completely free of any bacteria. Iron-fixing bacteria and sulfate-reducing bacteria are commonly present in many of the target formations as well as CSG produced water in Wyoming. The presence of the bacteria generally creates operational issues for the injection well, such as fouling.

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770 A spreadsheet summarising this data is included as Appendix 10.
771 Mentioned in chapter 1, since 2005, 528 permits were issued by the WDEQ (for both general and individual permits) and there remains in force 182 permits for aquifer injection projects using CSG produced water in the Powder River Basin. This sample, which is almost one-third of all UIC permits issued since 2005 for injection of CSG produced water, includes all the permits (both current and historic) for the three key operators — Anadarko Petroleum, Yates Petroleum and JM Huber — and the currently authorised facilities for High Plains Gas LLC, which acquired many wells from Marathon Oil, a subsidiary of Pennaco Energy Inc. I reviewed all the correspondence for each of these wells, which is included in the WDEQ’s GEM database, in order to record the level of exceedances and administrative compliance actions. The permits are listed in Appendix 3 and a summary of the review is in Appendix 10.
773 Fouling occurs where a build-up forms on surfaces within the well which impedes its function: Letter from WDEQ to WOGCC, 15 August 2011, regarding UIC permit 09-699 for WYS007-00165 held by Anadarko Petroleum Corporation available in the WDEQ’s GEM database: Wyoming Department of Environmental
To prevent this occurring, sodium hypochlorite is commonly used to disinfect the CSG produced water. Sodium hypochlorite is a strong oxidizer and can mobilise metals in the subsurface if used in large concentrations, so there are limits to the quantities that should be used. Where exceedances of the zero-limit occurred, operators had disinfected the produced water, but minute traces of bacteria remained. For example, exceedances for injection well called Iberlin Injector #13 (WYS-019-00223) had non-compliances in February and May 2009 for having a sulfate-reducing bacteria in the injectate measuring 10 cfu, even though the baseline water quality test of the target formation reported the same quantity of resident bacteria. Another example where an exceedance occurred was due to inappropriate testing methodology; the injectate was tested before the disinfection had time to work. Despite the zero-limit requirement for iron-fixing and sulfate-reducing bacteria in the UIC permits, there are no limits for these in the National Primary Drinking Water Regulations because it is not viewed as a health hazard.

Similarly, some of the violations were incorrectly entered data, such as for injection well (WYS-019-154), where values for arsenic in the injectate were reported in milligrams per litre (mg/l) rather than micrograms per litre (µg/L). At other times, pressure limits for the injection were exceeded only to be followed by permit relaxations after new step rate tests had been submitted.


776 Email from St Mary Land and Exploration Company (the previous owner of the Nance wells), to WDEQ, 14 December 2009, regarding UIC 5CS-1 WYS-005-249 (held by JM Huber) available in the WDEQ GEM database: Wyoming Department of Environmental Quality, Login (GEM) <http://deq.wyoming.gov/wqd/underground-injection-control/resources/gem-login/>.


779 Step rate tests are used to determine the safe injection pressure for an injection well by increasing pressure from low to high, to discover the point at which the formation will fracture: Hoss Belyadi et al, Hydraulic
6. Conflict resolution mechanisms

There will always be the inevitable conflicts because rules can never anticipate all future possibilities and resource users ought to be able to discuss and resolve what is or is not a rule infraction.\(^780\) Scholars argue that low-cost and timely conflict resolution mechanisms allow for the testing of rules in manner that is considered as legitimate by resource users.\(^781\) Conflict resolution mechanisms that exist above the level of the local resource will ensure that a ‘local elite’ has not overly influenced rule-making.\(^782\)

(i) Conflicts over impacts of water extraction

This design principle has been shaded green because conflicts between groundwater users (including with the CSG industry), in retrospect, do not appear to have been overly troublesome in the PRB. The well interference process with the WSEO and conflict resolution under the standard water rights agreements required by the US BLM appear to be generally effective low-cost fora. Moreover, there is an indication that there are informal avenues (involving the media and political influence) that facilitate conflict resolution. These are discussed below.

First, conflicts between water rights holders (not involving CSG activities) are through the adjudication process conducted by the Board of Control of the WSEO, which usually occurs at the time of completion of wells. In my opinion, this is a relatively low-cost forum compared to, for example, other states in the USA where adjudication between water users is often conducted at the first instance through the Courts.

Second, where any water well, including a CSG well, unreasonably interferes with adequate stock and domestic wells,\(^783\) the WSEO has the power to order that well to cease or reduce extraction unless a ‘make good’ supply of water is made available.\(^784\) Recall that the right of a water appropriator does not include the right to have the water level or artesian pressure at the appropriator’s point of diversion maintained at any level or pressure higher than that required for maximum beneficial use of the water in the source of supply.\(^785\) A complaint must be made by the

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\(^{780}\) Ostrom, *Understanding Institutional Diversity*, above n 382, 268.

\(^{781}\) Ostrom, *Commons*, above n 692, 5; Ostrom, *Understanding Institutional Diversity*, above n 382.

\(^{782}\) Ostrom, *Understanding Institutional Diversity*, above n 382, 268.

\(^{783}\) Note, this does not apply to other water users, such as for intensive livestock or irrigation: WS § 41-3-911 (2018).

\(^{784}\) WS § 41-3-911 (2018).

\(^{785}\) WS § 41-3-933 (2018).
surface or groundwater user, a fee of US$100 must accompany the complaint to defray administrative costs, and the WSEO must then investigate and report to the parties with recommendations.\(^\text{786}\) The key requirements that must be satisfied in such cases is that the complainant must have a valid water right, an adequate well and that the interference must be unreasonable. The complainant bears the onus of proof that his or her well is adequate. For example, the complainant must establish that the well fully penetrates the aquifer (or at least to the same depth as the other well), that there are no issues in the integrity of the casing or piping, that any screening has not corroded, that the well has not sanded in, that electrical components are properly functioning and that the casing would accommodate a pump if the well has become sub-artesian. The investigation by the WSEO will determine whether the interference was unreasonable, but it must be more than a simple drop in water levels or pressure. The WSEO has published various interference reports that it has conducted on its website.\(^\text{787}\)

Participant W1, a representative of the WSEO, explained that there had actually been very few legitimate claims of well interference.\(^\text{788}\)

There had been an historical assistance program that had drilled water wells for many landowners. Unfortunately, these wells were usually drilled with a 2-inch pipe. When the water levels dropped, these wells would be impacted because pumps could not be installed. It is arguable that it was the insufficiency of the piping that was the problem—the water was still there but the decrease in head wouldn’t allow it to flow and pumps could not be installed in the 2-inch casings. The WSEO would conduct an internal investigation to determine who was at fault—sometimes, it was the well construction. There was one high-profile case involving an elderly couple that was splashed over the media. The Governor called in all the gas companies and they voluntarily fixed the issue on the back of that media coverage.\(^\text{789}\)

Participant W7, a representative of landowners, confirmed that the disputes that led to litigation were largely settled out of Court.\(^\text{790}\)

In addition, because most CSG extraction involves federal resources in the PRB, most operators have water well agreements with landholders that have wells within the circle of influence of their CSG activities. This is because the Buffalo Resource Management Plan 2015 requires

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\(^{786}\) WS § 41-3-911 (2018).


\(^{788}\) Participant W3, a representative of a peak landholder and rancher organisation, concurred with this view: Interview with Participant W3 (Casper, Wyoming, 11 August 2017).

\(^{789}\) (Presumably by drilling a new well); Interview with Participants W1 and W2 (Cheyenne, Wyoming, 10 August 2017).

\(^{790}\) Interview with Participant W7 (Sheridan, Wyoming, 15 August 2017).
operators to enter into agreements with nearby landholders. The ‘Circle of influence’ is defined in the standard agreement as having a radius of half a mile from the CSG producing well (and within area of 502.66 acres). The term ‘impaired well’ is one that is properly permitted with the WSEO and that experiences a significant reduction of capacity to deliver water in quantity or quality sufficient to support the ordinary and customary use of the well. The standard agreement requires the producer to undertake baseline assessments of the landholder wells in the circle of influence as well as to establish a monitoring program. If the landholder considers the well to be impaired, the landholder must first establish that the issue is not due to impaired integrity of the well itself prior to notifying the producer. Once notified, the producer must provide adequate water to the landholder by reconfiguring, redrilling, drilling a new well or by any other means. All costs associated with this are borne by the producer. An ad hoc Arbitration Board is established to resolve disputes. If disputes result in legal action, the costs are borne by each party, except if the landholder prevails. In that circumstance, their costs are borne by the producer. The agreement terms ‘run with the land’ and it binds heirs and successors, assigns of both the landholder and producer, and terminates only on the plugging and abandonment of the relevant CSG wells. Therefore, resolution of conflicts for these agreements will be either through arbitration or then through civil remedies in the Wyoming State Courts.

(ii) Conflicts over impacts of aquifer recharge

Unfortunately, conflicts over aquifer injection are via costly traditional litigious avenues and, therefore, are attributed a red grading in this analysis (despite appearing to have rarely been needed).

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792 Buffalo Field Office, Record of Decision and Resource Management Plan Amendments for the Powder River Basin Oil and Gas Project (2003), above n 538, App G.

793 Ibid, App G.

794 The Arbitration Boards are formed in the event of a dispute and require 5 members to be appointed for a two-year term: 1 representative of the WSEO, 2 members selected by the vote of the Landholders within the area of influence of the extractive well, and 2 members selected by the operator that is a party to the agreement; see Buffalo Field Office, Record of Decision and Resource Management Plan Amendments for the Powder River Basin Oil and Gas Project (2003), above n 538, App G, 9.

795 As to whether the producer continues to be bound along with its assigns, see Pennaco Energy, Inc v KD Co LLC, 363 P 3d 18 (Wyo, 2015), which involved both surface use agreements and water well agreements. By applying general principles of contract law to the particular wording used in the relevant agreements, Kautz J found that the operator continued to be liable where the operator had assigned its interests, where there was no express clause providing for termination of the operator’s obligations on assignment, and where the later assignee had not made the necessary financial payments. In that case, the words ‘run with the land’ did not appear to be used.
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Impacts causing harm that are due to breaches of permit requirements or the regulations generally are actionable by the WDEQ as against the operator. Civil or criminal remedies that may exist for impacts of aquifer recharge are in addition to the provisions in the Wyoming regulations for breaches of the regulations or permits. Tortious claims (for negligence or nuisance by third parties) for groundwater contamination are pursued via general civil actions against the operator, WDEQ or both. Yet, these conflicts appear to have been rare. Participant W3, a representative of a peak organisation representing landholders and ranchers, stated that he was not aware of any conflicts for aquifer injection of treated CSG produced water, certainly none that led to litigation. The review of the large sample of permits undertaken in this research confirms this point.

7. Minimal recognition of rights to organise

Scholars argue that a degree of recognition of the rights of resource users to organise themselves provides legitimacy to any rules devised so that they are less likely to be challenged. It also facilitates rule changes by the resource users to reflect changing circumstances over time, which enables an ‘ever more effective regime.’ Without this design principle, governance arrangements risk becoming inflexible.

(i) Rights to organise relating to extraction

Even though stakeholder advisory groups, such as the PRB Interagency Working Group and other taskforces, did form during CSG development, they did not have any formal rights to participate in rule development. (There are opportunities to be heard during water permitting, such as during adjudication for non-CSG water use or well placement discussion with the BLM, but these avenues are distinct from rule-making for water use.) There are rights to organise for water extraction where the WSEO has designated a Control Area, as discussed above. While this did not occur, the ability was present in the Wyoming Statutes under § 41-3-915(c). The sub-design principle is graded amber to reflect the opportunities for self-organisation, despite the lack of formal rights to do so.

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797 Such as was seen with respect to surface discharges in Swartz v Beach, 229 F Supp 2d 1239 (D Wyo, 2002).
798 Interview with Participant W3 (Casper, Wyoming, 11 August 2017).
799 A spreadsheet summarising this data is included as Appendix 10.
800 Ostrom, Commons, above n 692.
801 Ostrom, Understanding Institutional Diversity, above n 382.
802 See above discussion at chapter 4, section 3(ii) about collective choice arrangements for injection at p 127, and chapter 3, section 3(b)(iv) about the formation of the PRB Interagency Working Group at p 109.
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(ii) Rights to organise relating to injection

This sub-design principle is attributed a red grading because the WDEQ is entirely the decision-maker for the UIC permit. It has delegated authority from the federal government under the *Safe Drinking Water Act*\(^{803}\) and is constrained by the federal legislation. There is no ability for stakeholders such as operators and landholders to self-organise. Despite this, the participants perceived themselves as having an ability to influence the rules.\(^{804}\) Therefore, while there are clearly no legal rights to self-organise, there may be informal networks that fill this void, to some extent.

8. Nested enterprises

Scholars highlight that large robust resource systems tend to feature nested organisational enterprises, where smaller-scale organisations sit within larger organisational structures.\(^{805}\) The benefits for nested enterprises are the opportunity for face-to-face communication, which can address, in a simple manner, many of the local and regular issues that may arise.\(^{806}\) The nested arrangements also can build trust between resource users and the regulator, and can enable coordination and collaboration between the regulatory agencies.

This sub-design principle is shaded green for the PRB context, because there is a polycentric nested organisational framework relating to governance both for extraction of CSG produced water and for injection.

Wyoming is not a large state in comparison to Queensland. In 2018, the population of Wyoming was recorded as approximately 600,000 people, living in an area of approximately 260,000 km\(^2\).\(^{807}\) It takes roughly 6–7 hours to drive from the north to the south of the state.\(^{808}\) The Surat CMA groundwater model developed by the Office of Groundwater Impact Assessment (OGIA)\(^{809}\) has an area larger than the entire state of Wyoming.\(^{810}\) Despite the relative proximity of the various production fields to the state capital, Cheyenne, each regulator has multiple field offices...

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\(^{803}\) 42 USC §300f et seq (42 USC Ch 6A Subch XII) (2017).
\(^{804}\) See this chapter (4), section 3(ii) relating to collective choice arrangements for injection at p 127.
\(^{805}\) Ostrom, *Understanding Institutional Diversity*, above n 382, 269.
\(^{806}\) Ostrom, Commons, above n 692, 6.
\(^{808}\) It takes approximately 6 hours to drive from Brisbane, the Queensland state capital, to the regional town of Roma, situated in the middle of the Surat CMA. In comparison, Queensland has a population of approximately 4 million in an area of 1,727,000 km\(^2\); Queensland Government, *Interesting Facts about Queensland*, 2017, <https://www.qld.gov.au/about/about-queensland/statistics-facts/facts>.
\(^{809}\) The Office of Groundwater Impact Assessment (OGIA) is a government body that assesses and manages the cumulative impacts of CSG produced water production, see below chapter 5, section 3(b)(iii) at p 171.
\(^{810}\) 299,000 km\(^2\) or 460 km x 650 km; Office of Groundwater Impact Assessment, UWIR (2016), above n 26, 79.
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throughout the state, managing operations in their respective areas. For example, the US BLM has field offices in Kemmerer, Rock Springs, Pinedale, Lander, Cody, Worland, Rawlins, Casper, Buffalo and Newcastle. The key agencies that governed CSG development in the PRB were the US BLM branch office at Buffalo, the WDEQ branch office at Sheridan, the WOGCC in Casper, and the WSEO in Cheyenne, the state capital. Each agency has local offices staffed by locals. Participant W20, a representative of the US BLM, noted:

The upside of being a field office is that … [we] are part of the community and everyone knows everyone. People know … [us], [we] … will bump into people at the grocery store and church, and so this enables trust to develop. Certainly, at the Powder River Basin level, the BLM enjoys that trust. 811

Because there are multiple agencies812 involved in governing CSG extraction as well as aquifer injection of CSG produced water, there has been coordination of these numerous agencies from the start of development through various coordinating committees.813 The PRB Interagency Working Group, set up by the US BLM’s Resource Management Plan 2015 for the PRB,814 also provided for coordination and collaboration among the different regulatory agencies.

Consultation arrangements among the agencies embedded in the permitting process also contribute to some integration of the governance of injection with other water uses. Where the resource is federally owned, Participant W5, a representative of industry, explained:

The federal APD is sent to the Wyoming Oil and Gas Conservation Commission [WOGCC]. … The [WOGCC] adopts that as its APD and assigns an API number. The federal BLM uses that number as well. The [WOGCC] keeps the records of the [WSEO’s] UW5 also if you supply it to them. … the different state agencies are somewhat independent of each other. 815

Also recall that site inspections, including all relevant stakeholders, occur prior to the issuance of the APD. 816

811 Interview with Participants W19 and W20 (Buffalo, Wyoming, 22 August 2017).
812 The US BLM, the WOGCC, the WSEO and the WDEQ.
813 For example, the PRB Interagency Working Group noted at chapter 3 section 3(b)(iv), above p 109; see also text relating to collective choice arrangements for injection and comments by Participant W4, a representative of industry: Interview with Participant W4 (Casper, Wyoming, 11 August 2017), this chapter (4) section 3(ii), above p 128.
814 This was established pursuant to the Powder River Basin Record of Decision in 2003 following the NEPA process: Buffalo Field Office, Record of Decision and Resource Management Plan Amendments for the Powder River Basin Oil and Gas Project (2003), above n 538, App E; see also BLM, PRB Interagency Working Group, above n 651.
815 Interview with Participants W5 and W6 (Sheridan, Wyoming, 14 August 2017).
Similarly, consultation takes part in the injection permitting arrangements. Injection, unlike other further beneficial uses of produced water, requires no further water permit and, therefore, it is outside of the WSEO’s area of control. Consequently, quantities of water that are recharged into aquifers are not accounted for within the basin. When an operator applies for a UIC permit, the decision-maker is the WDEQ but the application materials are also provided for comment to the US EPA, the US BLM (where appropriate), the local County government, the Wyoming Game and Fish Department, the WOGCC, the WSEO and the Wyoming Historical Preservation Officer, as well as other interested parties such as the peak landholder organisation, the PRB Resource Council and, of course, the relevant landholder(s). Therefore, most stakeholders (including the WSEO) are afforded an opportunity to have an input in the permit for the recharge.

9. Measurement against the AIA design principles

(i) Were the AIA design principles adopted?

Having analysed the regulatory frameworks and the quantitative and qualitative data against the AIA design principles, I can now answer the fifth research sub-question for the PRB:

<table>
<thead>
<tr>
<th>Have the regulatory frameworks in each jurisdiction adopted the AIA design principles?</th>
</tr>
</thead>
</table>

Table 6, below, presents the summary of the analysis provided above, relating to the PRB governance arrangements and the corresponding heat map follows:

817 Obviously, different issues would have been raised by different stakeholders in the various applications that occurred over time. The point is that they all had an opportunity to be heard with respect to the individual UIC wells proposed, and that the WDEQ overtly coordinated the application process with the various government departments and other stakeholders.
### Presence, partial presence, or absence of the Aquifer Injection and Augmentation Design Principles

<table>
<thead>
<tr>
<th>Ostrom’s design principles</th>
<th>Specific aspects relevant to governance of groundwater where CSG activities and aquifer injection of CSG produced water takes place</th>
</tr>
</thead>
</table>
| 1. Clearly defined boundaries of the resource | (a) Social boundaries
| | (i) Identity of groundwater users
| | (ii) Clarity of administrative boundaries to access the groundwater
| | (iii) Clarity of administrative boundaries for aquifer injection
| | (b) Biophysical boundaries
| | Physical boundaries of the groundwater resource |
| 2. Congruence between appropriation and provision rules and local conditions, including benefits and costs | (a) Congruence between local conditions and rules
| | (i) Appropriation rules that reflect local conditions for water extraction
| | (ii) Rules for injection that reflect local conditions
| | (b) Investment/extraction proportionality
| | (i) Appropriators pay for the appropriate proportion of water extracted
| | (ii) Economic benefit/costs of injection |
| 3. Collective choice arrangements | (i) Collective choice arrangements relating to extraction
| | (ii) Collective choice arrangements relating to injection |
| 4. Monitoring of the resource as well as the monitors | (a) Monitoring of the resource
| | (i) Monitoring of extraction
| | (ii) Monitoring of injection
| | (iii) Monitoring of the resident groundwater resource
| | (b) Monitoring the monitors
| | Monitoring the monitors |
| 5. Graduated sanctions | (i) Sanctions relating to extraction
| | (ii) Sanctions relating to injection |
| 6. Conflict resolution mechanisms | (i) Conflict resolution relating to extraction
| | (ii) Conflict resolution relating to injection |
| 7. Minimal rights to organise | (i) Rights to organise relating to extraction
| | (ii) Rights to organise relating to injection |
| 8. Nested enterprises | Nested enterprises involving each of the regulators |

Table 6. Grading attributed to presence/absence of AIA design principles in the PRB
Figure 14. Heat map of AIA design principles for PRB governance framework

(NOTE: Numbers for sub-design principles correspond to chapter headings above)
Did success correlate with the AIA design principles in the PRB?

I can now also answer the sixth research sub-question for the PRB:

Did success (or ‘not success’) of the overall governance framework for groundwater and for extraction of CSG and injection correlate with the adoption (or absence) of the AIA design principles?

As mentioned at the end of Chapter 3, the fact that the resource has recovered to some extent in a narrow timeframe does not necessarily provide a conclusive finding that the governance framework was successful. The recovery of the groundwater system does indicate a certain level of hydrogeological resilience in terms of the physical characteristics of the groundwater resource. It is not possible to conclude decisively either way whether governance arrangements for the groundwater system, or the governance of access to groundwater by the CSG industry, were successful due to the truncated operations. Yet, there are indications that the framework for the groundwater system generally and for the extraction of CSG produced water was relatively successful, mainly due to the changes in decision-making that occurred in response to conflict and a lack of continuing trust issues. I conclude that the governance of the injection process was successful due to the ready uptake by numerous operators from the early days of CSG development.

Each of the findings of success can be correlated with the presence/absence of AIA design principles. I will first consider the presence/absence of AIA design principles with respect to the overall governance of the groundwater system and correlate that with the tentative finding of relative success noted above. I will then consider the governance of the separate operational phases of extraction and injection, separately in turn.

For groundwater governance overall, the analysis in this chapter suggests that the relatively successful Wyoming governance framework relating to the groundwater system correlates with the presence of many of the AIA design principles. Table 7, below, reveals that out of the 21 more detailed AIA design principles, 8 are fully present (green), 8 are partially present (amber) and only 5 are absent (red).
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<table>
<thead>
<tr>
<th>Sum of presence/partial presence/absence of AIA design principles</th>
<th>AIA design principles relating to governance of the groundwater system:</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 are fully present (green)</td>
<td>Identity of groundwater users</td>
</tr>
<tr>
<td></td>
<td>Clarity of administrative boundaries to access the groundwater</td>
</tr>
<tr>
<td></td>
<td>Clarity of administrative boundaries for aquifer injection</td>
</tr>
<tr>
<td></td>
<td>Appropriation rules that reflect local conditions for water extraction</td>
</tr>
<tr>
<td></td>
<td>Rules for injection that reflect local conditions</td>
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<tr>
<td></td>
<td>Monitoring of injection</td>
</tr>
<tr>
<td></td>
<td>Conflict resolution relating to extraction</td>
</tr>
<tr>
<td></td>
<td>Nested enterprises involving each of the regulators</td>
</tr>
<tr>
<td>8 are partially present (amber)</td>
<td>Physical boundaries of the groundwater resource</td>
</tr>
<tr>
<td></td>
<td>Collective choice arrangements relating to extraction</td>
</tr>
<tr>
<td></td>
<td>Collective choice arrangements relating to injection</td>
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<tr>
<td></td>
<td>Monitoring of extraction</td>
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<td>Monitoring of the resident groundwater resource</td>
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<td></td>
<td>Monitoring the monitors</td>
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<tr>
<td></td>
<td>Sanctions relating to injection</td>
</tr>
<tr>
<td></td>
<td>Rights to organise relating to extraction</td>
</tr>
<tr>
<td>5 are absent (red)</td>
<td>Appropriators pay for the appropriate proportion of water extracted</td>
</tr>
<tr>
<td></td>
<td>Economic benefit/costs of injection</td>
</tr>
<tr>
<td></td>
<td>Sanctions relating to extraction</td>
</tr>
<tr>
<td></td>
<td>Conflict resolution relating to injection</td>
</tr>
<tr>
<td></td>
<td>Rights to organise relating to injection</td>
</tr>
</tbody>
</table>

Table 7. Sum of presence/absence of AIA design principles for governance of the groundwater system in the PRB

The presence or absence of the AIA design principles can also be summarised for the governance of the two separate activities in the PRB. For the 13 relevant AIA design principles relating to the extraction of CSG produced water in the PRB, see Table 8, below.
Sum of presence/partial presence/absence of AIA design principles | AIA design principles with respect to extraction of CSG produced water
---|---
5 are present (green) | Identity of groundwater users
| Clarity of administrative boundaries to access the groundwater
| Appropriation rules that reflect local conditions for water extraction
| Conflict resolution relating to extraction
| Nested enterprises involving each of the regulators
6 are partially present (amber) | Physical boundaries of the groundwater resource
| Collective choice arrangements relating to extraction
| Monitoring of extraction
| Monitoring of the resident groundwater resource
| Monitoring the monitors
| Rights to organise relating to extraction
2 are absent (red) | Appropriators pay for the appropriate proportion of water extracted
| Sanctions relating to extraction

Table 8. Sum of presence/absence of AIA design principles for extraction in the PRB

For the 13 relevant AIA design principles relating to the injection of CSG produced water, see Table 9, below.

Sum of presence/partial presence/absence of AIA design principles | AIA design principles with respect to injection of CSG produced water
---|---
5 are present (green) | Identity of groundwater users
| Clarity of administrative boundaries for aquifer injection
| Rules for injection that reflect local conditions
| Monitoring of injection
| Nested enterprises involving each of the regulators
5 are partially present (amber) | Physical boundaries of the groundwater resource
| Collective choice arrangements relating to injection
| Monitoring of the resident groundwater resource
| Monitoring the monitors
| Sanctions relating to injection
3 are absent (red) | Economic benefit/costs of injection
| Conflict resolution relating to injection
| Rights to organise relating to injection

Table 9. Sum of presence/absence of AIA design principles for injection in the PRB

There does appear to be a correlation between the presence of the AIA design principles and the findings of success for the injection stage, at least, in that there are significantly more AIA design principles present or partially present than absent. Also, the relatively successful overall groundwater governance and governance of extraction indicate somewhat of a correlation with the
number of design principles present or partially present. This is shown in Table 10, below, which presents the findings of success along with the sum totals of the relevant AIA design principles:

<table>
<thead>
<tr>
<th>Aspect of governance regime:</th>
<th>Success or not-success?</th>
<th>Sum of presence/partial presence/absence of AIA design principles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater governance overall</td>
<td>Not possible to conclude either way due to truncated operations. There are indications that the framework was <em>relatively successful</em>, due to an absence of residual trust issues and the changes in decision-making that occurred in response to conflict.</td>
<td>Out of 21 overall AIA design principles: 8 are fully present (green) 8 are partially present (amber) 5 are absent (red)</td>
</tr>
<tr>
<td>Governance of extraction of CSG produced water</td>
<td>Not possible to conclude either way due to truncated operations. There are indications that the framework was <em>relatively successful</em>, due to an absence of residual trust issues and the changes in decision-making that occurred in response to conflict.</td>
<td>Out of 13 relevant AIA design principles: 5 are present (green) 6 are partially present (amber) 2 are absent (red)</td>
</tr>
<tr>
<td>Governance of injection process</td>
<td><em>Successful</em> due to the ready adoption of the process by many operators and the quantum injected over many years.</td>
<td>Out of 13 relevant AIA design principles: 5 are present (green) 5 are partially present (amber) 3 are absent (red)</td>
</tr>
</tbody>
</table>

*Table 10. Correlation between success/not-success and presence of AIA design principles in the PRB*

As the above analysis reveals, the presence/absence of the AIA design principles does suggest a correlation with my conclusions about the (relative) success of the PRB governance framework. But it is not enough to consider only the PRB framework. Interestingly, there are actually more sub-design principles present for the governance of the extraction of CSG produced water (11) as opposed to the governance of the injection process (10). This may suggest that, for the governance of the injection activity, certain design principles may not be as important as others. I need another jurisdiction against which to test my findings about the relationship between the AIA design principles and success, and to determine the relevant importance of specific design principles. A comparison with the Surat CMA will help with that analysis.
PART C: AQUIFER INJECTION OF CSG PRODUCED WATER IN THE SURAT CMA, QUEENSLAND

This Part presents both the formal laws and policies that govern aquifer injection in the CSG context within Queensland Australia, as well as the empirical data from permits, documents, reports and semi-structured interviews. Chapter 5 details the geographic setting and regulatory framework in place. Chapter 6 analyses the regulatory framework and empirical data against the AIA design principles, which were presented at the end of Chapter 2.

Figure 15. Author’s photograph of the Queensland setting: pastoral land north of Roma, Queensland
CHAPTER 5: REGULATORY FRAMEWORK IN QUEENSLAND

This chapter addresses the third and fourth research sub-questions, regarding the relevant regulatory mechanisms in place in the Surat CMA and the overall success of the governance framework. Like Chapter 3 relating to the PRB, this chapter commences with a description of the Surat CMA setting. It then demonstrates the relevant legislative mechanisms for the two phases of aquifer injection of CSG produced water in the Surat CMA: the statutory right to extract the CSG produced water, corresponding with the scope of the petroleum lease; and the relevant environmental authority (EA) conditions and various subsidiary environmental documents. As was the case for the PRB, these legislative mechanisms are granted within the context of the CSG project permitting arrangements and this context is also important. It is particularly important in the later analysis conducted in Chapter 6.

This chapter concludes by arguing that the governance arrangements for groundwater generally and for the extraction of CSG produced water have been and are unsuccessful in the Surat CMA. I also conclude that the governance of the injection of CSG produced water in the Surat CMA has been and is relatively unsuccessful.

1. Geographical, geological and hydrological description of the Surat CMA

The Surat CMA is a large area of south-central Queensland that straddles the Great Dividing Range, with the southern Fitzroy River Basin to the north of the range and, to the south, the northern Murray–Darling Basin (Figure 16, below).\textsuperscript{818} The Murray–Darling Basin river system within the Surat CMA includes the Condamine and Balonne rivers, which generally flow in a westerly then southerly direction. On the northern side of the range, the Nogoa, Comet, Dawson and Boyne river systems flow in a northerly and easterly direction. Rainfall is variable and evaporation rates are high.\textsuperscript{819} Many rivers and streams are highly ephemeral, and some are spring-fed.\textsuperscript{820} The climate is sub-tropical and most of the area is categorised as semi-arid.\textsuperscript{821}

\textsuperscript{818} Office of Groundwater Impact Assessment, UWIR (2016), above n 26, 19.
\textsuperscript{819} Ibid; Klohn Crippen Berger, above n 26.
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The major land-use in the region is agriculture (broad-acre cropping in the east, grazing in the west and numerous feedlots throughout) with other land uses including urban, industrial, resource extraction (CSG, conventional petroleum, and gas and coal mining) and conservation.\textsuperscript{822}

Figure 16. Landscape of the Surat CMA\textsuperscript{823}

\textsuperscript{823} Office of Groundwater Impact Assessment, UWIR (2016), above n 26, 21.
The Surat CMA covers parts of three geologic basins: the southern Bowen Basin, the northern portion of the Surat Basin and the western Clarence Moreton Basin. The Bowen Basin is the oldest and therefore the deepest of the basins, which was formed through sedimentation from the early Permian to Triassic periods. The CSG-producing coal measures in the Bowen Basin are the Bandanna and deeper Cattle Creek Formations. The overlying Surat Basin ‘comprises a mainly Jurassic to Cretaceous age sequence of alternating layers of sandstones, siltstones and mudstones.’ The Clarence Moreton Basin lies in the south-east of the other basins. Unconsolidated alluvial sediments and volcanic deposits overly all the basins. The Condamine Alluvium is one such accumulation, which was deposited during the Cenozoic Era (which began 65 million years ago and continues to the present). Further detail about the geology and hydrogeology of the Surat CMA presented in Appendix 2(b).

2. Current status of groundwater in the Surat CMA

Recognition of declining water levels in the GAB is not new. Declining pressures in artesian bores was evident soon after the first bores were sunk in the late 1800s. The calculation of extraction exceeding recharge was recognised in the 2000s. In 2016, a regional-scale water balance was calculated for all the aquifer groups in the Surat geological basin. Focussing on water levels rather than a calculation of balance of recharge less extraction is preferable because, for large systems like the GAB, the movement of water can be so slow, the response time could be in the hundreds to thousands of years. Nonetheless, the calculation is helpful because it is difficult to manage water resources practically simply based on pressure levels: the management of quantum is required to manage pressure changes. See Table 11, below, for the summary table of findings, which shows all aquifer systems in a negative balance.

Relevantly, for water level trends in GAB aquifers, the Gubberamunda Aquifer Group is the most exploited system, and even though in some areas there may be declines, overall, there is a pattern of recovery and stability. The Hutton Sandstone is showing declining trends and the Precipice is also showing declining trends. In addition, the overlying Condamine Alluvium has

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825 Ibid.
826 Ibid, 23.
828 Ibid, 25.
829 Ibid, above n 447; Tan and Quiggin, above n 439.
830 Ibid, above n 439, 270.
833 Ibid, 94.
834 Ibid, v.
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experienced significant drawdown (20 metres) due to agricultural extraction over the past 60 years. In contrast, the Reedy Creek injection project, undertaken by AP LNG as at June 2017, had injected 15 GL of treated CSG produced water into the Precipice Sandstone.

Office of Groundwater Impact Assessment, UWIR (2016), above n 26, 44. In contrast, the groundwater levels of the Walloon Coal Measures have remained relatively unchanged in that area, which suggests an impediment to flow in that area, or low connectivity.

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Table 11. Summary of pre-development (1900) and post-development (2015) GAB water balance within the Surat CMA as derived by the Queensland Office of Groundwater Impact Assessment.837

<table>
<thead>
<tr>
<th>Sub Basin Area</th>
<th>Aquifer Group</th>
<th>Recharge</th>
<th>Non-CSG Extraction</th>
<th>CSG Extraction</th>
<th>Natural discharge to surface</th>
<th>Net vertical flow</th>
<th>Net lateral flow</th>
<th>Imbalance (Change in storage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surat Basin (CMA Area)</td>
<td>Rolling Downs Aquifer Group</td>
<td>28,487</td>
<td></td>
<td></td>
<td></td>
<td>5,446</td>
<td>3,309</td>
<td>-2,683</td>
</tr>
<tr>
<td></td>
<td>Gabbermunda Aquifer Group</td>
<td>32,592</td>
<td></td>
<td></td>
<td></td>
<td>-7,035</td>
<td>-6,076</td>
<td>-1,913</td>
</tr>
<tr>
<td></td>
<td>Hutton &amp; Injune Aquifer Group</td>
<td>97,499</td>
<td></td>
<td></td>
<td></td>
<td>867</td>
<td>6,851</td>
<td>-143</td>
</tr>
<tr>
<td></td>
<td>Precipice Aquifer Group</td>
<td>23,984</td>
<td></td>
<td></td>
<td></td>
<td>554</td>
<td>2,748</td>
<td>-98</td>
</tr>
<tr>
<td></td>
<td>Clematis Aquifer Group</td>
<td>89,542</td>
<td></td>
<td></td>
<td></td>
<td>-26</td>
<td>77</td>
<td>-1,525</td>
</tr>
<tr>
<td>Total Surat</td>
<td></td>
<td>272,103</td>
<td></td>
<td></td>
<td></td>
<td>-193</td>
<td>6,998</td>
<td>-1,955</td>
</tr>
</tbody>
</table>

Same as pre-development

NOTE: -ve values are flows out of the basin and +ve values are recharge.

837 Klohn Crippen Berger, above n 26, 94.
3. Regulatory framework

As at 2016, approximately 6,500 CSG wells (for production and exploration) have been drilled in the Surat CMA, extracting approximately 65 GL per year, and there are approximately 22,500 non-CSG water bores, extracting approximately 203 GL annually (from the GAB as well as from shallower formations). Like Wyoming, but perhaps even more so, the mechanisms governing aquifer injection of CSG produced water sit within a broad framework regulating gas extraction. Understanding this context will help the subsequent analysis in terms of the AIA design principles. Perseverance with a discussion of this wider context is therefore necessary, as it was with the PRB. Although, like the framework for Wyoming, I have tried to present the slice of the framework that is most relevant to this topic.

A key feature of Australian resources law is that on-shore resources (such as CSG and water) are vested in the States and Territories and, therefore, governance generally sits with those governments. Similarly, due to the history of settlement, nearly all land is controlled by the state, therefore, Queensland laws are most relevant to the activities. The three first key approvals listed below (the petroleum lease and environmental authorities at both state and Commonwealth levels) are linked in terms of assessment, so that applications under each of the three pieces of legislation are often lodged and assessed contemporaneously.

A pictorial representation of the key regulatory mechanisms and subordinate management and monitoring plans for Queensland CSG projects is shown in Figure 18, below. The figure indicates the mechanisms and instruments that govern access to the CSG produced water and aquifer injection, and where they sit (circled in red) in the project-wide framework. As shown, a gas project in the Surat CMA requires numerous approvals, but the key approvals that relate to the extraction of the CSG and CSG produced water are:

- Queensland petroleum lease under the Petroleum and Gas (Production and Safety) Act 2004 (Qld) (P&G Act);
- Queensland environmental authority (EA) under the Environmental Protection Act 1994 (Qld) (EP Act) for petroleum activities and other environmentally relevant activities associated with the project;
- Commonwealth (federal) EA under the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act); and
- Queensland regional interest development approval (RIDA) under the Regional Interests Planning Act 2014 (Qld).

The RIDA, through the Queensland Department of State Development, Manufacturing, Infrastructure and Planning, can occur at any time prior to operations. For CSG activities, a RIDA will be required for the extraction activity if it is not exempt, such as for infrastructure that impacts protected areas mapped ‘priority agricultural areas’ and ‘strategic cropping areas’. While a RIDA.

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839 Water Act, s 26 states that ‘All rights to the use, flow and control of all water in Queensland are vested in the State’ and P&G Act, s 9 states that ‘petroleum on or below the surface of all land in Queensland … is and always has been the property of the Crown.’

840 Queensland was first part of the colony of New South Wales, prior to becoming its own self-governing colony in 1859. In 1867, land that was held by the Crown was vested in the legislature by section 40 of the Constitution Act 1867 (Qld). The Commonwealth was created on 1 January 1901.

841 Regional Planning Interests Act 2014 (Qld), ss 22–25 (such as pre-existing resource activities or where Conduct and Compensation Agreements exist with relevant landholders, and the activity is not likely to have a significant impact on the protected area or other land).

842 Regional Planning Interests Act 2014 (Qld), s 19.
approval will not usually contain any governing provisions relating to aquifer injection, any details of intended disposal of CSG produced water, including injection, will be set out in the application for the approval, particularly where the activities occur in the Central Condamine Alluvium (CCA). This approval is not directly germane to this research, although it does form part of the overall governance framework for CSG activities. As operations proceed, there will be many individual RIDAs for the separate relevant components, such as wells, ponds, tanks, roads, fences and pipelines.

Local government does not control CSG activities through zoning or land-use control. There are many other approvals or requirements for a gas field project, which are not relevant to this research but are listed in Appendix 5.

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844 Planning Act 2016 (Qld), s 43(5)(b); Planning Regulation 2017 (Qld), s 16 and sch 6 pt 5, except for building and operating an oil refinery; see also: P&G Act, s 113(2), which provides that using a structure, other than a temporary structure, for an office or residential accommodation is not an incidental activity to authorised activities under that Act, although local laws made pursuant to the Local Government Act 2009 (Qld) may apply. Local laws relating to vegetation or local roads may be relevant to the CSG project generally, but will not usually impact the injection activities.
Figure 18. Queensland governance framework of CSG activities, including the mechanisms governing aquifer injection of CSG produced water (circled red)

NOTE: The letters and roman numerals next to the jurisdictions and regulatory mechanisms in the figure identify the sections below, where they are discussed in detail.

The extraction of water during CSG production relies on a general statutory right to extract water, which is dependent on the Queensland petroleum tenure and Queensland EA. Therefore, there is no need for a separate water licence. The impacts on aquifers due to the extraction of water are managed through Chapter 3 of the Water Act 2000 (Qld) (Water Act). This legislation imposes a framework of obligations rather than approvals per se and is discussed further in this chapter, below at section 3(b)(iii) beginning p 170.

Unlike Wyoming, the CSG project is authorised through both Queensland and Commonwealth environmental legislation via project-wide EAs, rather than per well or group of wells. It is within this context that the first phases of access to the CSG produced water is regulated. This has implications for the resulting environmental assessments and regulation (discussed below). Also, unlike Wyoming, there are no discreet legislative powers that govern the second operational

845 Petroleum and Gas (Production and Safety) Act 2004 (Qld) (P&G Act), ss 185, 188; Water Act 2000 (Water Act), s 808.
phase, being aquifer injection in Queensland (or Australia). The mechanism for the aquifer injection of CSG produced water is within the general EA for the whole project. Management of CSG produced water is principally governed by the conditions of the Commonwealth and Queensland EAs.\textsuperscript{846} CSG water is considered a ‘waste’ by the legislation\textsuperscript{847} and is managed by the conditions of the environmental authorities.\textsuperscript{848} The key operating requirements for aquifer reinjection are usually found in the Queensland EA for the entire CSG project as well as in the subordinated management and monitoring plans, which are often drafted by the gas operator and approved by the Queensland and Commonwealth departments of Environment.

No mechanisms govern entitlements to the aquifer space or the recovery of the recharge water. Depending on the end use of the recharge water, end use obligations are governed by the Queensland Water Quality Guidelines 2009\textsuperscript{849} and the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (the ANZECC 2018 Guidelines)\textsuperscript{850} as well as the Australian Guidelines for Water Recycling: Augmentation of Drinking Water Supplies (NRMMC-EPHC-NHMRC 2008)\textsuperscript{851} and the Australian Drinking Water Guidelines 6 2011.\textsuperscript{852}

This chapter starts with a discussion of the Commonwealth environmental approval process before addressing the Queensland regulatory mechanisms. The Queensland regulatory mechanisms

\textsuperscript{846} Prior to 2014, the Water Supply (Safety and Reliability) Act 2008 (Qld) (Water Supply Act) was relevant where operators supplied treated CSG water for the purposes of a municipal drinking water supply. In 2010, provisions were inserted into the Water Supply Act that required the regulation of CSG water as recycled water where it may enter a drinking water supply (see explanatory notes to the Electricity and Other Legislation Amendment Act 2014 (Qld) and explanatory notes to the Water and Other Legislation Act 2010 (Qld)). In 2014 (by the Electricity and Other Legislation Amendment Act 2014 (Qld)), following recommendations by the Queensland Competition Authority, after an extensive review of the regulation of the industry, the regulation of CSG water (which was in Pt 9A of the Water Supply Act) was excluded from that Act so that it could be solely regulated under the EP Act. Generally, the definition of ‘recycled water’ specifically excludes water generated from a ‘resource activity’, including a petroleum activity (schedule 3 Water Supply Act’s definition of ‘recycled water’ and ‘waste water’ and EP Act, s 107 definition of ‘resource activity’).

\textsuperscript{847} EP Act, s 13.

\textsuperscript{848} Or through the Waste Reduction and Recycling Act 2011 (Qld) (Waste Act). A beneficial re-use approval under the Waste Act will be generally required where the produced water is of a certain quality and is used via surface disposal; in particular, if the CSG water is taken off-tenement.


are discussed in detail, starting with the Queensland petroleum tenure and EA because they are the key mechanisms that determine the governance mechanisms relating to the extraction of water and subsequent aquifer injection. The chapter will then address the statutory right to extract the water, because this is entirely dependent on the scope of the petroleum tenure and Queensland EA.

a) Commonwealth instruments

Even though the Queensland government has jurisdiction for CSG and water generally, the Commonwealth Government’s key piece of environmental legislation, the EPBC Act, is relevant. It requires an approval for development that may have a significant impact on ‘Matters of National Environmental Significance’ (MNES), which include water resources where CSG development is concerned.853

If a proponent considers that a development may ‘significantly impact’854 a MNES, then the proponent must refer the action to the Commonwealth Department of Environment to determine whether it requires an approval.855 Referrals are usually quite detailed and include information on the proposed activity, including the relevant location, timeframes, local government and state government requirements, other environmental impact assessments, consultation with Indigenous stakeholders, a description of the environment, and likely impacts and measures designed to avoid negative impacts.856 The proponent must also state whether the proposal ought to be a ‘controlled action’.857 If the department considers that the proposed development is not likely to impact the

853 MNES include listed threatened species and communities, listed migratory species, wetlands of international importance (Ramsar wetlands), nuclear actions, Commonwealth marine areas, world heritage properties and national heritage places, and water resources that are impacted upon by large coal-mining and coal seam gas development: EPBC Act, ch 2. The latter MNES, being water resources impacted by large coal mining and CSG development, is known as the ‘water trigger’ and was added on 12 June 2013, due to widespread concern about the impacts on water resources by these industries. Large coal mines and coal seam gas development since that date require an EPBC Act approval for significant impacts on any water resources: EPBC Act, s 24D. Prior to that date, these types of projects sometimes required an EPBC Act approval on other grounds (such as impacts on other MNES such as listed species and communities). However, the breadth of the environmental assessment in that case did not require direct analysis of the water impacts of the project. Any subsequent conditions imposed by the federal Department of Environment would not have directly related to water impacts.


855 EPBC Act, s 68.

856 EPBC Act, s 72; Environmental Protection and Biodiversity Conservation Regulations 2000 (Cth), Pt 4.

857 EPBC Act, s 68(3) and (4).
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MNES significantly, then a decision will issue accordingly (within 30 days) and no environmental assessment or approval will be required under the EPBC Act.858

Alternatively, if the department decides that the proposal is a ‘controlled action’ under the EPBC Act, a decision under the EPBC Act is necessary, which requires an assessment of the impacts on MNES, most notably now ‘water resources’.859 For Queensland projects, the Commonwealth Department of Environment may rely on the EIS prepared for the state Department of Environment for the state approvals below.860

Proposed expansions of existing projects, which may have already gained approval, will now usually require the proponent to refer the proposal for approval at a Commonwealth level because of the ‘water trigger’. The breadth of the EIS materials will often require somewhat of a reassessment of matters already approved because, for example, water treatment for the expansion will tend to be the same as what is already in operation.

Both the Commonwealth and Queensland departments of environment may request advice as to the adequacy of a draft EIS from the Independent Expert Scientific Committee on Coal Seam Gas and Large Mining Development (IESC).861 The IESC also produces bioregional assessments of relevant catchments (such as the Maranoa–Balonne–Condamine subregion, which is within the Surat CMA) as one of the key mechanisms to assist its advisory capacity.862

(i) Relevant guidelines at the Commonwealth level

There are guidelines created at a national level that will also be relevant to any CSG project involving aquifer injection of CSG water. The National Harmonised Regulatory Framework for Natural Gas from Coal Seams863 was formulated on 31 May 2013 by an historic agency that was

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858 EPBC Act, Pt 7, div 2. 859 EPBC Act, Pt 8.
861 In 2012, a national partnership agreement was reached between the Commonwealth government and the New South Wales, Victoria, Queensland, South Australia and Northern Territory governments for referrals to the IESC; Australian Government, New South Wales, Victoria, Queensland, South Australia and the Northern Territory, National Partnership Agreement on Coal Seam and Large Coal Mining Development (2012) <http://www.federalfinancialrelations.gov.au/content/npa/environment/national-partnership/past/coal_mining_development_NP.pdf>.
862 These assessments are available online at Australian Government, Bioregional Assessments, Assessments, Undated, <https://www.bioregionalassessments.gov.au/>
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replaced by the Council of Australian Governments (COAG) Energy Council. The framework focussed on four key areas: well integrity, water management and monitoring, hydraulic fracturing, and chemical use. Aquifer injection was considered within the water management topic as a ‘leading practice for recycling produced water for beneficial use’. After a review of the National Harmonised Framework, a new guide was agreed to by the Commonwealth, State and Territory resources ministers in 2018, which resulted in 16 new leading practices within 6 broad themes. The injection of CSG produced water is included as a leading practice for managing cumulative impacts and ensuring that produced water volumes are accounted for and managed. Where produced water (either treated or untreated) is to be re-injected into an aquifer, the framework recommends application of the Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2) Managed Aquifer Recharge (2009).

As mentioned, if the recovered water is intended to be used as a drinking water supply, the Australian Guidelines for Water Recycling: Augmentation of Drinking Water Supplies (NRMMC-EPHC-NHMRC 2008) and the Australian Drinking Water Guidelines will also be relevant.

b) Queensland instruments

As already discussed, extraction of CSG is generally governed by the P&G Act and the EP Act. The extraction of ground water associated with production of gas is authorised under the P&G Act rather than the Water Act. The disposal of this water by injection is generally managed through the EA under the EP Act. In addition, the Queensland government has made a commitment to applying an AM approach for both development of CSG resources and water. These mechanisms

866 Energy Council, Council of Australian Governments, above n 865, 18–21.
869 Australian Government, National Health and Medical Research Council, and Natural Resource Management Ministerial Council, above n 852.
870 Water Act, s 808 and P&G Act, ss 185 and 196.
871 For CSG development, see: Queensland Government, Adaptive Management, above n 246; with respect to water, see: Commonwealth of Australia et al, Intergovernmental Agreement on a National Water Initiative, above n 247, [78] and [79].
are discussed below, starting with the petroleum tenure and environmental authorities, then finally the entitlement to extract the CSG produced water.

(i) Petroleum tenure

Since 2004, petroleum and gas have been regulated pursuant to the P&G Act, which also brought in a new CSG regime. The Petroleum Act 1923 (Qld) continues in operation for petroleum tenures that pre-date 2004 so that native title issues can be resolved.\textsuperscript{872} Because the focus of this research concerns the regulation of CSG production, the provisions of the P&G Act are relevantly discussed.

Tenure to the resource is regulated through the P&G Act and granted by the Queensland Department of Natural Resources and Energy (QDNRME). To explore (or test or evaluate the feasibility) for petroleum and coal seam gas production, an exploration permit (authority to prospect or ATP) is required.\textsuperscript{873} ATPs are issued following a tender process and for a term of 12 years with relinquishment requirements (8.3\%) of the area of the ATP each year.\textsuperscript{874} An application for an ATP must be accompanied by a work program.\textsuperscript{875} An ATP can be renewed but not for a term longer than the original 12 years.\textsuperscript{876} A production licence in the form of a petroleum lease (PL) is usually only issued to an ATP holder subject to various safety, environmental, capability and development requirements. Sometimes, they are issued by way of a competitive tender. The PL is generally granted for 30 years. Production must start within 2 years of the PL issuance\textsuperscript{877} and the application is required to be accompanied by evidence that this will take place.

The Petroleum and Gas (Production and Safety) Regulation 2004 (Qld) (P&G Reg) prescribes safety requirements for petroleum and gas activities. There are a multitude of mandatory and preferred codes relevant to various activities, which are listed in Schedule 1 to the regulation.\textsuperscript{878}

\textsuperscript{872} See Explanatory Notes, Petroleum and Gas (Production and Safety) Bill 2004.  
\textsuperscript{873} P&G Act, s 32.  
\textsuperscript{874} Where part of the area is relinquished to the government: P&G Act, ss 65–71.  
\textsuperscript{875} P&G Act, s 77.  
\textsuperscript{876} P&G Act, s 85(7).  
\textsuperscript{877} P&G Act, s 154.  
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(ii) EP Act managing water quality

Petroleum tenures such as an ATP or a PL cannot be issued without a corresponding EA under the EP Act. Therefore, operators apply at the same time for both these permits. The Queensland Department of Environment and Science (QDES) is the administering authority of the EP Act, which is the primary environmental legislation in Queensland. The EP Act regulates ‘environmentally relevant activities’ via the requirement for an EA, and CSG extractive activities are defined as ‘environmentally relevant activities’. Decisions involving the grant of an EA, or a minor or major modification to an EA, must have regard to the precautionary principle, other principles associated with ecologically sustainable development, but also matters such as best practice environmental management, the financial implications of the requirements and the public interest.

CSG produced water (or associated water) comes within the definition of a ‘waste’ in the EP Act because it is a ‘left over, or an unwanted by-product, from an industrial, ... activity.’ Injection of a waste fluid into a natural underground reservoir or aquifer is regulated as part of the CSG extraction activity under the Environmental Protection Regulation 2019 (Qld) (EP Reg). The regulator must refuse to grant an application for an EA for an activity that involves or may involve the release of waste directly to groundwater, if the injection may affect a surface ecological system adversely or deteriorate the environmental values of the receiving groundwater.

In the process of applying for an EA, information must be provided for the relevant environmental values; potential impacts and also actions proposed to prevent these impacts; the quantity, flow rate and quality of CSG water that is likely to be generated; and the management

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879 P&G Act, ss 41 and 132(2); EP Act, ch 5 (although, one EA can apply to multiple petroleum tenures).  
880 The administering department of the EP Act has changed names over the last 10 years due to government changes. The current department, the Department of Environment and Science, was established following the November 2011 election; the preceding department, the Department of Environment and Heritage Protection, was established in April 2012 following the change of government at that time. It replaced the former Department of Environment and Resource Management, established after the March 2009 election, which had replaced the Queensland Environmental Protection Agency.  
881 EP Act, ss18, 107. Other ‘environmentally relevant activities’ are resource activities (mining, geothermal and greenhouse gas storage), agricultural environmentally relevant activities (sugar cane and large cattle grazing) and prescribed environmentally relevant activities defined in the Environmental Protection Regulation 2019 (Qld) (EP Reg) sch 2 (such as aquaculture, chemical processing, sewage and water treatment, etc).  
882 EP Act, s 176, 235, 241 and schedule 4, ‘standard criteria’ but not for amendments proposed by the department or with agreement with the operator: EP Act, s 219.  
883 P&G Act, ss 41 and 132(2); EP Act, ch 5 (although, one EA can apply to multiple petroleum tenures).  
884 EP Reg, sch 3, item 7.  
885 EP Reg, s 41. This provision contrasts directly with the Wyoming framework, which requires protection of groundwater resources by reference to various categories, see chapter 3 section 3(3)(iii) above, and WY Rules and Reg Env WQ Ch8 ss 4, 5.
measures for the CSG produced water and the criteria against which the applicant will measure management performance (the ‘measurable’ or ‘management criteria’). Ex A publicly notified Ex EIS will be required Ex to fully assess the potential adverse and beneficial environmental, economic and social impacts of the project, as well as the management, monitoring, planning and other measures proposed to minimise adverse environmental impacts. Most CSG projects are ‘coordinated projects’ under the State Development and Public Works Organisation Act 1971 (Qld) (because they involve complex state and Commonwealth approval requirements, have potentially significant impacts and are of regional strategic significance). The Queensland Coordinator-General manages the EIS process for coordinated projects; they will evaluate the EIS and recommend and impose conditions for the project, which must be included in any EA. Since 2012, the Queensland government will refer all CSG and coal-mining developments that are likely to have a significant impact on water resources (such as being likely to substantially change the quantity, quality or availability of surface or groundwater) to the IESC for advice. The preparation of the EIS is a

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888 An EIS is required where an activity would have a total disturbance area greater than 2,000 hectares at any one time during the life of the proposed activity. This includes areas occupied by well pads (single- or multi-directional), access tracks and roads, water storage dams, and process plants; see Department of Environment and Heritage Protection, Queensland Government, Triggers for Environmental Impact Statements under the Environmental Protection Act 1994 for Mining and Petroleum Activities (2010) <https://environment.des.qld.gov.au/management/impact-assessment/pdf/eis-guideline-trigger-criteria.pdf>.
889 EP Act, s 40.
891 However, not all projects are coordinated projects; some are assessed by the QDES under the EP Act. The project proponent can decide to refer the project to the Coordinator-General or the Coordinator General can declare the project without a referral: State Development and Public Work Organisation Act 1971 (Qld), ss 26 and 27AA. There are advantages for an operator to refer the proposed development to the Coordinator-General because Coordinated Projects streamline the EIS stage to some degree, there are different appeal provisions, and an emphasis on development and economic considerations of the project, rather than environmental impacts.
893 Ibid, ss 26, 29, 34A, 34D. There is also the opportunity to have an ‘impact assessment report’ (IAR) rather than an EIS if the Coordinator-General is of the opinion that the environmental effects of the project do not require an EIS, due to their scale and extent. The IAR does not require the preparation of terms of reference and may or may not involve public notification: State Development and Public Works Organisation Act 1971 (Qld), ss 34E–34L.
894 EP Act, s 205 (these were then known as the Coordinator-General’s conditions); any other conditions that the QDES may impose cannot be inconsistent with the Coordinator-General’s conditions.
895 When the Queensland government signed the National Partnership Agreement on Coal Seam Gas and Large Mining Development; Australian Government et al, National Partnership Agreement on Coal Seam and Large Coal Mining Development, above n 861.
substantial task, which takes much time and expense for operators. There is now an 18-month statutory time limit for the submission and acceptance of the EIS (which will include separate reports prepared by environmental consultants on the various environmental impacts). As mentioned above, it is also relied on for any Commonwealth assessment.

The nature of CSG development impacts on the depth of information that can be realistically and sensibly included in the EIS. There is no regional or cumulative environmental assessment for the leasing of the CSG resource, like there is in the US NEPA requirements. Environmental assessments are conducted by operators at the project level. Petroleum tenure is granted first as exploration permits (ATPs), which cover very large areas of land. Once certainty develops around where the commercially viable resource is located, the ATPs are converted to the smaller PLs. At the time of preparing the EIS, it is usually unknown where wells and other infrastructure will be located, and also the exact quantities of water that will be produced. Therefore, the regulator conditions the projects requiring subsequent management reports (be they injection management reports or CSG Water Monitoring and Management Plans, or general environmental management plans) to be developed as operations progress, when further information becomes available. In a sense, the regulator gets a second bite of the cherry in terms of permitting, because its approval is required for these plans. It is important to note that there are no legislative criteria for decisions relating to subsidiary management documents like a CSG produced water management plan or an injection management plan. Nevertheless, because those decisions are made under authority of the EP Act, they ought to be made in pursuance of the legislative objective of ecologically sustainable development. This is the context in which AM is applied by the Queensland regulator (QDES) and the Commonwealth Department of Environment.

**CSG Water Management Policy**

As part of the application for an EA, the CSG operator must show how the CSG produced water will be managed in accordance with the government’s *CSG Water Management Policy 2012*.897 Since 1 October 2014: *State Development and Public Work Organisation Act 1971* (Qld), s 27A. 898 See this chapter (5), section 3(a), above p 162. 899 Nelson, above n 112. 900 Allison Rose and Revel Pointon, ‘Earning a Licence to Mine: Rethinking the Use of Adaptive Management in Light of Recent Mining Land Court Outcomes’ (2018) 32 (9&10) Australian Environment Review 220. 901 EP Act, s 3 states: ‘The object of this Act is to protect Queensland’s environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (ecologically sustainable development).’ Ecologically sustainable development is otherwise undefined in the legislation. The argument that the objects of legislation should guide decision-making was made in Fisher, above n 440, 87; Katie Woolastan and Evan Hamman, ‘The Operation of the Precautionary Principle in Australian Environmental Law: An Examination of the Western Australian White Shark Drum Line Program’ (2015) 32(4) *Environmental and Planning Law Journal* 327, 339. 902 This sets out the government’s position on the management and use of CSG water; EP Reg, s 28.
Successive CSG Water Management policies have been issued by the Queensland Government in 2008, 2010 and December 2012. As mentioned in Chapter 1, changes to the policies have related to the phasing out of evaporation dams. The policy guides the management and use of CSG water under the EP Act, as well as what happens to the CSG produced water after it is extracted. It does not impact on the obligations under the Water Act (such as the ‘make good’ obligations), which relate to the impacts of the actual extraction on groundwater resources as discussed below.

The CSG Water Management Policy (2012) currently prescribes the following management hierarchy for CSG produced water:

- **Priority 1** – CSG water is used for a purpose that is beneficial to one or more of the following: the environment, existing or new water users, and existing or new water-dependent industries.
- **Priority 2** – After feasible beneficial use options have been considered, treating and disposing CSG water in a way that firstly avoids, and then minimises and mitigates, impacts on environmental values.

Injection of CSG water into depleted aquifers for recharge purposes is considered in the Policy as a beneficial use.

**Guidelines and standards for injection bores**

The Guideline for Treated Coal Seam Gas (CSG) Water Injection Well Construction Requirement (CSG Injection Well Guideline) sets out the technical requirements for wells used in connection with the aquifer injection of treated CSG produced water (but not brine). The wells must also comply with the current standards for water bore drilling activities as if they were water bores. Therefore, the drilling of these wells must also comply with the following standards:

- Queensland government’s Minimum Standards for the Construction and Reconditioning of Water Bores that Intersect the Sediments of Artesian Basins in Queensland and

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903 See the historic Queensland, Department of Environment and Resource Management, Coal Seam Gas Water Management Policy (2010) available online through Queensland Government, Library Catalogue https://www.qld.gov.au/environment/library; South-East Queensland Water (Distribution and Retail Restructuring) and Other Legislation Amendment Act 2010 (Qld); Environmental Protection (Greentape Reduction) and Other Legislation Amendment Act 2012 (Qld).


905 Ibid, see Table 1 – CSG water management options, 3.


908 Queensland, Department of Natural Resources, Mines and Energy, Minimum Standards for the Construction and Reconditioning of Water Bores that Intersect the Sediments of Artesian Basins in Queensland.
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- Commonwealth Government’s Minimum Construction Requirements for Water Bores in Australia.909

The environmental authority – key operating requirements

The EA contains conditions that govern the activities carried out pursuant to the petroleum tenure to protect the environment from that activity. The QDES imposes the conditions as part of the decision on the application for an EA for the entire project (therefore, conditions relate to all parts of the project from noise, dust, odour, water, rehabilitation, environmental offsets and financial assurance or bonding).910

For the disposal of CSG produced water, the key requirements will be found in the conditions that relate to groundwater and wastewater, and the operator’s CSG Water Management Plan and any relevant other subsidiary plans such as an approved injection management plan. An example of EA condition requirements for one of the AP LNG tenements is presented in Appendix 6. These conditions and documents must include the measurable criteria (termed ‘management criteria’) against which monitoring is measured to determine the effectiveness of the CSG water management.911 The criteria will include measures relating to the quantity and quality of the water used, treated, stored or disposed of, the protection of the environmental values affected by each relevant CSG activity and the disposal of waste, including, for example, salt generated from the management of the water.912

Environmental Protection (Water and Wetlands Biodiversity) Policy 2019

In addition, the Environmental Protection (Water and Wetlands Biodiversity) Policy 2019 (Qld) (EPP Water) is relevant because it prescribes the set water quality parameters for various types and uses of waters.913 Unfortunately, groundwater systems are not specifically noted in the EPP


910 See EP Act, ch 5, pt 5, div 6. The EP Reg has additional requirements for assessment by the Department, regarding aquifer injection relating to petroleum authorities. As mentioned above, EP Reg, s 41 requires the Department to refuse to grant the application if it considers that the release of the waste (to groundwater) is affecting adversely, or may affect adversely, a surface ecological system, or that the waste is likely to result in a deterioration in the environmental values of the receiving groundwater.

911 EP Act, s 126.


913 EPP Water, s 6 and sch 1.
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Water, but they will be relevant where the groundwater is put to agricultural uses (for both irrigation and livestock uses) and potable uses. The EPP Water\textsuperscript{914} prescribes compliance with the Queensland Water Quality Guidelines 2009\textsuperscript{915} and the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2018 Guidelines),\textsuperscript{916} which provide specific water quality parameters for these subsequent uses.

A note in the Queensland Water Quality Guidelines\textsuperscript{917} reveals the cautious attitude applied in Australia for activities that impact groundwater. The note highlights the current state of uncertainty relating to fauna within the groundwater systems and the systems generally:

Little is known of the lifecycles and environmental requirements of these quite recently discovered communities, and given their high conservation value, the groundwater upon which they depend should be given the highest level of protection.

As a cautionary note the reader should be aware that different conditions and processes operate in groundwater compared with surface waters and these can affect the fate and transport of many organic chemicals. This may have implications for the application of guidelines and management of groundwater quality.\textsuperscript{918}

(iii) Water Act

Extraction during CSG production

In 2010, amendments were made to both the P&G Act and the Water Act to provide for a framework whereby petroleum activities would hold underground water rights coupled with underground water obligations.\textsuperscript{919} No water licence is required for the extraction of water that is necessarily or unavoidably taken during activities authorised by the petroleum tenure (such as exploration or production).\textsuperscript{920} Section 185 of the P&G Act states:

\begin{itemize}
  \item EPP Water, s 8.
  \item Department of Environment and Heritage Protection, Queensland Water Quality Guidelines 2009, above n 849.
  \item Australian and New Zealand Environment and Conservation Council, and Agriculture and Resource Management Council of Australia and New Zealand, Australian and New Zealand Guidelines for Fresh and Marine Water Quality, above n 850.
  \item Department of Environment and Heritage Protection, Queensland Water Quality Guidelines 2009, above n 849.
  \item Department of Environment and Heritage Protection, Queensland Water Quality Guidelines 2009, above n 849, under heading 2.7.
  \item By the Water and Other Legislation Act 2010 (Qld).
  \item P&G Act, ss 185 & 188 and Water Act, s 808. Tenure holders must report extraction data to the Department: Petroleum and Gas (General Provisions) Regulation 2017 (Qld), s 43.
\end{itemize}
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The holder of a petroleum tenure may take or interfere with underground water in the area of the tenure if the taking or interference happens during the course of, or results from, the carrying out of another authorised activity for the tenure.

These are known as the tenure holder’s ‘underground water rights’ and these are subject to corresponding ‘underground water obligations’, which are set out in Chapter 3 of the Water Act.921 The water taken or produced is known collectively as ‘produced water’ and as ‘CSG water’ (for CSG projects) or ‘associated water’.922 There is no limit to the amount of water that may be extracted and it may be used for any purpose within or outside the area of the tenure subject, of course, to the provisions in the EP Act and the Waste Reduction and Recycling Act 2011 (Qld) (Waste Act).923 While an approval is not required for this extraction, impacts due to the quantity of water taken are sought to be managed through the underground water obligations framework in Chapter 3 of the Water Act. These obligations are automatic, consequent on extraction, and are explained in detail in Appendix 8 to this thesis. Generally, they involve operators conducting baseline assessments of water bores before development, monitoring groundwater, preparing an underground water impact report (UWIR) and also committing to ‘make good arrangements’ with affected landholders. Within the Surat CMA, to address the cumulative impacts of multiple operators, the Office of Groundwater Impact Assessment (OGIA) has been established to prepare the relevant UWIR.924 All operators provide data to OGIA so that a UWIR can be prepared that presents overall extractions and short- and long-term predictions of impacts, and also establishes the responsibility of various operators for ‘make good’ obligations and monitoring.

Extraction for Non-CSG activities

As already mentioned, legislative rights govern the use of water in Queensland. The Water Act regulates water extraction in Queensland by requiring any take or interference of water to be authorised by that Act or another Act (such as the P&G Act).925 There is a general authorisation to take or interfere with groundwater for any purpose, subject to the provisions of the relevant water

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921 P&G Act, s 185 and Water Act, ch 3.
922 For petroleum projects, P&G Act, s 15A; see s 185(4), which states that ‘underground water taken or interfered with under subsection 1(a), from a petroleum well is associated water.’
923 P&G Act, ss 185 (3)–(5). Previously, CSG water was only authorised to be provided to landholders that overlapped the petroleum tenure for stock and domestic use (the old s 186 P&G Act). A water licence was required if the water was provided to an off-tenement land holder. Since the introduction of the underground water obligations in Chapter 3 of the Water Act, and the governance framework in the EP Act and Waste Act, s 185 was amended and s 186 was omitted by the Land Water and Other Legislation Amendment Act 2013 (Qld) so that disposal of CSG water was no longer also governed under the Water Act.
924 Water Act, ch 3A.
925 Ibid, s 808.
Therefore, one must check whether the specific water plan curtails this general authorisation.

Water Plans are prepared by QDNRME for different catchment areas of the State. The plans allocate the quantum of water provided for consumptive and environmental purposes, and are created following a significant planning and consultation process for each catchment. The plans are implemented through water management protocols for the relevant catchment, which set out water dealing or trading rules, water sharing rules, seasonal water assignment rules and any volumes of unallocated water reserved for particular purposes or stated locations. Figure 19, below, indicates the various water catchment areas in Queensland. The relevant water catchments that apply to different parts of the Surat CMA are the Fitzroy, Burnett, Condamine–Balonne, Moonie and Border rivers and GAB areas.

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926 Water Act, s 101(1)(c) (Historically ss 20(2) and (3)). The general authorisation is also subject to the designation of underground water areas by the Water Regulation 2016 (Qld), none of which are relevant to this research.

927 Ibid, ch 2, pt 2.
This figure is an historic map, which was included in QDNRME’s website but is no longer available on the internet. It is historic because it shows the Border Rivers and Moonie plan areas as separate; however, they were combined in the new water plans issued in 2019. It is still a useful depiction of the other plan areas throughout the state: Department of Natural Resources and Mines, Queensland Government, *Catchment Areas* <https://www.dnrm.qld.gov.au/water/catchments-planning/catchments>. 

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In the case of the Surat CMA, the general authorisation is limited by the relevant water plans:

- Water Plan (Fitzroy Basin) 2011 (Qld) (Fitzroy WP);
- Water Plan (Burnett Basin) 2014 (Qld) (Burnett WP);
- Water Plan (Condamine and Balonne) 2019 (Qld) (C-B WP);
- Water Plan (Border Rivers and Moonie) 2019 (Qld) (BR and M WP); and
- Water Plan (Great Artesian Basin and Other Regional Aquifers) 2017 (Qld) (GABORA).

These water plans set out the extent to which groundwater is regulated for non-CSG users in that area. There are some areas within these plans, mostly shallower formations that are not part of the deeper GABORA aquifers, where groundwater extraction remains unregulated. These are areas of the Condamine and Balonne, Border Rivers and Moonie Water Plans, which are not included within the groundwater management areas in those specific water plans, and also the small portion of the Surat CMA that is within the Burnett Water plan.

The main authorisations for non-CSG users to take or interfere with water under the Water Act are, to a limited extent, the general statutory authorisation but, more relevantly, water licences or allocations. The works associated with accessing water, such as the construction of bores, are also within the ambit of the Planning Act 2017 (Qld) and may require a development permit.

Stock, domestic use and prescribed activities are generally exempted from needing a water entitlement. It should be noted that most land use controls on domestic or pastoral uses do not require a consideration of the availability of water. Additionally, in some areas of the Condamine

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929 And non-mining use.
930 C-B WP, s 10 and sch 4; BR and Moonie WP, s 12 and sch 4; Burnett WP, s 8 and sch 4.
931 Authorisations can be by way of a general statutory authorisation or by way of a water allocation, interim allocation, licence, seasonal water assignment, water permit, or a resource operation or distribution operation licence; Water Act, ch 2, pt 3. Water permits are short-term authorisations for particular purposes; Water Act ch 2, pt 3, div 3. Seasonal water entitlements (for either water licences or allocations) are sometimes called ‘temporary trades’ because they allow for unused water to be assigned to another water user. Resource operations licences and operation licences apply to of water schemes; Water Act, ch 2, pt 3, divs 5 and 6.
932 In certain water plans, the construction of a bore is an assessable development under the Planning Act, where a development permit is required from the State Assessment and Referral Agency: Planning Regulation 2017 (Qld), sch 10 pt 19.
933 Fitzroy WP, s 116; C-B WP, s 38; BR and Moonie WP, s 40; GABORA, s 26.
934 For example, in the Western Downs Regional Council planning area, dwelling houses, animal husbandry and even cropping are accepted development (they do not require planning approval) where they comply with the relevant codes, which do not mention access to water resources, see: Western Downs Regional Council Planning Scheme (2017), table of assessment 5.5.9, relating to rural zone and rural zone code 6.2.9 and the rural activities code 9.3.4, available at <https://www.wdrc.qld.gov.au/doing-business/planning-development/western-downs-planning-scheme-2017/>. This is similar to some parts of the USA, see: Lora Lucero and A Dan Tarlock, ‘Water Supply and Urban Growth in New Mexico: Same Old, Same Old or a New Era’.
and Balonne and Border Rivers plan areas, the exemption for stock and domestic use is limited to existing works. In the GABORA Plan area, domestic use and stock use (in some areas) is only exempted where the bore is controlled with a watertight delivery system and the extraction would not affect groundwater-dependent ecosystems and other users by certain drawdown levels. In the GABORA, there is also an exemption for economic or social purposes for Aboriginal or Torres Strait Islanders or prescribed activities, as long as it is no more than 2 ML, the bore is controlled and the cumulative drawdown for a groundwater-dependent ecosystem or another person is less than the trigger levels.

In all other cases, a water licence, allocation, permit or seasonal water assignment will be required (the latter 2 authorisations are for short-term uses). Licences are the form of entitlement that have historically been used in Queensland; they are gradually being phased out as Queensland adopts the reforms required by the NWI. Licences attach to land and can only be relocated with the consent of the department rather than traded. Allocations do not attach to land and can therefore be traded. As mentioned above in Chapter 2, it is not settled law in Queensland as to whether water licences or allocations are property rights. Each licence or allocation has a nominal volume, which can be adjusted by an announcement by the regulator throughout the year: ‘shortage


930 GABORA, s 26(3).

931 Ibid, s 26(2).


933 See discussion at chapter 2, section 4(d), above p 71.


935 Refer to above n 443.
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powers’ may limit extraction in times of scarcity. For example, since 1 July 2018, parts of the Central Condamine Alluvium have had announced allocations of 50% and 70%, and sub-areas of the Oakey Creek Groundwater area are at 80%.

In reality, water for non-CSG purposes is now limited (except for domestic use across the basin and for stock use in most areas) in the Surat CMA. In the Condamine–Balonne, Border Rivers and Moonie plan areas, the relevant plans require an application for a water licence to be refused if it would increase the amount of water that may be taken from the plan area. An application may be made for a water licence that may undergo public notification and is assessed against criteria in the Water Act as well as existing entitlements, the water plan and the public interest. Nevertheless, the preferred method of granting licences is through purchase of unallocated water when released by the department, either via a public auction, tender, fixed-price sale or a grant for a particular purpose (but it is usually through the tender process). The amount of unallocated water that is available is limited by the relevant water plan and, periodically, the department makes available amounts through this process. For example, in 2014 and 2016, there were releases of unallocated water in the GAB plan area through a tender process.

Since the GABORA commenced in 2017, while it is still possible to obtain a water licence with respect to unallocated water, the quantum of unallocated water in the basin has been significantly reduced (from 17.2 GL in the 2006 water plan to 2.225 GL in the new GABORA). Therefore, in the future, the most likely avenue for acquiring water rights in the Surat CMA will be

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945 C-B WP, s 33; BR and Moonie WP, s 35.
946 Water Act, s 112.
947 Water Act, ch 2 pt 3 div 2. The relevant Water Plans may provide a process whereby water licences may be granted (Water Act, s 116) and, usually, this process will be followed by the department rather than through the other process required by the Act (Water Act, ss.107–114). See also Water Act, s 129, which provides that an application is to be refused if it is inconsistent with a Water Plan.
948 Fitzroy WP, s 48 and Fitzroy Resource Operations Plan (September 2015), s 26 the repealed Water Regulation 2002, pt 2 div 1C; GABORA, s 22; Water Regulation 2016 (Qld), s16.
949 Fitzroy WP, s 38 and sch 8; Burnett WP, s 36; C-B WP, s 41 and sch 9; BR and Moonie WP, s 43 and sch 10; GABORA, s 16 and sch 4.
via purchase through tender or purchase and relocation of existing entitlements, but the current rules in place restrict this process. For example, water licences from the Hutton groundwater unit can only be relocated away from areas that are experiencing stress (from the Surat Hutton sub-area to the Eromanga Hutton sub-area, or from the Eastern Downs Marburg sub-area to the Surat Hutton sub-area). 951

**Total extraction of water in the Surat CMA**

The amounts and types of non-CSG water extraction in the Surat CMA area was summarised in the UWIR 2016 (see Table 12, below). For the total area, from both GAB and non-GAB sources, agriculture is the largest user, and the relatively uncapped stock and domestic take is not insignificant. These are circled in red in the table, below.

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Table 12. Non-CSG extraction in the Surat CMA as at 2016[^952]

<table>
<thead>
<tr>
<th>Formation</th>
<th>Number of bores</th>
<th>Estimated groundwater extraction (ML/year)</th>
<th>Total (ML/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-GAB</td>
<td>S&amp;D</td>
<td>Total</td>
</tr>
<tr>
<td>Non-GAB upper formations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condamine Alluvium</td>
<td>1,144</td>
<td>2,709</td>
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<tr>
<td>Other alluvium</td>
<td>322</td>
<td>1,201</td>
<td>1,523</td>
</tr>
<tr>
<td>Main Range Volcanics &amp; Tertiary Volcanics</td>
<td>1,233</td>
<td>5,924</td>
<td>7,157</td>
</tr>
<tr>
<td>Other Cenozoic age units</td>
<td>11</td>
<td>165</td>
<td>176</td>
</tr>
<tr>
<td>Upper Cretaceous formations</td>
<td>7</td>
<td>210</td>
<td>217</td>
</tr>
<tr>
<td>Sub-total</td>
<td>2,777</td>
<td>10,209</td>
<td>12,986</td>
</tr>
<tr>
<td>GAB formations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wallumbilla Formation</td>
<td>3</td>
<td>90</td>
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<tr>
<td>Bungil Formation</td>
<td>3</td>
<td>232</td>
<td>235</td>
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<tr>
<td>Mooga Sandstone</td>
<td>8</td>
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<td>551</td>
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<tr>
<td>Oolallo Formation</td>
<td>31</td>
<td>620</td>
<td>651</td>
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<tr>
<td>Oubberamunda Sandstone</td>
<td>62</td>
<td>499</td>
<td>561</td>
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<tr>
<td>Westbourne Formation</td>
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<td>Springbok Sandstone</td>
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<td>233</td>
<td>265</td>
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<td>Walloon Coal Measures</td>
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<td>Durabillera Formation</td>
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<td>Hutton and Marburg Sandstones</td>
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<td>2,646</td>
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<td>Evergreen Formation</td>
<td>46</td>
<td>559</td>
<td>604</td>
</tr>
<tr>
<td>Precipice and Helidon Sandstones</td>
<td>29</td>
<td>293</td>
<td>322</td>
</tr>
<tr>
<td>Moolayember Formation</td>
<td></td>
<td>151</td>
<td>151</td>
</tr>
<tr>
<td>Sub-total</td>
<td>813</td>
<td>7,422</td>
<td>8,236</td>
</tr>
<tr>
<td>Non-GAB lower formations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clematis Sandstone</td>
<td>7</td>
<td>145</td>
<td>152</td>
</tr>
<tr>
<td>Rewan Group</td>
<td></td>
<td>111</td>
<td>111</td>
</tr>
<tr>
<td>Bandanna Formation</td>
<td>10</td>
<td>93</td>
<td>103</td>
</tr>
<tr>
<td>Bowen Permian</td>
<td>27</td>
<td>716</td>
<td>743</td>
</tr>
<tr>
<td>Basement Rocks</td>
<td>12</td>
<td>88</td>
<td>100</td>
</tr>
<tr>
<td>Sub-total</td>
<td>56</td>
<td>1,153</td>
<td>1,209</td>
</tr>
<tr>
<td>Total</td>
<td>3,646</td>
<td>18,784</td>
<td>22,430</td>
</tr>
</tbody>
</table>

Table 12. Non-CSG extraction in the Surat CMA as at 2016[^952]


182
Figure 20, below, presents the proportions of water users, including CSG extractors and amounts extracted (in ML).

A substantial amount of extraction of groundwater in the area is unmetered, even if licences state volumetric limits. Metering requirements are in Schedule 11 of the *Water Regulation 2016* and they relate to various sub-catchments in the State. Generally, in the Surat CMA, stock and domestic, agricultural, industrial and town water extraction is unmetered, except for where extraction is from the Border Rivers Alluvium, Central Condamine Alluvium and Oakey Creek groundwater areas; parts of the Dalrymple Creek Alluvium area; and a small part of the Mulgildie South Precipice sub-area of the GABORA, unless they are specifically conditioned (which is now rare). Admittedly, metering will also be conditioned for seasonal water assignment or where a GAB water licence is relocated, but this has only been a requirement since the GABORA was introduced in 2017. In contrast, CSG extraction is metered and extraction is regularly reported to QDNRME.

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954 These were amended in February 2019 by the *Water (Metering and Compliance) Amendment Regulation 2019* (Qld).

955 Water Reg, sch 11.

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OGIA, and made publicly available on the internet via the Queensland Government Queensland Digital Exploration Reports System (QDEX) reports webpage.

Is injection within the ambit of the Water Act?

As mentioned above, the Water Act regulates the taking of or interference with groundwater, where water plans and the regulation curtail the general statutory authorisation. Storing CSG produced water via injection into underground reservoirs (in the area of the tenure) necessarily impacts the water already in the formation. Impacting underground water in this way does not constitute a ‘taking’, but it is arguably within the meaning of ‘interfere’. Because the word ‘interfere’ is not defined in the Water Act, Bowskill J found recently, for coal mining, that:

it bears its ordinary meaning, which in this context is a broad one meaning to obstruct, hinder, get in the way of or prevent the flow of water.

The requirement for a water licence in circumstances where there is interference with groundwater has been applied to mining and quarrying activities, where the natural flow of groundwater is altered due to the pit void construction so that the water seeps into the pit and subsequently evaporates. The movement of the underground water caused by the injection of a treated CSG produced water would, therefore, arguably fall within the broad natural meaning of the word ‘interfere’ as used in the Water Act and recently interpreted by Bowskill J.

The statutory right for CSG activities to take and interfere with water during the course of or resulting from carrying out another authorised activity for the tenure means that water entitlements are not likely to be required for these activities. Examples given in the legislation refer to the extraction of the water as a necessary part of the exploration or production activities authorised under the Act and during the drilling of a petroleum well or water observation bores. Amendments were inserted into the P&G Act in 2016 to restrict this statutory authority so that where the take

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957 P&G Act, s 186(4). Extraction and use of non-associated water must be measured and reported to the chief executive, and Water Act, s376, requires the UWIR to include the quantity of water taken.
960 Prior to the amendments to the Mineral Resources Act 1989 and the Water Act by the Water Reform and Other Legislation Amendment Act 2014 (Qld) and the Environmental Protection (Underground Water Management) and Other Legislation Amendment Act 2016 (Qld); these amending Acts extended the statutory right to take water, as part of extractive activities that had been held by the petroleum and gas sector, to mining activities.
961 P&G Act, s 185.
962 By the Water Reform and Other Legislation Act 2014, the relevant sections commenced 6 December 2016.
or interference is for its use in the carrying out of another authorised activity, water licences will be required after 6 December 2021. Key authorised activities for petroleum leases include constructing and operating a facility for the processing and storage of produced water, whether or not the produced water was produced on-tenement or by the operator. Any interference with groundwater that occurs during the course of storage of treated produced water underground by injection will arguably continue to be covered by the statutory right in s 185 of the P&G Act. This is because it occurs ‘during the course of’ storage of treated water and the interference ‘results from’ the storage in the underground reservoir (the operative verbs in the authorising s 185), and because it does not ‘use’ (the operative verb in s 186) further water during that process.

For non-CSG operators who inject treated water into a groundwater formation, who are not covered by the statutory right to take or interfere with underground water, the situation will be different. The necessity for a water licence to ‘interfere’ with the resident groundwater in the aquifer will turn on the provisions in the relevant Water Plan. For aquifers within the GABORA water plan, a water licence will be required.

4. Conclusion for regulatory mechanisms

a) Queensland legal mechanisms for aquifer injection

We can now answer the third research sub-question for the Surat CMA:

What are the legal mechanisms that govern aquifer injection of CSG produced water in the Surat CMA, Queensland, Australia?


In summary, for aquifer injection in the CSG context, the project operator requires a petroleum lease, and the corresponding Queensland and Commonwealth EAs, which will in turn also require various subsidiary management plans such as an injection management plan and a CSG water management plan. The regulatory mechanisms that govern the aquifer injection activities specifically in Queensland are:

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963 P&G Act, s 186. For petroleum tenure in the Surat CMA, water licences are required for these activities 5 years after the commencement of the section, which commenced 6 December 2016. Activities outside the Surat CMA will require licences 2 years after 6 December 2016.

964 P&G Act, s 111A.
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- For access to the CSG produced water: the statutory right to extract the CSG produced water corresponding with the scope of the petroleum lease; and
- For the injection activity involving CSG produced water: the relevant conditions within the Queensland and Commonwealth EAs, and the subsidiary CSG water management plans and injection management plans.

b) Success or not success?

I can also address the fourth research sub-question for the Surat CMA:

<table>
<thead>
<tr>
<th>What does the empirical data suggest about the relative success or ‘not success’, in terms of sustainability, of the governance framework relating to:</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. The overall groundwater system?</td>
</tr>
<tr>
<td>b. Extraction of groundwater in the CSG context?</td>
</tr>
<tr>
<td>c. Injection of groundwater?</td>
</tr>
</tbody>
</table>

Queensland governance of the overall groundwater system appears to show significant weaknesses due to the overall deterioration of the resource. New studies in terms of the GAB have revealed that key aquifers are showing long-term declining trends, in some cases for over a century, and these were already evident before CSG development and are to some extent independent of CSG development. CSG development has certainly compounded the impacts within the Walloon Coal Measures and further impacts on groundwater users are predicted in both the short and longer term. Both factors (the pre-existing declines and future impacts) suggest that the overall groundwater governance in the Surat CMA has significant weaknesses.

The trends of over-extraction are being alleviated to some extent by the now significant amount of treated CSG produced water being recharged to the GAB. To date, AP LNG has recharged 15 GL to the Precipice Sandstone aquifer. Yet, it has taken many years of research and trials to achieve operational status in 2017. No readily publicly available material relates to the status of

965 Klohn Crippen Berger, above n 26, 71 and 73, showing selected hydrographs for the Hutton and Gubberamunda Sandstone aquifers.
967 If the historic levels of water extraction and the deterioration of the groundwater predating 2004 is considered, one could argue that the weaknesses in the governance system were present prior to the CSG industry being introduced. For the levels of historic water extraction, see Office of Groundwater Impact Assessment, above n 66, 132 (for historic extraction) and app D (for groundwater level trends).
969 Ibid.
the Santos Roma Aquifer injection project, targeting the Gubberamunda aquifer near Roma, and no other operators have adopted the process. In terms of impacts to water quality, there appears to have been minimal negative outcomes for AP LNG’s recharge project. This has been verified by extensive monitoring conducted by the operators and summarised in groundwater monitoring reports made publicly available by the operator.\(^\text{970}\) Therefore, despite overall deterioration in groundwater levels, which is exacerbated by overallocation of the resource system, the recharge project has been a positive impact.

In terms of conflict and trust, substantial community concern in relation to the impacts of CSG extraction on water resources has emerged during the period of rapid development. Four government inquiries and an independent review have examined water extraction by the petroleum and gas industry.\(^\text{971}\) Anti-CSG and citizen organisations such as ‘Lock the Gate’ and the ‘Basin Sustainability Alliance’ have emerged during the same period.\(^\text{972}\) Recent research on farmer perceptions of coexistence with the CSG industry in the Surat CMA reveals ongoing tensions relating to the impacts on water resources (among other things).\(^\text{973}\) The Queensland GasFields Commission, an independent statutory body established in 2012, is charged with facilitating the relationships among stakeholders.\(^\text{974}\) The Commission provides a wide array of information for landholders and industry, including a landholder guide and a ‘GasApp’, an application for smart phones that includes links to information and a compensation calculator.\(^\text{975}\) Despite this, there continues to be a lack of trust in the CSG industry, including the overall governance framework relating to water resources and the environment, especially in the context of CSG extraction.\(^\text{976}\) Moreover, substantial scholarly

\(^{970}\) Henning Prommer et al, *Geochemical Response to Reinjection* (2016) <https://gisera.csiro.au/project/geochemical-response-to-re-injection/>. This study was undertaken by researchers from GISERA, which collaborates with the Commonwealth Scientific and Industrial Research Organisation, the Commonwealth and State governments, and industry. See GISERA, https://gisera.csiro.au/; this is further discussed in chapters 6 and 7, below.


\(^{974}\) *GasFields Commission Act 2013* (Qld), s3


\(^{976}\) Gillespie et al, above n 173; Hunter, above n 971; Witt et al, above n 28; Walton and McCrea, above n 173.
works have critiqued the governance arrangements relating to the impacts of the CSG industry on water resources.\textsuperscript{977} These circumstances indicate a certain level of conflict and a lack of trust in the overall governance framework relating to water resources in the context of CSG extraction.

There has been widespread dissatisfaction with the governance framework in Queensland, particularly in terms of equity. A number of participants from different backgrounds, who were interviewed for this research, argued that it is inequitable for there to be no restriction on CSG operators’ rights to extract groundwater, while the same resource is capped and restricted to non-CSG water users.\textsuperscript{978} For example, one landholder participant complained that, ‘while the gas companies are extracting in an open slather manner, restrictions on agriculture make no sense’.\textsuperscript{979}

Other landholders complained:

> Ordinary landholders in the area have licences that are limited to domestic uses and stock watering, and would not be able to obtain a licence for irrigation. But because the gas companies can extract the water, they are irrigating in the area. But this use is deemed inappropriate for other users on the basis of the current status of water resources and so it is impossible to get a water licence for that purpose. This seems anomalous.\textsuperscript{980}

Some participants consider that the increased extraction by CSG operators has exacerbated pressure on the resource, which has resulted in the reduced quantum for unallocated water in the GABORA Water Plan.\textsuperscript{981} From the point of view of landholders, it appears as though the Queensland

\textsuperscript{977} See chapter 1, section 1(c), above p 15 - 16; Robertson, above n 90.
\textsuperscript{978} Interview with Participant Q3 (Telephone interview, 23 October 2017); Interview with Participant Q4 (Dalby, Queensland, 25 October 2017); Interview with Participants Q8 and Q9 (Roma, Queensland, 22 April 2018); see also Tan, George and Comino, above n 112; Poh-Ling Tan et al, ‘Water Planning in the Condamine Alluvium, Queensland: Sharing Information and Eliciting Views in a Context of Overallocation’ (2012) 474 Journal of Hydrology 38.
\textsuperscript{980} Interview with Participants Q8 and Q9 (Roma, Queensland, 22 April 2018).
\textsuperscript{981} Interview with Participant Q3 (Telephone interview, 23 October 2017); Lock the Gate, Submission No 28, to the Commonwealth Senate, Inquiry into the Adequacy of the Regulatory Framework Governing Water Use by the Extractive Industry, 15 December 2017; The Basin Sustainability Alliance, Submission No 20 to the Commonwealth Senate, Inquiry into the Adequacy of the Regulatory Framework Governing Water Use by the Extractive Industry, 14 December 2017; Helen Bender, Submission No 29, to the Commonwealth Senate,
government has prioritised CSG development over agricultural interests. At the same time, there is a perception that the resources industry faces a heavy tax burden in comparison to other users, and contributes more to knowledge and monitoring. A landholder with CSG experience noted:

there is a water market and that groundwater licences can be purchased. There is also an open tender also making it available. Furthermore, there has always been free stock and domestic use of groundwater ... The government taxes the resources companies quite well and landholders have actually been tapping in to it for years and not paying anything.

It should also be highlighted that other water users, who can also be said to be cumulatively impacting the resource through over-abstraction and, in some cases, contamination due to fertilisers, do not have similar obligations.

These appear to be symptoms of an overall governance framework that is not robust and probably points to an assessment of unsuccessful, at least for the present. Also, the framework appears to be unsuccessful for the governance of the extraction of CSG produced water. Similarly, regarding the governance of the subsequent injection of the CSG produced water, the framework appears to have been relatively unsuccessful because, despite finally returning treated CSG produced water to one depleted aquifer, it was a process that took many years to achieve and was not readily adopted by any other operators in the Surat CMA, nor does it seem it is likely to be adopted by any other operators in the future. These are presented in Table 13, below:

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982 Helen Bender, Submission No 29, to the Commonwealth Senate, Inquiry into the Adequacy of the Regulatory Framework Governing Water Use by the Extractive Industry, Undated; this was also noted by Poh-Ling Tan, KH Bownmer and C Baldwin, ‘Continued Challenges in the Policy and Legal Framework for Collaborative Water Planning’ (2012) 474 (Dec 12) Journal of Hydrology 84, 86.

983 Interview with Participant Q6 (Telephone interview, 26 October 2017).

984 Prof Andrew Garnett, University of Queensland, UQ Centre for Coal Seam Gas, Submission No 18, to Commonwealth Senate, Inquiry into the Adequacy of the Regulatory Framework Governing Water Use by the Extractive Industry, 22 January 2018.

985 Interview with Participant Q6 (Telephone interview, 26 October 2017).
Aspect of governance | Success or not-success?
---|---
Groundwater governance overall | Unsuccessful
Governance of extraction of CSG produced water | Unsuccessful due to continued deterioration of the overall groundwater resource, and existing conflict and lack of trust
Governance of injection process | Relatively unsuccessful due to the long delay and reluctance by other operators to adopt (despite the quantum injected)

Table 13. Summary of success/not-success of governance regime relating to groundwater, extraction and injection in the Surat CMA

The analysis of the Queensland framework and empirical data through the lens of the AIA design principles provide a further analysis for these findings in the next chapter.
CHAPTER 6: QUEENSLAND FRAMEWORK
MEASUREMENT AGAINST THE AIA DESIGN PRINCIPLES

Figure 21. Photograph of a Surat CMA injection facility, taken from the Queensland GasFields Commission’s Twitter account

Having canvassed the relevant Queensland governance mechanisms that relate to aquifer injection in the CSG context, I can now analyse this framework against the theoretically ideal AIA design principles. This chapter addresses the fifth and sixth research sub-questions, relating to the presence of the AIA design principles and whether there is a correlation between the design principles and the outcomes of the governance arrangements.

As with Chapter 4, where Wyoming’s regulatory framework was analysed in terms of the theoretical model to produce a ‘heat map’, this chapter presents the data collected for the Surat CMA in a similar way. Each of the design principles are considered in turn and graded in terms of whether it is present (green), partially present (amber) or absent (red) in the regulatory framework. Where AM has been applied, that approach is also discussed as relevant. After this detailed analysis, a summary table of the grading of the presence or implementation of the sub-principles and a corresponding jurisdiction specific heat map is presented.

Together, the analysis, summary table and heat map reveal that most of the design principles have not been met in the Queensland governance of aquifer injection of CSG produced water. These findings correlate with my earlier research findings as to the (relatively) unsuccessful
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governance framework. The general absence of AIA design principles correlate with my conclusion that the governance arrangements for groundwater generally and for the extraction of CSG produced water have been and are unsuccessful, and that the governance of injection of CSG produced water has been and is relatively unsuccessful in the Surat CMA.

1. **Clearly defined boundaries**

   a) Clarity around the social boundaries relating to the resource:

      (i) Identity of resource users

         There are key exceptions relating to the identity of resource users, how much groundwater can be extracted and uncertainty as to the aquifers from which groundwater is extracted. These findings result in this AIA design sub-principle being graded amber.

         The different requirements in terms of licencing water extraction means that it is difficult gain an accurate picture of exactly who is accessing groundwater and on what terms. Where extraction does not require licencing (such as for non-GAB stock and domestic users’ extraction), there is no reliable record of who is extracting water, from which location and aquifer, and how much water is extracted. Some of this information for licenced extraction is spread across multiple locations. The spreadsheets of data available through the Business Queensland website lists details such as location details and nominal authorised extraction limits. Copies of licences, which would include relevant conditions, can be accessed via a land title search for the relevant land parcel where the licence is located (because the licence attaches to the land parcel). Nevertheless, title searches are not free. The locations of registered water bores are also noted on Queensland Globe, but cross-checking these bores with the spreadsheet of licence data issued by QDNRME and against landholder records does not always provide consistent information. In addition, the aquifer attribution for the bore is often absent or inaccurate. The CSG wells are noted on Queensland Globe and the UWIR. There are biannual reports from CSG operators that list the quantum of CSG produced water extracted by each well via the QDEX report webpage, hosted by the Queensland

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986 See chapter 5, section 3(b)(iii) under the sub-headings ‘Extraction for non-CSG activities’, above p 171 and ‘Total extraction of water in the Surat CMA’, above p 178–180.


988 The current cost of a title search is A$36.60, which does not include a copy of the actual licence document.


990 This is because it is often difficult for drillers to determine this; Office of Groundwater Impact Assessment, above n 66, 121.
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government.991 Therefore, while there is information in the public domain, Queensland is yet to reach a level of clarity and transparency that would lead to this sub-principle being graded green.

(ii) The administrative boundaries to access groundwater

This AIA design sub-principle is attributed an amber grading for several reasons. First, the broad statutory authorisation relating to CSG extraction of groundwater calls into question whether there is, in fact, any administrative boundary for water extraction by the CSG industry (because it is essentially unlimited). Second, the overall weaknesses relating to compliance activities relating to the rules for extraction of all water resources in Queensland992 calls into question the efficacy of the administrative rules generally. This is despite the rules relating to water extraction being described as ‘well developed’ and a ‘significant strength.’993

(iii) The administrative boundaries for aquifer injection

The administrative rules relating to aquifer injection are attributed a red grading because they are not clear (or certain). The use of adaptive management to the conditions governing recharge result in changes over time as the project progresses. Yet, it should be noted that, to some extent, this has provided an avenue to develop appropriate conditions over time.

The relevant mechanism governing aquifer injection is a collection of conditions that are embedded within the EAs for the entire CSG project. They are not a separate entitlement for the activity of recharge, nor are they available transparently to the public. Determining the breadth and nature of the regulatory requirements is by no means straightforward. Being project-specific, one must look to the actual wording of the combined conditions in both the Commonwealth and Queensland EAs and the corresponding subsidiary management plans (which are not always made publicly available) to determine whether the aquifer injection activities994 are an ‘entitlement’.

For example, the Arrow Energy Commonwealth EA995 requires a CSG water monitoring and management plan that must detail how CSG produced water will be beneficially re-used ‘and/or’ whether groundwater re-pressurisation techniques will be used and how they will be managed.996 The Queensland EA includes conditions that authorise an injection trial involving one well for 180

991 Queensland Government, QDEX Reports, above n 958.
993 Waldron, Tan and Johnson, above n 992, 1.
994 Either feasibility studies, pilot programs or actual operations.
996 Ibid, condition 13(m).
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days of injection. Its CSG Water Management Strategy simply notes that the company will verify which strategy it will adopt (either providing CSG produced water to substitute existing water use or injection). In this case, the operator has an entitlement (found in the Queensland permit) to conduct a trial, if desired.

In contrast, the Commonwealth EAs for Santos, QGC and AP LNG each require the implementation of ‘a program and schedule for field piloting aquifer injection of CSG produced water’. The Queensland EAs provide the conditions that authorise the specific activities and the subsidiary CSG water management plans further detail how this will be done. No requirements are the same as they are location- and project-specific. For these operators, there is essentially a federal mandate to conduct aquifer injection feasibility studies, and field pilot programs if CSG extraction is to take place. The Queensland permitting arrangements have been crafted over time to detail how this is to be done. It is only after the entire suite of authorising documents are considered that it is possible to determine what obligations or opportunities exist for the various permitting arrangements.

**AM and the EA conditions relating to injection**

Even though there is uncertainty around the rules governing aquifer injection, arguably, the adoption of an AM approach has provided the opportunity for the development of appropriate requirements as the projects have proceeded. This grading will, no doubt, be highly

997 EPPG00972513 (9 May 2017) (Qld), conditions BE1–BE5.
999 EPBC 2008/4059 (22 October 2010) (Cth).
1000 EPBC 2008/4398 (22 October 2010) (Cth).
1001 EPBC 2009/4974 (24 October 2014) (Cth).
1002 Santos Ltd EAs: EPPG00898213 (19 September 2017) (Qld), conditions BE1–3, and EPPG00928713 (13 July 2018) (Qld), conditions BE2–BE25; QGC Pty Ltd EA: EPPG00903513 (15 September 2016) (Qld), conditions B18 and B19; Arrow Energy Pty Ltd EA: EPPG00972513 (9 May 2017) (Qld), conditions BE2 and BE4; AP LNG EAs: EPPG00885313 (8 February 2017) (Qld), condition B41, and EPPG00853213 (21 June 2018) (Qld), condition B52; EPPG00853013 (10 May 2018) (Qld), conditions B62–B66.
contentious because there are certainly gaps in how the regulators have enforced and applied an AM approach across the board, as discussed below. Some would argue that this lends itself to a red grading for the entire process. Yet, commitments by the operators in some circumstances have enabled appropriate rules or regulatory mechanisms to be developed by the regulator. This process has taken many years and has not been applied rigorously in all circumstances. Nonetheless, it has now resulted in large quantities of treated CSG produced water augmenting the Precipice Sandstone aquifer. Therefore, AM has, to some extent, softened the otherwise absence of clear administrative rules relating to aquifer injection. To reflect this positive outcome, despite the overall absence of a true adaptive approach, the criterion has been given an amber grading but with a red outline (to reflect the contestable grading).

The AM approach applied in the Queensland context has been unique. It has been applied at the operational level of projects as they proceed by both the operators and the administrative officers in QDES. There are no peer-reviewed articles on how both the regulator and operators have applied this process. As mentioned above,1004 the need for an AM approach is due to the Queensland governance framework, where the cumulative and basin-wide impacts are difficult to assess. This is because it relies on multiple independent project-specific environmental assessments conducted by operators (not in a holistic fashion by the regulatory agency). Moreover, the tenure granting process also allows for approvals to be granted prior to full knowledge about a project (or other projects) being known.1005 At the time the exploration permits are granted, it is impossible to know exactly where exploration activities will be undertaken. Similarly, even when the PL is granted, there is still uncertainty as to where the production wells will be located, how the development will proceed across a basin and the likely impacts such as the future quantum of water production. The legislative requirements for details about CSG water management at the time of the EA application require details around what is ‘reasonably expected.’1006 The adoption of the method in this way can be precautionary, because it should address these uncertainties relating to the projects going forward. Subsidiary management plans that must be subsequently approved by the regulator after EAs are issued provides the regulator with some continued control over operations as development and knowledge progresses.

AM is currently factored into this process through the following steps: monitoring is required; evaluation of the subsequently developed management plans occurs after the approval is issued; further monitoring and reporting then occurs and, if necessary, compliance activities before

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1004 Chapter 5, section 3(b)(ii), above p 168.
1005 Rose and Pointon, above n 900.
1006 EP Act, s 126.
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management plans and EA conditions are reassessed.\textsuperscript{1007} Much of the monitoring, evaluation and learning is outsourced in this framework to operators, but with varying degrees of commitment and success. All that is technically necessary is for the operator to provide an ‘evaluation’ of whether the CSG produced water management has been effective.\textsuperscript{1008} Nonetheless, the regulator is still required to apply an authentic adaptive approach, taking into consideration the information supplied by the operators. As already mentioned, caselaw sets out the requirements for AM in Australia,\textsuperscript{1009} there are no legislative requirements for decision-making to be publicly notified or public participation in this post-approval decision-making.\textsuperscript{1010}

There is criticism of how AM has been applied in Queensland for CSG activities.\textsuperscript{1011} Yet, the criticisms focus on the legislation and EAs at a certain point in time, rather than the entire governance arrangements including the subsidiary management plans, monitoring reports and ultimate administrative actions. No scholars have yet considered these further materials and actions. With a more in-depth analysis, one can see that AM is, in fact, occurring albeit in varying degrees. AM in this context appears to be simple single-loop learning essentially by some (but not all) operators, rather than double- or triple-loop learning as discussed in Chapter 2.\textsuperscript{1012} A flaw in the approach seems to be, first, a lack of clear decision-making thresholds and actions to be triggered at those thresholds; and second, a reluctance or inability on the part of the regulator to undertake compliance activities for this process. Both flaws centre on the compliance system adopted by the regulator: 1 of the 4 key requirements for AM in Australia.\textsuperscript{1013} Where operators show a lacklustre attempt at learning (and reporting), the regulator does not appear to be requiring these operators to apply authentic efforts towards the required outcomes or objectives.

For example, the legislation, in a practical way, implements an AM approach with respect to CSG produced water management. Mechanisms in the legislation are embedded so that an adaptive

\textsuperscript{1007} This was the process relied on by McDonald P in Adani Mining Pty Ltd v Land Services of Coast and Country & Ors [2015] QLC 48 (15 December 2015) in upholding an AM approach, see discussion at chapter 2 section 2(c), above p 54.
\textsuperscript{1008} EP Act, s 316K.
\textsuperscript{1009} Telstra Corporation v Hornsby Shire Council (2006) 67 NSWLR 256, 276, [164]; and discussion in Chapter 2 section 2(c) above, beginning at p 51.
\textsuperscript{1010} Rose and Pointon, above n 900
\textsuperscript{1011} Swayne, above n 112; Jessica Lee, ‘Theory to Practice: Adaptive Management of the Groundwater Impacts of Australian Mining Projects’, above n 112; Slattery, above n 112.
\textsuperscript{1012} Double-loop learning would reflect changed understandings of whether measurable or management criteria, or specific CSG water monitoring and management plan requirements are appropriate. Triple-loop learning would reflect changed understanding about the overarching aims of the regulatory framework and the ability of the CSG industry to mitigate impacts. It may also entail, for example, reconsidering the policy of allowing CSG extraction across the board, regardless of impacts. These higher order learnings are discussed further in Chapter 7.
\textsuperscript{1013} Telstra Corporation v Hornsby Shire Council (2006) 67 NSWLR 256, 276, [164].
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approach is required. Operators must annually report against measurable or ‘management’ criteria.\textsuperscript{1014} The management criteria are included in the CSG water management plans submitted by operators and accepted by the QDES. The objective of this exercise is effective and sustainable CSG produced water management,\textsuperscript{1015} and the requirement can drive learning and (hopefully) improvements in water management. The discreet management criteria, along with performance targets, provide the basis for evaluation of an individual operator’s CSG produced water management. Clearly, the performance targets and criteria used will determine the rigour of any subsequent evaluation. Even where operators may have uniform laudable objectives, such as ‘maximising beneficial use of CSG water,’ the performance targets to achieve this outcome set by the operators can effectively negate the overall objective of ‘effective and sustainable water management’.

A comparison between the annual returns of AP LNG, Arrow Energy and Santos relevantly reveals this problem (and is summarised in Table 14, below).\textsuperscript{1016} The AP LNG Combabula project had quite specific performance targets for ‘maximising beneficial use of CSG water’, such as ‘commission Reedy Creek aquifer injection scheme by July 2015’ and ‘once Reedy Creek aquifer injection scheme [is] operational, maintain proportion of treated CSG water beneficially used at 100% under normal operating conditions’.\textsuperscript{1017} These performance targets clearly ‘maximise [the] beneficial use of CSG produced water’ because they result in more water being injected into aquifers that is then available for other users. In contrast, Arrow Energy sets its key performance indicators for the same objective as: ‘water supply agreements in place’, ‘records of treated water supply (quantity and quality) for beneficial use are maintained’, and ‘complaints from landholders actioned in a timely manner are maintained’.\textsuperscript{1018} Similarly, Santos’s management criteria was simply to comply with the conditions in the EAs.\textsuperscript{1019}

\textsuperscript{1014} EP Act, ss 308 and 309. The measurable or management criteria (see Chapter 5 section 3(b)(ii), above p 169) are the criteria that require monitoring and assessing and relate to the effectiveness of the management of water, including quantity and quality of water used, treated, stored and disposed of, the protection of environmental values and the disposal of waste (salt): EP Act, s 126. They are agreed between the operator and regulator.
\textsuperscript{1015} EP Act, ss 3 and 126(1)(e).
\textsuperscript{1016} The QGC, \textit{Annual Return for EPPG0090315 (Woleebee Creek Project Area) (2015–16)} and QGC, \textit{Annual Return for EPPG0090315 (Woleebee Creek Project Area) (2016–17)} made available by QDES for QGC, which excluded QGC’s evaluation of its CSG water management.
\textsuperscript{1017} AP LNG, \textit{Annual Return for EPPG00853213 (Combabula)} (2016–17).
\textsuperscript{1018} Arrow Energy, \textit{Annual Return for EPPG00972513 (Dalby Expansion)} (2015–16).
\textsuperscript{1019} Santos Ltd, \textit{Annual Return for EPPG00898213 (Roma Shallow Gas)} (2014–15).
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| Specific operator measures for management criteria for ‘maximising beneficial use of CSG water’ |
|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| Commission Reedy Creek aquifer injection scheme by July 2015 | Water supply agreements in place | Comply with the conditions in the EAs |
| Once Reedy Creek aquifer injection scheme operational, maintain proportion of treated CSG water beneficially used at 100% under normal operating conditions | Records of treated water supply (quantity and quality) for beneficial use are maintained | Complaints from landholders actioned in a timely manner are maintained |

Table 14. Different operator measures for the management criteria of maximising beneficial use of CSG water

Each of the operators reported that the measures indicated were met. AP LNG’s commissioning of its Reedy Creek aquifer injection scheme took place and injected 100% of the treated CSG produced water from its water treatment facility. Even though performance indicators were met for both Arrow Energy and Santos, it is difficult to understand how the operators met the objective of ‘maximising beneficial use of CSG water’ by meeting these targets. Each of the operators’ annual returns appear to have been accepted by the regulator with no record of any enforcement action (although these are not usually reported transparently). The annual returns in question were obtained by the author only after making a direct application to the QDES: they are not freely available automatically. Given the varying degrees of how the approach has been applied by operators, there is not a transparent compliance system that enforces operators to apply authentic efforts at experimentation and learning.

Another example of AM applied by operators, but not necessarily enforced by the regulator, relates to the Commonwealth EA conditions. Each operator must report on the operations governed by the CSG Water Monitoring and Management Plans, report any non-compliances and report on how the operator will adjust operations to meet the conditions of the approval where necessary. The adaptation, in this context, is clearly single-loop learning because adaptation relates to the existing operational requirements: refining management plans and corresponding operations to reduce impacts and risks. The annual environmental returns by AP LNG, Santos and QGC document this process and illustrate how the operators, in each case, propose to manage operations adaptively.

1020 This arrangement is an example of the duplication and, perhaps, fragmentation that exists within the overall governance arrangements, which is discussed further below under section 8, relating to ‘nested enterprises’.
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going forward.\textsuperscript{1021} These evaluations and adaptations do not point to leaps in learning that reframe administrative action or operations, but they do incrementally improve action strategies on the part of operators. However, as with the Queensland position, the compliance activities of the Commonwealth Department of Environment are not made available transparently. While the operators appear to be applying an AM approach, an effective compliance program is not obvious.

The most effective application of AM, as applied by the operators, can be seen in terms of the learning that has taken place with respect to recharge activities. As mentioned, there is no specific permit or regulatory mechanism for the process and no aquifer injection using CSG produced water had ever occurred in Queensland prior to the approvals for gas extraction being granted. Nonetheless, the objective of re-pressurising aquifers was included in each of the Commonwealth EAs for the four gas extraction projects when they were approved.\textsuperscript{1022} To achieve this objective, all of the CSG projects were required to apply the staged approach advocated in the \textit{Commonwealth Australian Guidelines for Water Recycling: Managing Health and Environmental Risks} (Phase 2) \textit{Managed Aquifer Recharge} (2009).\textsuperscript{1023} Thus, a unified approach to permitting was applied. First, feasibility studies are required, followed by pilot trials prior to operational CSG produced water injection. Information from each stage feeds into the planning and implementation of the next stage. The information gathered at each stage allows for amendments to be made to the Queensland EAs governing the projects, and these become the substantive limits for the projects (for example, for water quality of injectate and injection pressures). In this way, the Queensland EAs were able to evolve: amendments of the environmental approval conditions occurs concurrently with this learning in a step-wise fashion.\textsuperscript{1024} During the stage where feasibility studies were


\textsuperscript{1022} EPBC 2010/5344 (19 December 2013) (Cth), Arrow Energy Pty Ltd; EPBC 2008/4059 (22 October 2010) (Cth), Santos Ltd; EPBC 2008/4398 (22 October 2010) (Cth), QGC Pty Ltd; EPBC 2009/4974 (24 October 2014) (Cth) AP LNG.

\textsuperscript{1023} Natural Resource Management Ministerial Council, National Health and Medical Research Council, and Environment Protection and Heritage Council, above n 867; despite not all of it being relevant, because that guideline deals with recycled water from other sources and ASR. In the past, there had been a Queensland Government CSG water injection policy (but it is not now publicly available).

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conducted, learning occurred as to where aquifer injection is suitable and when it is appropriate,\textsuperscript{1025} or in contrast inappropriate, particularly where low transmissivity of the aquifer would result in a very large footprint for the injection facility,\textsuperscript{1026} or where there are springs nearby,\textsuperscript{1027} or insufficient storage space in relevant aquifers.\textsuperscript{1028} Santos and AP LNG proceeded to the next stage of injection trials. Nevertheless, as already mentioned, there is no public record of the results or outcomes of the Santos trial. The AP LNG trial teased out any potential risks to the aquifer, at both local and regional scales, from full-scale aquifer injection prior to that occurring.\textsuperscript{1029} This reduced uncertainty around potential water-quality impacts because they were reviewed and reported on by a third party.\textsuperscript{1030} AM was clearly applied by AP LNG (at the very least), and this ultimately enabled its Reedy Creek and Spring Gully injection facilities to go ahead, despite the uncertainty and lack of a discreet permit (or collection of conditions) in the first place.

Therefore, an analysis of the secondary management reports reveals that AM is principally applied and adopted by some operators to varying degrees to eliminate uncertainty. The operators are conducting monitoring, research and evaluating outcomes. Yet, not all operators perform this function transparently. There are indications that there is a gap relating to decision-making and compliance measures by the regulator. There is no evidence of evaluation, learning and re-evaluation of requirements by the decision-maker. It is assumed that both departments were satisfied that aquifer injection was not suitable in certain cases, particularly where the feasibility studies ruled out the process and where they were subsequently abandoned (Santos) or not undertaken by the operators (Arrow Energy and QGC). However, because the decision-making and compliance activities of QDES and the Commonwealth Department of Environment are not publicly available, it is equally arguable that no decision was, in fact, made by the Departments. This research reflects findings relating to the management of surface water environmental flows within the Australian Murray–Darling Basin (the Edward–Wakool system), where AM was found to occur, but it was not obvious.\textsuperscript{1031} Without open discussion with the departments, it is impossible to know for

\textsuperscript{1026}AP LNG, Stage 2 CSG Water Monitoring and Management Plan, above n 1003, 301.
\textsuperscript{1027}Santos, Stage 2 revision 2 CSG Water and Monitoring and Management Plan, above n 1003, 89.
\textsuperscript{1028}Ibid, 118.
\textsuperscript{1029}It was noted in the AP LNG, Spring Gully Annual Fluid Injection Report (16 August 2016) that levels of arsenic had increased in one of the bores following injection: AP LNG, Annual Return for EPPG00885313 (5 September 2016) (Qld).
\textsuperscript{1030}Prommer et al, above n 970. This study was undertaken by researchers from GISERA, who collaborated with the Commonwealth Scientific and Industrial Research Organisation (CSIRO), the Commonwealth and State Governments, and industry: GISERA, The National GISERA Agreement (Alliance Agreement) (26 March 2019), <https://gisera.csiro.au/research-independence/national-gisera-agreement/>.
\textsuperscript{1031}Allan and Watts, above n 302.
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There may have been a re-evaluation by (at least) the Commonwealth Department of Environment that aquifer injection should be investigated in all circumstances (as reflected in the uniform conditions for studies and trials in the EAs). If this is the case, double-loop learning has in fact occurred. More on this topic is discussed in chapters 7 and 8.

For the purposes of this chapter, it is enough to acknowledge that AM has been a positive influence (albeit quite limited) for a design principle that was otherwise lacking. This is despite the lack of transparent decision-making and compliance activities by the regulator which, in itself, is alarming.

b) The physical boundaries of the resource

On the one hand, missing information, particularly relating to extraction, detracts from the efforts to clarify the boundaries of the resource by experts. On the other hand, the extensive and ongoing work by experts, especially the adaptive groundwater model by OGIA, improves knowledge about the physical boundaries of the resource over time. On balance, this criterion has been attributed an amber grading.

The total quantum of water extracted from the Surat CMA by CSG operators is publicly reported. Extraction data for non-CSG users, for example in the UWIR reports, are the result of estimations for some users due to the lack of metering for non-CSG water extraction. As mentioned in Chapter 5, metering of extractions is only required in various parts of the State and rarely undertaken for stock and domestic users. Even where licences require the holder to meter water use and report that use to the QDNRME, that information is not publicly available. This issue ultimately impacts on the clarity around the boundaries of the resource.

Despite this flaw in measurement, since the CSG industry commenced, there have been greater efforts to understand the groundwater resource. This addresses concerns by many who have argued that, at the time of developing the CSG resources, the knowledge about groundwater resources was insufficient. One landholder participant highlighted that ignorance about the

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1032 CSG operators must report the quantum of water extracted annually through their reporting obligations and, collectively, these are reported in the UWIRs and annual updates on the UWIRs: Queensland Government, Business Queensland, Surat CMA Underground Water Impact Report (1 July 2018), <https://www.business.qld.gov.au/industries/mining-energy-water/resources/land-environment/surat-cma/uwir>; QDEX webpage, above n 958.


1034 Chapter 5, section 3(b)(iii) at p 180.

1035 Water Regulation 2016, sch 11. For the Surat CMA, the areas requiring metering of extraction are the Border Rivers Alluvium, Central Condamine Alluvium, Oakey Creek groundwater area, parts of the Dalrymple Creek Alluvium area and a small part of the Mulgildie South Precipice sub-area of the GABORA (in this part, stock and domestic use is also metered); see also Waldron, Tan and Johnson, above n 992.

1036 Interview with Participants Q8 and Q9 (Roma, Queensland, 22 April 2018); interview with Participants Q10 and Q11 (Roma, Queensland, 24 April 2018).
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resource was also a factor in water use by non-CSG users.\textsuperscript{1037} Participant Q10, a landholder, explained:

\begin{quote}
in retrospect we had all been cowboys with respect to the water resource. They [we] extracted it but didn’t really understand the formations. The gas industry has been the medium through which much knowledge has been gained.\textsuperscript{1038}
\end{quote}

The same participant explained that the Walloon Coal Measures, which is now understood to be multiple coal seams, was previously considered an aquifer and that its name has since changed from the Walloons (aquifer) to the Walloons Coal Measures.\textsuperscript{1039}

A hydrogeological atlas has been produced by Geoscience Australia,\textsuperscript{1040} and the Commonwealth Government’s Bioregional Assessment Program also has contributed to knowledge of the resource.\textsuperscript{1041} Understandings of the groundwater flow within the GAB have developed, changing from an assumption that the flow was generally to the south-west to clarity around discharges along the eastern margins.\textsuperscript{1042} The estimates of the basin’s recharge continue to be reviewed and unfortunately the review of estimates are showing a downwards trend.\textsuperscript{1043} Clarity around regional groundwater trends is also developing, \textsuperscript{1044} and about the contact zones between the Surat geological basin, the upper Bowen basin formations and the Condamine Alluvium/Walloon Coal Measures.\textsuperscript{1045} Despite the ongoing research, there appears to be continuing concern by some

\begin{itemize}
\item \textsuperscript{1037} Interview with Participants Q10 and Q11 (Roma, Queensland, 24 April 2018).
\item \textsuperscript{1038} Ibid.
\item \textsuperscript{1039} Ibid.
\item \textsuperscript{1041} Bioregional assessments, such as the Maranoa-Balonne-Condamine Bioregional Assessment, provide baseline assessments of the basin. The assessments also identify areas that could be potentially impacted by development so that the regulator and proponents of development can apply local-scale modelling to aid decision-making. The assessments are available online at Australian Government, Bioregional Assessments, Assessments, Undated, <https://www.bioregionalassessments.gov.au>.
\item \textsuperscript{1044} Klohn Crippen Berger, above n 26; Office of Groundwater Impact Assessment, UWIR (2016), above n 26.
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landholders about the connectivity between the Walloon Coal Measures and aquifers such as the Hutton and the CCA.¹⁰⁴⁶

**AM and the OGIA model used to clarify boundaries of the resource**

A green grading has been attributed to this feature of the Queensland framework, due to the success by OGIA in adaptively managing and updating collective understanding about the physical groundwater resources in the Surat CMA.

In addition to the efforts described above, a hydrogeological model has been created by OGIA for the groundwater in the Surat CMA from data provided by operators (on a mandatory basis).¹⁰⁴⁷ The model contributes to the current knowledge about the groundwater resource in that area. This model is continually updated and refined with the steady stream of information being supplied by industry monitoring.¹⁰⁴⁸ OGIA also undertakes specific technical research projects (such as relating to groundwater flows).¹⁰⁴⁹ The model is made available to the public and explanations as to how it has been updated, including the forecasted predicted impacts, are clearly communicated by OGIA in annual reports and technical reports.¹⁰⁵⁰ OGIA has the power to require operators to furnish information.¹⁰⁵¹ OGIA has noted that there have been some issues relating to the form of information supplied to it by operators as well as accurate bore construction details and that, together with QDES compliance, actions are undertaken where appropriate.¹⁰⁵² Therefore, there appears to all four required steps for an authentic AM approach as required by the Australian Courts: monitoring, research, periodic evaluation and compliance measures. The clearly adaptive

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¹⁰⁴⁶ Interview with Participant Q3 (Telephone interview, 23 October 2017); interview with Participant Q4 (Dalby, Queensland, 25 October 2017).
¹⁰⁴⁸ Significant advances in knowledge have been gained due to the availability of data produced during CSG development. In 2010, there was only handful of monitoring points in the deeper aquifers. Now, there are approximately 200 monitoring bores in those deeper systems. The requirements for operators to conduct baseline assessments of bores in Part 3 Chapter 3 Water Act supports this process, along with the prescribed ongoing groundwater monitoring strategy in the UWIR.
¹⁰⁵¹ Water Act, s 460: the manager of OGIA may give an operator a notice to furnish information and if the notice is not complied with, a maximum penalty of 1,665 penalty units (A$217,365.75 as at 1 July 2018).
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approach by OGIA in updating its model and publicly reporting this information, contributes to the knowledge of groundwater resources. This process has been a positive step in increasing the collective knowledge about the groundwater resources in the Surat CMA. More about this is discussed in chapters 7 and 8.

2. Congruence between appropriation and provision rules and local conditions, including benefits and costs

   a) Congruence of rules and local conditions

      (i) Appropriation rules for water extraction that reflect local conditions

         Even though appropriation rules for non-CSG water extractors are catchment based on the whole, access to water by the CSG industry is not. The statutory right to extract water does not provide for the specific attributes of the location of extraction; no separate permit is required for a CSG well that extracts water and, therefore, this criterion has been given a red grading.1053

         Local impacts are supposed to be taken into account in the corresponding EA for the CSG extractive activity.1054 But the approvals for many of the CSG projects in the Surat CMA were granted prior to the impacts of extraction becoming known. To address this problem, an AM approach to the impacts of development was adopted in 2009.1055 Therefore, this approach has been largely applied to mitigate impacts (such as in respect of the management of CSG produced water) rather than curtailing extractive activities even when the impacts are irreversible.1056 This is sensible from an economic perspective, because mining and gas project investment decisions require a degree of certainty for future extraction. However, it can lead to consequences for other land users and the environment.1057 The state government’s application of the AM approach, in this context, has been generally criticised by other scholars,1058 as well as specifically within this research.1059

         In some parts of the GAB, notably at the south-eastern margins of the Surat Basin in the Surat CMA, some landholders within CSG production areas have limited physical recourse to deeper

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1053 Groundwater rules that apply to non-CSG industries do reflect the geographic issues and are basin specific, taking into account the specific issues that impact the resource in the relevant area.

1054 EP Act, ss 125 and 126; EPBC Act ss 24D and 24E.


1057 Randall, above n 112.


1059 In terms of the requirements for managing CSG water, see above, this chapter (6) section 1(a)(iii), beginning at bottom of p 193.
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formations such as the Precipice Sandstone, and very limited legal recourse to ‘capped’ resources, such as the Hutton Sandstone. When CSG extraction extends to these properties, the ability to ‘make good’ impacts from these deeper aquifers or other water sources will be extremely limited. For example, as explained by Participant Q3, a landholder, his business relies on a number of Walloon Coal Measures bores and a Hutton bore, and he is not physically able to access any other aquifers because they are not present. He is within the areas predicted to be impacted by approved future gas extraction. When the gas operations extend to his property, they will most certainly impact him by dewatering the Walloon Coal Measures. Make good arrangements can only come from the Hutton Sandstone (because there are no other groundwater resources), which is already showing reduced pressure and is capped by the QDNRME. For him, there can not be coexistence with CSG extraction because CSG operators will not be able to ‘make good’ likely predicted impacts from existing groundwater resources. Being within the Murray–Darling Basin catchment, alternative surface water resources are also limited. Moreover, the legislative framework does not provide any mechanism to require gas extraction to cease in those circumstances (this is discussed more in terms of the adequacy of the conflict resolution mechanisms, below).

Participant Q3 stated that his business is ‘totally reliant on water; no water means no business. The business has been expanding and is a proven business,’ and he felt that ‘the decision to privilege CSG extraction at the expense of businesses like mine [his] was short sighted.’ Thus, Participant Q3 reflects the downside of the state-wide statutory right: it does not take into account the variations in geography that may have drastic impacts for some users.

Participant Q3 is not likely to be alone in this situation. Presently, there are 91 existing bores that are predicted to be impacted by CSG extraction within the next three years (‘immediately affected areas’ or ‘IAA bores’) and 459 existing bores that are predicted to be impacted within the future (‘long term affected areas’ or ‘LAA bores’). At least 86 IAA bores and 338 LAA bores target the Walloon Coal Measures, which will be dewatered in order to extract the CSG. These

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1060 If there are any resource activities that were not approved prior to the commencement of the Regional Planning Interests Act 2014 (Qld), the CSG operator will likely require a RIDA and this may constrain the CSG activities. This is because landholders with agricultural businesses are likely to be on land that is either mapped as a ‘strategic cropping area’ or ‘priority agricultural area’. To obtain a RIDA, the CSG operator will need to show that the resource activity does not impact the agricultural activity. This will be difficult where the activities will directly impact the water resources because they drive the agricultural production. Although, it must be highlighted that the Regional Planning Interests Act 2014 (Qld) has a focus on land use and impacts to water resources are secondary, except with respect to priority agricultural areas (which overly the CCA).

1061 Interview with Participant Q3 (Telephone interview, 23 October 2017).

1062 For a discussion of ‘immediately affected areas’, ‘long term affected areas’ and the interesting conflict resolution mechanisms in place to deal with the impacts of CSG extraction on other water users, see Appendix 8.


1064 Ibid.
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bores will need alternative access to other groundwater supplies if they are to be ‘made good’. The pictures of where the IAAs and LAAs are located (taken from OGIA’s most recent approved UWIR) are shown in Figures 22 and 23, below.

Figure 22. Map of immediately affected area (IAAs)\textsuperscript{1065}

\textsuperscript{1065} Office of Groundwater Impact Assessment, UWIR (2016), above n 26, 84.
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Figure 23. Map of long term affected areas (LAAs)\textsuperscript{1066}

It is difficult to know, without targeted geological research, how many landholders with bores in the IAAs or LAAs are in the same position as Participant Q3, whereby the local geology prevents the landholder from the ability to access other groundwater formations.\textsuperscript{1067} The Precipice Sandstone is the main formation from which water can still be made available from within then GAB,

\textsuperscript{1066} Ibid, 88.
\textsuperscript{1067} Because other groundwater formations of a suitable quality are non-existent.
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and it is not uniformly present across the Surat CMA, as shown in Figure 24, below. By cross-checking the IAAs and LAAs with the map, revealing the thickness of the Precipice Sandstone, it is possible to surmise (particularly for the areas north-east of Roma and near Cecil Plains, which are circled in red) that it is unlikely that Q3’s situation is unique.

Figure 24. Map showing thickness of the Precipice Sandstone aquifer, highlighting areas where the aquifer is absent and where LAA bores/wells are likely to exist

Adapted from: Office of Groundwater Impact Assessment, above n 66, 293.
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(ii) Rules for injection reflect local conditions

As already noted, the rules relevant to injection are not clear and project approvals have developed over time through AM. Through this process, local conditions appear to have been addressed to some extent because the permit requirements are not all the same. That said, they do not go so far as allowing a matching of injectate quality to lower quality aquifers that may be available. There appears to be an overall apparent preference for the injectate to be of a potable quality, despite the presence of many lower quality local aquifers. Therefore, this sub-design principle has been shaded amber to acknowledge the fact that, through the AM process, local conditions were considered to some extent (but not adequately).

Specific water-quality parameters in EA conditions and operational requirements in subsidiary management plans appear to vary between projects and this is the result of the staged approach conducted by the operators. The results of the different stages appear to have resulted in bespoke conditions being drafted. It is not possible to know exactly why particular conditions have been drafted in a particular way, because the administrative decisions are not readily publicly accessible. Therefore, the AM approach in connection with this design principle has also been shaded amber and outlined red to acknowledge the lack of transparency around decision-making by QDES.

A preference for the CSG produced water to be treated to a very high quality and injected into high-quality aquifers (such as the Precipice Sandstone, which has mean TDS of 200 mg/L)\textsuperscript{1069} appears to have been applied by QDES and the operators. It is worth noting that the average TDS of CSG produced water from the Walloon Coal Measures is around 3000 mg/L.\textsuperscript{1070} In contrast, the water quality requirements for TDS for aquifer injection activities in the various EAs are, respectively:

- max 600 mg/L (for AP LNG’s Combabula/Reedy Creek);\textsuperscript{1071}
- 300 mg/L (AP LNG’s Spring Gully);\textsuperscript{1072} and
- electrical conductivity of 1000 microS/cm, which is equivalent to 640 mg/L TDS (Santos’ Roma Shallow Gas project).\textsuperscript{1073}

\textsuperscript{1069}Klohn Crippen Berger, above n 26.
\textsuperscript{1070}Office of Groundwater Impact Assessment, above n 66, 40.
\textsuperscript{1071}EPPG00853213 (21 June 2018) (Qld).
\textsuperscript{1072}EPPG0085313 (8 February 2017) (Qld).
\textsuperscript{1073}EPPG00898213 (19 September 2017) (Qld).
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(Admittedly, two EAs do allow injectate to be simply within the 95th percentile of certain target formations,\textsuperscript{1074} but these projects have not proceeded to operational stages.)

There are aquifers in Queensland that have lower-quality water that perhaps could be utilised for injection. This would obviously depend on their transmissivity and capacity for storage in the area intended for injection.\textsuperscript{1075} A figure showing the stratigraphy of the Surat CMA with the mean TDSs reported is below (Figure 25). The Rolling Downs Aquifer Group has a mean TDS of at least 3000 mg/L, the Bungil and Mooga Sandstones has between 1000 and 7000 mg/L, the Orallo Formation has 1200 mg/L, the Gubberamunda Sandstone has 1000 mg/L, the Springbok Sandstone has 1000 mg/L, and for the Hutton has between 600 and 2,500 mg/L.\textsuperscript{1076} It is important to keep in mind that the measures for TDS displayed in the figure are the mean amounts and that there will always be local variations. Nonetheless, they show that, while somewhat locally driven conditions relating to the recharge process appear to be present, they do not go so far as to take advantage of available lower-quality groundwater resources.

\textsuperscript{1074} The Gubberamunda/Hutton/Precipice Sandstone aquifers for AP LNG’s Condabri project; EPPG00853013 (10 May 2018) (Qld) and the Gubberamunda for AP LNG’s Walloons project; EPPG00968013 (22 June 2018) (Qld).

\textsuperscript{1075} The Precipice Sandstone and the Gubberamunda Sandstone are the most permeable consolidated formations in the Surat CMA, and there is wide variability of permeability across the Hutton and Springbok sandstones: Office of Groundwater Impact Assessment, UWIR Draft (2019), above n 26, 31, 32.

\textsuperscript{1076} Klohn Crippen Berger, above n 26, 30–33.
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Figure 25. Illustration showing hydro-stratigraphy of the Surat CMA, showing mean reported TDS for various aquifers

b) Congruence between costs and benefits

(i) Appropriators pay for the proportion and impact of water extracted

The costs of fees for utilising groundwater in Queensland do not correspond to the proportion of water extracted, and so this sub-criterion is shaded red.

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The CSG operators are responsible for approximately one-third of the groundwater extracted in the Surat CMA but, arguably, financially contribute a larger share of the management of groundwater resources in the Surat CMA. The CSG operators entirely fund the OGIA, which manages the cumulative impacts of CSG extraction in the region.1078 The net levy in 2015–2016 for OGIA was A$4,060,000.1079 Additionally, the recharge projects that replace approximately 15 GL of water to the GAB were entirely funded by AP LNG and their upstream partner, Origin. APPEA states that the industry has invested A$3 billion in water treatment and recycling infrastructure where 41.8 GL of water was provided for beneficial use (mostly for irrigation).1080 QGC highlights that it has spent:

more than $1 billion on water-related treatment facilities, research, modelling and management including more than $120 million on groundwater research and monitoring in the Surat Basin to support sustainable water management practices.1081

These costs provide benefits for all Surat CMA water users, not just to address impacts directly related to CSG activities.1082 A significant amount of research is funded by the operators,1083 and monitoring conducted by industry is extensive across the basin. The information from these activities benefit users across the basin.

In comparison, other non-CSG water users, for example, agriculture and stock and domestic use, do not contribute in a way that reflects their relative impacts. Water licence fees directly

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1080 APPEA, Submission No 22, to the Commonwealth Senate, Inquiry into the Adequacy of the Regulatory Framework Governing Water Use by the Extractive Industry, January 2018, 34.
1083 See Office of Groundwater Impact Assessment, Annual Report 2017, <https://www.dnrm.qld.gov.au/__data/assets/pdf_file/0007/1257838/surat-uwir-annual-report-2017.pdf>, 15; University of Queensland, UQ Centre for Coal Seam Gas, Submission No 18, to Commonwealth Senate, Inquiry into the Adequacy of the Regulatory Framework Governing Water Use by the Extractive Industry, 22 January 2018, 3: ‘the data generated by resource exploration and the operations of the CSG industry has been critical input in expanding scientific knowledge of water resource systems. In the case of CSG, it is important to note that the large resource developments themselves have generated huge amounts of new data and scientific insights simply not achievable without these developments.’
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contribute to the costs of managing the groundwater resources.\(^{1084}\) If all 22,500 bores in the Surat CMA (as reported in the UWIR 2016) are licenced, this would provide A$1,886,625 in recurring licence fees.\(^{1085}\) Undoubtedly, landholders incur significant costs to access the water, such as through the construction of bores, and the deeper the bores, the more expensive it is.\(^{1086}\) Regardless, these access costs are incurred by anyone extracting water, CSG operators included, and do not contribute to the costs of managing the basin. Therefore, costs borne by the different classes of water users are not equal. Two-thirds of extraction are by non-CSG users who have had a very significant and continuing collective impact of certain GAB aquifers like the Hutton and Gubberamunda Sandstone aquifers. They do not contribute to two-thirds the costs of managing the resource,\(^{1087}\) nor is the cost to society of the depletion of these key aquifers addressed.

(ii) Economic costs/benefits of injection for those who undertake injection

The question whether there are inherent economic incentives in aquifer injection requirements (entitlements) requires additional targeted empirical research. There are strong indications that the process involves greater economic costs in Queensland than even in Wyoming. Therefore, this aspect of the recommendations is attributed a red question mark, indicating that further information is required, but it seems likely that the process does not have an appropriate cost/benefit ratio.

\(^{1084}\) The application fee is minimal, at present A$133.20, and there is an annual recurring fee of A$83.85; Schedule 12 Water Regulation 2016; the annual fee was waived in the 2017–2018 financial year for water licence holders in local government areas that are drought declared and on individually drought-declared properties; Queensland Government, Queensland Budget Strategy and Outlook 2017–2018; <https://www.treasury.qld.gov.au/resource/state-budget-2017-18/>., 202. Water harvesting charges do apply to water used in Water Management Areas, which are areas that are either declared by a regulation, water plan or water management protocol. There are 21 water management areas listed in schedule 14, Water Regulation 2016, which attract water charges of generally A$4.45 per ML. All of these water management areas relate to either surface water or groundwater outside the Surat CMA and are, therefore, not relevant to this study.


\(^{1087}\) The Commonwealth Department of Agriculture and Water Resources confirmed this point in its submission to the Senate Inquiry into Water Use by the Extractive Industry; Department of Agriculture and Water Resources, Submission No 30, to the Commonwealth Senate, Inquiry into the Adequacy of the Regulatory Framework Governing Water Use by the Extractive Industry, Undated, 5–6.
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There have been two reports that highlight the relative costs of aquifer injection relating to the CCA. QDNRM commissioned reports in 2012–2013, outlining the business case for different options relating to the use of CSG produced water in the CCA. The alternative that had the best economic cost/benefit ratio did not involve injection – supplying the water to the Chinchilla weir. Injection into the CCA was the most expensive option for operators. In 2013, a further comparison between alternative injection and substitution schemes was conducted by ARUP. In this second report, the injection alternative was also not the cheapest option. Obviously, for CSG produced water that is treated to a similar extent, surface discharge in the immediate vicinity of treatment will always be more cost effective than injection, because the activity is expensive in itself. The inability to account for the beneficial re-use of the water, because it is a ‘waste’, and also the high treatment costs required by the current EA conditions, would appear to increase the net cost of the process in Queensland.

Costs to treat CSG produced water, obviously, will vary due to the quality characteristics and quantity of the CSG produced water, and the intended quality of the treated output. However, as one landholder (with previous CSG employment experience) noted, he believed that it costs CSG companies around A$1000 ML to treat the CSG produced water. Considering the different treatment options, he stated that:

if we want to encourage a process, we must ensure that costs are minimal, not over-regulated and that it can used ‘fit for purpose’.

Similarly, another participant with previous regulatory experience remarked:

It seems as though there should be some incentive or recompense for those who have recharged water, or alternatively some extra cost imposed on those who do not. There should be a quid pro quo for having undertaken the process.

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1089 Interestingly, supplying the treated CSG produced water to the Chinchilla weir was what was adopted by QGC.
1090 Tree Crop technologies Pty Ltd, above n 1088, 123.
1092 ARUP, above n 1091.
1093 Interview with Participant Q6 (Telephone interview, 26 October 2017).
1094 Ibid.
1095 Interview with Participant Q7 (Brisbane, Queensland, 1 November 2017).
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Each operator undertakes its own business case for its own water management strategy. The business case will differ depending on the geography of the project, availability of suitable aquifers, the quantity and the quality of the CSG produced water, and the existing demand for the water by nearby landholders and also water-quality requirements for the treated output. The figures relating to these calculations are shrouded in commercial confidentiality and so are not publicly available. Despite this, various operators reflect on the economic feasibility of aquifer injection projects in their reports. Santos notes that the minimum requirements for a MAR project are that ‘MAR should have a net positive environmental outcome; the economic cost of MAR should be affordable for the project; and MAR should promote beneficial social equity.’ It also notes that the financial feasibility of a MAR project is determined based on the capital and operating expense required, a comparison with the cost of existing water treatment and management infrastructure, the potential to offset any future aquifer depletion and the triple bottom line of combined environmental, economic and social costs. Santos has not proceeded to use aquifer injection, or MAR, in its fields, which indicates that this balancing exercise may have weighed against injection.

No publicly available economic data is available for aquifer injection of CSG produced water into other groundwater sources, such as the Gubberamunda Sandstone around Roma or the Precipice Sandstone at Reedy Creek and Spring Gully. Because AP LNG has proceeded to the operational phase of injection at its facilities at Reedy Creek and Spring Gully, there can be assumed to be some factors that have encouraged this activity, despite the general lack of economic incentives. One landholder participant explained that the transmissivity and depth of the Precipice Sandstone at the point of injection activities was what made it more economically viable to do so (implying that, due to the transmissivity, lower costs of injection are incurred). Other factors unrelated to the direct economic cost of injection but related to the relative cost of other alternative disposal options may also be relevant. For example, a lack of alternative discharge options (such as a lack of access to the Dawson River) may mean that the only alternative is the extremely expensive option of physically transporting the water elsewhere. This may indirectly make the injection option more economically attractive.

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1096 Santos, Stage 2 Revision 2 CSG Water and Monitoring and Management Plan, above n 1003, 70.
1097 Ibid, 89.
1098 Interview with Participants Q10 and Q11 (Roma, Queensland, 24 April 2018).
3. **Collective choice arrangements**

(i) **Collective choice arrangements relating to the extraction of water**

Consultation not participation\(^{1099}\) occurs for extraction of water by both CSG and non-CSG users, and the effectiveness of the consultation to influence the rules has been broadly questioned. Therefore, this sub-criterion is shaded red.

The Queensland legislature and government controls all water usage.\(^{1100}\) Rules are not necessarily jointly framed by government agencies and relevant stakeholders. Rather, legislation and statutory instruments are enacted (or tabled) through Parliament and administered by government agencies. Governments can be replaced through the normal democratic processes, but management of a CPR like the GAB may not be optimised within election cycles and amid the broad issues that often determine democratic elections. Investigations of agency administration may occur under the *Ombudsman Act 2001* (Qld). Such investigations will not necessarily cure defects in the existing legislative framework and policy. If an administrative action is in accordance with the legislative framework, the Ombudsman must first consider that it was ‘unreasonable, unjust, oppressive, or improperly discriminatory in the particular circumstance’.\(^{1101}\) If the Ombudsman makes an adverse finding and appropriate steps are not taken by the agency, a report is made to the Premier and tabled in Parliament.\(^{1102}\) If the administrative actions are in accordance with current government policy, this remedy may be ineffectual.

Participatory arrangements for water planning and allocation in Queensland are not the higher levels of participation – such as ‘partnerships’, ‘delegated power’ or ‘citizen control’ – as enumerated by Arnstein.\(^{1103}\) It is also questionable as to whether such arrangements equate to the higher levels of participation in the IAP2 framework, where stakeholders are ‘involved’, ‘collaborate’ or are ‘empowered’.\(^{1104}\) Generally, governance arrangements are made via consultation, which ensures that stakeholders may be heard, but not necessarily heeded.\(^{1105}\)

For example, the creation of the statutory right to extract water by CSG operators and the later extension of that right to the mining sector underwent extensive community consultation with

\(^{1099}\) See chapter 2 section 2(b), above p 49 which notes the difference by reference to Arnstein’s Ladder of Participation and the IAP2 Spectrum of Participation.

\(^{1100}\) In 1910, the Crown (in right of the State) adopted the power in rights to ‘the use, flow and to the control of water’, including artesian groundwater; see *Rights in Water and Water Conservation and Utilization Act 1910* (Qld), s 5.

\(^{1101}\) *Ombudsman Act 2001* (Qld), s 49.

\(^{1102}\) Ibid, s 51.

\(^{1103}\) Arnstein, above n 291.

\(^{1104}\) IAPP, above n 291.

\(^{1105}\) Arnstein, above n 291.
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various community groups, industry fora, information sessions with landholders, and various documents such as discussion papers and position papers.\textsuperscript{1106} Despite many submissions criticising the inherent unfairness of some water users being exempted from the water planning and allocation system,\textsuperscript{1107} the government continued its support of the statutory right to reduce red tape for the mining industry.\textsuperscript{1108} Participant Q3 expressed dismay at his perceived inability to influence the rules associated with water extraction, particularly by the petroleum industry, despite being a significant employer in the region and having been in operation for more than half a century.\textsuperscript{1109} Participant Q3 remarked:

[I have] ... no ability to influence the rules despite being the largest employer in the local town area. [We] ... are totally reliant on water; no water means no business. The business has been expanding and is a proven business. ... the decision to privilege CSG extraction at the expense of businesses like [ours]... was short sighted. [Our business has] ... been around for 60 years and CSG will end in at most 30 years.\textsuperscript{1110}

Similarly, Participants Q8 and Q9 stated:

the representatives of the gas companies are always young employees, that are nonetheless very nice, but are not the decision-makers. They are not the ‘Head Men’. These people come into ... [our] homes and tell [us] the owners of the properties what the gas company’s plans are. This gets back to having an impact on decision-making. No matter how much jumping up and down occurs, the government and the gas companies don’t listen to or hear the concerns of the landholder. If there was a change to decision-making that they would like to see, it would be for a change to enable the quiet country people to be heard. Having corporate as well as government people stationed locally, and being local, might get the message through.\textsuperscript{1111}

Water planning for non-CSG uses is also via consultation rather than participation,\textsuperscript{1112} and has also been the subject of criticism. Landholder stakeholders have criticised the consultative

\textsuperscript{1107} Environmental Defenders Office Queensland, above n 979; World Wildlife Fund – Australia, above n 979; Wilderness Society, above n 979.
\textsuperscript{1109} Interview with Participant Q3 (Telephone interview, 23 October 2017).
\textsuperscript{1110} Ibid.
\textsuperscript{1111} Interview with Participants Q8 and Q9 (Roma, Queensland, 22 April 2018).
\textsuperscript{1112} Water plans for 23 catchments in Queensland are developed through extensive community, technical and scientific consultation, but the decision-maker is the QDNRME. They are statutory instruments (under the
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process relating to the GABORA Water Management Protocol 2017, in which minimum separation distances between bores were changed between the draft available for consultation and the enacted Water Management Protocol. The Basin Sustainability Alliance, landholder organisation, argued:

As the WMP [Water Management Protocol] is made under the Chief Executive’s authority and he/she has no requirement to develop a Consultation Report about how they dealt with stakeholder submissions – they are able to make any changes they like without being publicly accountable or providing any explanation as to why the changes were made ... the [Basin Sustainability Alliance] lost all respect for the integrity or transparency of Queensland’s water planning framework or consultation processes.1113

Applications for water licences are generally publicly notified, but not for stock and domestic purposes.1114 Where the application is publicly notified, interested parties can make submissions and have a right of review then can appeal any decision.1115 However, these are appeal rights and it is arguable whether the interested parties have any real influence in the decision-making system other than through submissions and ensuring that administrative processes are followed (through judicial review).

(ii) Collective choice arrangements relating to injection of CSG produced water – the EA process

Even though operators may have some ability to influence the rules for aquifer injection (as seen in my discussion above relating to EA conditions),1116 other stakeholders have a limited ability for input into this process and, therefore, this sub-criterion is also shaded red.

Statutory Instruments Act 1992), which are ultimately tabled in the state Parliament and can be disallowed by resolution (Statutory Instruments Act 1992 (Qld), ss49 and 50). Therefore, they do pass through the Legislative Assembly of Queensland Members of Parliament. Participation in this process is by the State members of Parliament rather than local government or other interested parties. Therefore, it has limited direct stakeholder participation.

1113 The Basin Sustainability Alliance, Submission No 20 to the Commonwealth Senate, Inquiry into the Adequacy of the Regulatory Framework Governing Water Use by the Extractive Industry, 14 December 2017, 12–13; Tan, Bowmer and Baldwin similarly argued for policy guidelines endorsing principles of collaborative planning, improvements in stakeholder and community engagement, and transparency around decision-making (amongst other things): Tan, Bowmer and Baldwin, above n 981.

1114 See Water Act, div 2 Part 3 of ch2 and particularly ss 112 and 114; the relevant historic provisions (ss 208 and 209) in operation, prior amendments made by the Water Reform and Other Legislation Amendment Act 2014 inserting a new Chapter 2, also exempted petroleum tenure holders from requiring public notice of any water applications.

1115 Water Act, ch 6.

1116 See chapter 6, section 1(a)(iii), above p 190.
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The setting of the conditions in the relevant EAs is by the QDES. There is input by the operators because the application process for the EA affords the operator the ability to present material that supports drafting the conditions in certain ways. This provides an avenue for the operator to discuss various condition terms with the department. Submitters to the original application for the EA have the ability to have departmental decisions reviewed: either by way of an internal review,\(^{1117}\) or an appeal to the Land Court.\(^{1118}\) If a person can demonstrate that the decision interferes with a private right or results in special damage, an application can be made for judicial review of the decision by the Supreme Court of Queensland.\(^{1119}\) These are not simple avenues of influence. They are expensive and beyond the means of most stakeholders, except for ‘local elites’ who already have influence. Judicial review can only ensure that due process occurs;\(^{1120}\) therefore, the same decisions can be re-made using the correct process. Administrative decisions (or omissions) by QDES on the subsidiary management plans are not required to be published and, therefore, will be difficult to review.\(^{1121}\)

This lack of participation in decision-making has been a key criticism of the framework by local stakeholders, such as landholders and the local government. Many activities by resources projects, such as the location of waste treatment and workers camps, have direct local impacts that necessarily impact on local governance. Despite this, the local government does not have input (formally or informally) into the setting of the EA conditions.\(^{1122}\) Similarly, a local landholder complained that the consultation process embedded in the EIS process is merely a forum for the operators to tell the local stakeholders what they will be doing rather than consulting with them.\(^{1123}\)

Landholder Participants Q8 and Q9 explained that:

- there is no consultation, just ‘telling’... often landholders won’t bother to go to these meetings because the consultation process is useless.\(^{1124}\)

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\(^{1117}\) Under Environmental Protection Act 1994 (EP Act), ch 11, pt 3, divs 1 and 2.

\(^{1118}\) EP Act, s 523 and sch 2 pt 1, which is a rehearing of the matter unaffected by the review decision; EP Act, s 527; it should be noted that this avenue of appeal is only available for site-specific applications for petroleum activities, but given that, at present, all petroleum projects are ‘site-specific’ because there are only eligibility criteria and standard conditions for petroleum exploration, surveys and pipelines; see EP Act, ss 124, 112, 318 and the webpage, which has links to the ERA standards; Department of Environment and Science, Queensland Government, Environmental Authorities (12 April 2019) <https://environment.des.qld.gov.au/management/non-mining/environmental-authority.html>.

\(^{1119}\) The applicant must be a person ‘aggrieved’: Judicial Review Act 1991 (Qld), ss 19 and 20; Australian Conservation Foundation Inc v Commonwealth (1980) 146 CLR 493; Lock the Gate Alliance Ltd v Minister for Natural Resources and Mines [2018] QSC 021 (22 February 2018); Lock the Gate Alliance Ltd v Chief Executive under the Environmental Protection Act 1994 [2018] QSC 022 (22 February 2018).

\(^{1120}\) Judicial Review Act 1991 (Qld), s 20; Administrative Decisions (Judicial Review) Act 1977 (Cth), s 5.

\(^{1121}\) Sea Shepherd Australia Ltd v The State of Western Australia (2014) 200 LGERA 348.

\(^{1122}\) Interview with Participant Q5 (Roma, Queensland, 26 October 2017).

\(^{1123}\) Interview with Participants Q8 and Q9 (Roma, Queensland, 22 April 2018).

\(^{1124}\) Ibid.
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4. Monitoring

a) Monitoring of the activities impacting the resource and the resource

(i) Monitoring of groundwater extraction

This sub-criterion is shaded amber because there is a large portion of groundwater extraction that is not metered in the first place and water extraction data associated with particular bores is not made available. Yet, CSG extraction of water is reported to OGIA and QDNRME, and is also made available via six-monthly reports which display water and gas production, cumulatively and per well, in reports available through the QDEX report system on the QDNRME website.

(ii) Monitoring injection

Injection data is also not generally made available, therefore, this sub-design principle is shaded red. For example, no data has been made publicly available by Santos in relation to the Roma MAR Project pilot trial, targeting the Gubberamunda Sandstone aquifer. AP LNG has (seemingly voluntarily) made available information in the third-party review of injection activities and via groundwater reports. The Spring Gully Injection Management Plan 2017 requires injection bores to be monitored at 1-second intervals, and daily averages are reported to QDES and OGIA. But none of this information is readily available to the public.

(iii) Monitoring of the groundwater resource generally

There are widespread efforts to provide monitoring data for extant water levels and water quality by various levels of government and operators. Nevertheless, the lack of measurement of extraction and the disaggregated publication of monitoring data leads to this sub-criterion being shaded amber.

Efforts to provide monitoring information come from a variety of sources in a variety of ways, which make it difficult for users to gain an overall picture of groundwater impacts. The

1125 See chapter 5, section 3(b)(iii), above at p 180; Clare McKay and Alex Gardner, ‘Water Accounting Information and Confidentiality in Australia’ (2013) 41(1) Federal Law Review 127; Waldron, Tan and Johnson, above n 992.
1126 Queensland Government, QDEX reports, above n 958.
1127 Prommer et al, above n 970.
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Commonwealth Bureau of Meteorology (BOM)\textsuperscript{1130} presents monitoring information via various tools such as the National Groundwater Information System,\textsuperscript{1131} a web mapping portal called the Australian Groundwater Explorer,\textsuperscript{1132} the Australian Groundwater Insight web-portal\textsuperscript{1133} and the Groundwater Dependent Ecosystems Atlas.\textsuperscript{1134} However, BOM is prevented from disclosing information that relates to individual water use, so no water extraction data (if there was any) could be reported.\textsuperscript{1135} The location of monitoring wells operated by QDNRME\textsuperscript{1136} (and some CSG operators) and private bores is known.\textsuperscript{1137} There are laudable ‘citizen science’ initiatives, such as the DNRM\textsuperscript{E’s} ‘Groundwater Online’ and ‘Groundwater Net’, where a number of both GAB and non-GAB groundwater users (approximately 70 and 100, respectively) participate in groundwater monitoring initiatives: supplying information from private monitoring wells and receiving information about water levels and trends.\textsuperscript{1138} But their number is small (170), compared to the number who came along to information sessions and workshops run by the department (approximately 500),\textsuperscript{1139} and the overall quantum of appropriators (22,471 non-CSG groundwater bores in the Surat CMA).\textsuperscript{1140} Some of the relevant monitoring data from those bores is available on Queensland Globe,\textsuperscript{1141} and

\textsuperscript{1130} BOM is responsible for ‘collecting, holding, managing, interpreting and disseminating Australia’s water information’; s 120 and generally Part 7 of the Water Act 2008 (Cth) and Part 7 of the Water Regulations 2008.
\textsuperscript{1135} Water Act 2007 (Cth), s 123.
\textsuperscript{1137} There are approximately 88 monitored water-supply bores, which are mostly privately owned in the Great Artesian Basin Network within the Surat CMA area; Department of Natural Resources and Mines, Great Artesian Basin Ambient Network 2015–16 (January 2016) (now unfortunately no longer on the internet). In addition, there are 130 GAB monitoring bores across Queensland initiated under the Commonwealth government’s GABSI program, see Great Artesian Basin Coordinating Committee, Fact Sheet 6: Whole of Basin Monitoring Network, 2016, <http://www.gabcc.gov.au/sitecollectionimages/resources/b6ecbe1e-3a68-47a1-bf8d-092d7db8adea/files/whole-basin-monitoring-network-gab-factsheet.pdf>. There are also private monitoring bores, reported at approximately 100, under QDNRME’s ‘Groundwater Net’ program and 70 under the ‘Groundwater Online’ program: Office of Groundwater Impact Assessment, UWIR Draft (2019), above n 26, 114.
\textsuperscript{1138} Office of Groundwater Impact Assessment, UWIR Draft (2019), above n 26, 114.
\textsuperscript{1141} Queensland Government, Queensland Globe, above n 989.
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QDNRME’s Water Monitoring Information Portal. 1142 A recent commendable initiative of the department to present the information from landholders, the government and industry collectively is the digital ‘Groundwater Net Digital Report 2018’ platform, which provides groundwater information categorised by aquifers. 1143 QDNRME also notes locations of gas wells on the Qld Globe but not CSG produced water production data. While the data on Queensland Globe can be out of date (in some cases, it is almost a year old), the data on the water monitoring information portal is relatively current, albeit with respect to a smaller proportion of wells. A wealth of information about water extraction (by CSG operators) and groundwater data is received by OGIA but it is presented in a cumulative way in the UWIR rather than with respect to specific locations and wells. 1144 Detailed information about monitoring bore water level and quality is also provided in AP LNG’s groundwater assessment reports. 1145 Santos Ltd also makes available water monitoring data via its excellent water portal, which shows both water-level and -quality data for its monitoring bores. 1146

There are criticisms of the extant monitoring regime that relate to the location and breadth of monitoring. For example, the Surat CMA does not cover the entire Surat Basin and, therefore, OGIA manages some of that area and QDNRME manages the remainder. 1147 The IESC has argued that there is a lack of monitoring wells in the proximity of certain spring complexes, noting that the significant time lags typical of impacts to groundwater require better monitoring earlier. 1148

1144 Office of Groundwater Impact Assessment, UWIR (2016), above n 26, 94. A Joint Industry Plan was established between the CSG operators (Santos, Origin Energy and AP LNG) and QGC in 2013 in order to monitor groundwater to ensure that EPBC Act–protected springs suffer no adverse impacts for CSG extraction. This plan detailed 33 bores, which comprise the industry’s early-warning system for spring impacts, 12 bores measuring the regional impact to the Walloon Coal Measures and Bandanna Formation (the coal seams that are being dewatered) as well as approximately 400 bores comprising the joint industry monitoring network at the time. But that plan is now superseded due to changes in the model adopted by OGIA in the UWIR 2016 and practical problems that were incurred with the implementation of the trigger mechanisms in that plan, see AP LNG, Groundwater Management Plan Integrated Gas CDN/ID 11788517 (7 April 2017) <https://www.aplng.com.au/content/dam/aplng/compliance/Environmental%20and%20social%20management%20plans/Groundwater%20Management%20Plan.pdf>, 10–11.
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Additionally, it has been recommended that the number of QDNRME monitoring sites (including those relating to groundwater), which had recently been reduced, be reviewed.1149

Several participants confirmed these criticisms,1150 but one participant landholder is of the opposite opinion. The particular landholder has monitoring conducted by a CSG operator on his property, and he stated that he has his bores regularly tested and monitored, sometimes continually.1151 He felt that the Surat CMA now has the most amazing early-monitoring system for water availability, not just for his property but also throughout the basin.1152 He and his wife receive an email once a month from the company, they can also check the flow meters themselves and even have the ability (with the right technology) to access water data on their phones.1153 Clearly, it would seem that the information provided to landholders with CSG operators on their land is far superior than that to other landholders. This was confirmed by a representative of QDNRME, who provided anecdotal examples of how the monitoring data provided by industry helped inform landholders, even convincing them of the need for improvements to their own monitoring.1154 This was part of the impetus for the above-mentioned landholder monitoring group, known as ‘Groundwater Net’.1155

In short, the key issue for monitoring water levels and water quality is that not all information is readily accessible through one publicly available portal. It should be noted that DNRME are making good progress on this front with its ‘Groundwater Net Digital Report 2018’ platform. Nonetheless, a significant amount of information that is presented is collected by the operators rather than government. This not only impacts the confidence in the integrity of this data but, because it is disaggregated, it is difficult for the public to gain a thorough overall picture or have a high degree of confidence in the available monitoring data.1156

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1149 Waldron, Tan and Johnson, above n 992.
1150 Interview with Participant Q3 (Telephone interview, 23 October 2017); Interview with Participant Q7 (Brisbane, Queensland, 1 November 2017).
1151 Interview with Participants Q10 and Q11 (Roma, Queensland, 24 April 2018).
1152 Ibid.
1153 Ibid.
1154 Interview with Participant Q12 (Toowoomba, Queensland, 25 July 2018).
1155 Referred to above n 1137.
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b) Monitors monitored

This sub-criterion is shaded red because the government agencies that are responsible for making the monitoring data available are largely unaccountable to the public in Queensland.

There are several different monitoring networks that can be used to cross-check data, but there are no real avenues for the public to question this data. Because it is disaggregated, it is difficult to gain a comprehensive understanding of the information. The dissatisfaction, in terms of accountability for monitoring, was reflected by one local government representative who highlighted:

the department has essentially privatised the monitoring, because the CSG operators are reporting on most of the wells and even where the CSG companies further contract that job out, there does not appear to be independence in the monitoring. ... it is a bit like getting the fox to look after the hen house. It may be all above board, but this system will do nothing to counter the conspiracy theorists.1157

Some landholders have taken matters into their own hands, investing in monitoring to ensure that they have their own independent data. One landholder participant explained that he intends to install his own monitoring bores, which will cost him approximately A$100,000.1158

5. Graduated sanctions

(i) Sanctions relating to water over-extraction

This sub-criterion is shaded red for two reasons. First, the broad statutory authorisation means that there are no sanctions, because there are no volumetric limits on water extraction by the CSG industry. Second, even though there are technically graduated sanctions for non-compliance with water allocation rules (relating to both groundwater and surface water), the actual compliance measures applied by the regulator appear to be inadequate.1159 A recent independent audit reported that 75% of compliance cases resulted in no action and only 7 Penalty Infringement Notices being issued since 2003.1160

1157 Interview with Participant Q4 (Dalby, Queensland, 25 October 2017).
1158 Interview with Participant Q3 (Telephone interview, 23 October 2017).
1159 Water Act, ch 5, pt 3; there is an internal policy document Natural Resources Compliance Response Guidelines (May 2017) (unavailable to the public), which indicates that a risk-based approach is used for breaches and flexible sanctions applied from administrative actions to court orders, see Waldron, Tan and Johnson, above n 992, 106 and 108–109.
1160 The audit also noted that the sanctions could not be verified due to a lack of record keeping, see Waldron, Tan and Johnson, above n 992, 12 and 15–21.
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(ii) Sanctions relating to aquifer injection

This sub-criterion is shaded amber because, even though there are reported graduated sanctions for compliance measures relating to environmental regulation (which includes aquifer injection), the reports only include the more serious offences.\(^{1161}\) For the sub-design principle to be graded green, there would need to be transparent reporting of all sanctions to discourage free-riders and encourage compliance. The sanctions that have been imposed by QDES are reported by the Queensland Government in an enforcement register.\(^{1162}\) But this register does not include Penalty Infringement Notices for minor non-compliances or other administrative correspondence relating to compliance. The QDES notes, generally, the compliance measures undertaken in its annual reports and regular environmental regulatory updates sent via email to interested parties. In the 2016–2017 financial year, QDES reported that it issued 102 Penalty Infringement Notices for contraventions of EA conditions across the State and 45 environmental protection orders.\(^{1163}\) In the report, these measures are not attributed to any industry or operator, but the numbers do suggest that the department applies a graduated approach, thus warranting at least the amber grading.\(^{1164}\)

6. Conflict resolution mechanisms

(i) Conflicts over impacts of water extraction

This sub-design principle has been shaded red because the distinctive conflict resolution mechanisms in place for the impacts of water extraction by the CSG industry in the Surat Basin are not available.


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CMA are far from low-cost mechanisms in a local arena. Moreover, the overall efficacy of the framework is an issue for many landholders as well as industry.

As mentioned in Chapter 5, the impacts to water availability by CSG extraction (and now mining activities), are sought to be addressed through the ‘make good’ framework. The detailed legislative steps for these arrangements are summarised in Appendix 8 to this thesis. In summary, the arrangements rely on predicted impacts to landholders due to CSG extraction. The predictions are made through the detailed modelling performed by OGIA, based on data collected by operators. The predicted impacts are reported in the relevant UWIR, which triggers the requirements for bore assessments and specific make good arrangements with landholders. Alternative dispute resolution, arbitration or Land Court appeals are available in the event that agreement cannot be reached. Disputes in respect of ‘make good agreements’ can also be referred for investigations and recommendations to the Land Access Ombudsman. These arrangements are not low cost because they involve significant work by operators to collect data and by hydrogeologists to create the relevant model to predict when make good arrangements will be necessary, and they involve intense negotiations between landholders and operators to reach agreement.

There are many criticisms of the arrangements. The adequacy of the modelling used by OGIA has been questioned, on the basis that it is a regional model used to make predictions at a local level, and that it does not take into account the cumulative impacts of both CSG extractive

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1165 Water Act, ch 3.
1167 Under the Land Access Ombudsman Act 2017 (Qld).

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activities and non-CSG extractive activities, or groundwater and surface water interactions. Furthermore, long-term impacts that have not been predicted by a relevant UWIR, are not covered by the arrangements. Even where impacts have been predicted, the avenue for redress is through the dispute resolution mechanisms for make good obligations, being either a conference or ADR, then finally an application to the Land Court. If, at that time, the operator has essentially left the jurisdiction, the likelihood that these impacts will be addressed will be limited.

Furthermore, because we are seeing long-term downward trends related to the Hutton Aquifer, which appear not to be related entirely to CSG activities, not all negative impacts felt by landholders can be attributed to CSG activity. This will clearly lead to future conflict due to the bifurcated nature of the conflict resolution mechanisms: that Chapter 3 arrangements are drafted to manage cumulative CSG extraction but there are no mechanisms to address the impacts of cumulative extraction from all water users for the whole basin. A local government participant reflected this sentiment, noting that the ‘make good’ framework may make some sense with respect to one bore but questioning whether the impacts on bores over a whole basin can really be compensated. The framework also assumes that it is possible to make good all impacts and does not require CSG operations to be truncated or to cease. As mentioned above, currently, some water users rely entirely on groundwater from the CCA, the Walloon Coal Measures and the Hutton aquifer, because they cannot access deeper formations such as the Precipice Sandstone due to the hydrogeology of the area.

The ‘make good’ framework is a novel attempt to deal with predicted cumulative impacts and is not without merit. Nevertheless, it should be acknowledged that it is no panacea; it involves extensive efforts and costs borne by many, and there will be impacts from CSG extraction on groundwater resources that, perhaps, may never be able to be remediated.

1170 The Basin Sustainability Alliance, Submission No 20 to the Commonwealth Senate, Inquiry into the Adequacy of the Regulatory Framework Governing Water Use by the Extractive Industry, 14 December 2017, 23.
1172 Environmental Defenders’ Office of Australia, Submission No 4, to the Commonwealth Senate, Inquiry into the Adequacy of the Regulatory Framework Governing Water Use by the Extractive Industry, 19 December 2017, 5. This same sentiment was echoed by a local government participant Q4: Interview with Participant Q4 (Dalby, Queensland, 25 October 2017).
1173 Klohn Crippen Berger, above n 26, v.
1174 Interview with Participant Q4 (Dalby, Queensland, 25 October 2017).
1175 See this chapter (6) section 2(a)(i) ‘Appropriation rules for water extraction reflect local conditions’, above p 201–205.
(ii) Conflicts over impacts of aquifer recharge

None of the avenues of conflict resolution for aquifer injection are low-cost, local arenas and, therefore, this sub-criterion is also shaded red.

Where impacts to groundwater occur due to aquifer recharge activities, the avenue for redress available to a landholder is limited to a civil action against the relevant CSG operator in torts, for negligence or perhaps nuisance. This would be a difficult action to run, given the uncertainties present in groundwater systems and the necessity to prove a causal link between the aquifer recharge activity and damages suffered by the landholder.

However, if there are negative or harmful impacts to a groundwater system, the operator is likely to have committed an environmental offence under the EP Act. It is unlawful for a person to cause serious or material environmental harm unless it is authorised by an EA. Serious and material environmental harm are defined extremely widely. Material environmental harm includes adverse impacts on an environmental value that cost more than A$5000 to rectify; the maximum penalty is A$567,675 (4,500 penalty units) or 2 years imprisonment. Serious environmental harm includes impacts on environmental values that cost more than A$50,000 to rectify; the maximum subsequent penalty is A$788,437.50 (6,250 penalty units) or 5 years imprisonment. With spiralling civil works costs, the situations where activities fall within the definition of these offences are quite broad because the monetary thresholds are very low. In addition, it is an offence for an operator to contravene a condition of the EA (wilfully or otherwise); the maximum penalties are significant: A$788,437.50 (6,250 penalty units) or 5 years imprisonment or A$567,675 (4,500 penalty units), respectively. Therefore, if the impact to the groundwater system was caused by activities that fell outside of the EA conditions, the impact is likely to be an environmental offence. In this circumstance, orders will include not only the penalty but also requirements to clean up the impact. In some circumstances, but not all, this will not be possible.

Despite these onerous provisions, the costs of bringing such enforcement proceedings are extremely high. These are not low-cost conflict resolution mechanisms and one participant with previous bureaucratic experience noted that the government can be reluctant to bring such actions, due to the high associated financial and also administrative costs.
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7. **Minimal recognition of rights to organise relating to both water extraction and injection**

This design principle is shaded red in relation to both the rules for extraction and the rules relating to injection. Neither water users nor any other relevant stakeholders have any ability to self-organise in Queensland, because natural resources are entirely governed by the Queensland state government through the QDNRME and QDES in a centralised ‘command and control’ way. There are stakeholder groups present in the Surat CMA, such as the Local Government Association Queensland, Basin Sustainability Alliance, Great Artesian Basin Coordinating Committee, Queensland Farmers Federation, AgForce, APPEA and Queensland Resources Council (QRC), as well as working groups, which include a variety of stakeholders set up within the State government departments so as to perform a consultative role. Some of these, such as the landholder groups ‘Lock the Gate’ and the ‘Basin Sustainability Alliance,’ appear to have formed spontaneously and informally in reaction to CSG development and a perceived lack of influence. These bodies, regardless of how they are involved in consultation, can only influence the rules indirectly. Usually, it will be through informal lobbying, political pressure through the media and otherwise, informal and formal consultation, or litigation. Ultimately, the rules are established by

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1182 The Basin Sustainability Alliance is a not-for-profit organisation representing ‘landholder, community groups and individuals who are worried about the rapid and unrestrained development of the coal seam gas industry across Queensland’: Basin Sustainability Alliance, <http://notatanycost.com.au/>.
1183 The Great Artesian Basin Coordinating Committee provides advice ‘from community organisations and sectoral agencies to relevant Australian and State/Territory government Ministers on efficient, effective and sustainable whole-of-Basin resource management, and to coordinate activity between stakeholders’. Its membership comprises representatives from local governments and industry, as well as landholder and environmental stakeholders: Great Artesian Basin Coordinating Committee, The Committee, <http://www.gabcc.gov.au/committee>.
1185 AgForce is the peak body representing agricultural interests in Australia, particularly beef, sheep and grain: AgForce, AgForce (2019) <https://agforceqld.org.au/>.
1186 APPEA is the peak body representing the petroleum industry in Australia; its webpage is found at APPEA, <https://www.appea.com.au/>.
1187 QRC is the peak body representing the resources industry (mining as well as petroleum and gas) in Queensland: Queensland Resources Council (2019) <https://www.qrc.org.au/>.
1188 This has led to further conflict at times, which has even resulted in criminal proceedings. Drew Hutton, a ‘passionate and prominent advocate in the Lock the Gate campaign’ was arrested and convicted for obstructing QGC activities connected to the laying of a pipeline on a Queensland property near Chinchilla. The conviction was set aside, but the case reveals the frustration felt by these activists: *Hutton v the Queensland Police Service* [2012] QDC 368 (21 December 2012).
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the regulator in Brisbane. One local government participant specifically reflected on this, stating that he wondered whether decisions were made at a policy level before consultation took place.  

8. Nested enterprises

This design principle is shaded red because, on balance, there is little nesting of the organisational structures of the regulators in Queensland.

For example, the statutory right to extract groundwater as part of CSG extraction means that governance of this activity falls outside of water allocation and planning undertaken by QDNRME. Although, it should be noted that OGIA and the QDES CSG Compliance Unit is based in QDNRME. Regulation of CSG produced water extraction and injection are governed by QDES through the EA. QDES is in Brisbane, and the CSG compliance unit and OGIA are in Toowoomba. Neither agencies have local organisational units in the towns central to CSG activities: Chinchilla, Dalby, Miles or Roma. Recharge activities are also regulated by the Commonwealth Department of Environment in Canberra. The existence of two separate permit mechanisms governing the recharge activity (the State and Commonwealth EAs) also reflects the absence of a nested organisational structure for that process, despite administrative efforts to overcome duplication.  

QDNRME does feature nested arrangements relating to non-CSG extraction, but they are not necessarily coordinated with each other and the other departments. Governance of groundwater is divided between basins and each basin has its own team of officers, who work out of the local offices for that basin. Yet, data obtained by the regions is collected in locally held spreadsheets and databases, and there does not appear to be central oversight or review of these locally designed information systems. This reveals a lack of coordination between the separate local offices and higher administrative office in Brisbane.

As mentioned above, there is duplication between the Queensland EA and the Commonwealth EA relating to conditions for CSG produced water and injection, and there appears to be a lack of open coordination between the two relevant agencies. Unlike the Wyoming framework, where the WDEQ has been delegated authority under the US SDWA, two separate

1189 Interview with Participant Q4 (Dalby, Queensland, 25 October 2017).
1190 The Commonwealth Department of Environment has instituted various administrative steps to try to address this, for example, through meetings with senior staff from all jurisdictions, out-posting staff to other jurisdictions, greater reliance on state government conditions, and committing to open access to data and assessment information, see Department of Environment, Commonwealth, Submission No 100 to the Independent Review of the 2013 EPBC Act Amendment – Water Trigger, Undated, 4.
1191 The local business centres are throughout the State (but, for the Surat CMA, they are based in Toowoomba, Goondiwindi, St George and Warwick). Refer to the webpage at Department of Natural Resources, Mines and Energy, Queensland Government, Water Management Contacts, 2018, <https://www.dnrm.qld.gov.au/our-department/contact-us/water-related-applications-and-enquiries>.
1192 Waldron, Tan and Johnson, above n 992, 36.
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Approvals are necessary for activities in the Surat CMA. The impression is gained from permit reporting that there is a lack of coordination between these requirements, especially relating to CSG produced water. The overall lack of transparency around decision-making and reporting means that this can only be confirmed by communicating directly with the QDES and the Commonwealth Department of Environment. Yet, as mentioned above, both departments have not been open to communication for this research.

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1193 See the application of AM and Commonwealth EA conditions relating to CSG Water Monitoring and Management Plans at section 1(ii) under the heading ‘AM and the EA conditions’.
9. Measurement against the AIA design principles

(i) Were the AIA design principles adopted?

I can now answer the sixth research sub-question for the Surat CMA:

<table>
<thead>
<tr>
<th>Have the regulatory frameworks in each jurisdiction adopted the AIA design principles?</th>
</tr>
</thead>
</table>

Table 15, below, presents the summary of the analysis provided above relating to the PRB governance arrangements and the corresponding heat map follows:
Table 15. Grading attributed to presence/absence of AIA design principles for governance of groundwater in the Surat CMA
In addition, AM was applied in two key circumstances that impacted how various design sub-principles were implemented in Queensland. AM was somewhat applied by some operators in compliance with legislation and EA conditions: the key mechanisms for regulating injection. The use of AM by some operators has facilitated the development of appropriate conditions controlling injection. The application of the AM approach in this circumstance was flawed: some operators seemed to apply the approach voluntarily and compliance activities on the part of the regulator were missing. In addition, even though the approach appeared to tailor conditions somewhat to local conditions, this process did not appear to allow for matching of injectate to lesser-quality aquifers that may have been available. Nonetheless, this approach was still a positive development because it ultimately led to significant quantities of CSG produced water being injected, despite the original absence of any precedent permitting arrangements. Second, AM has been applied by OGIA with respect the development of its groundwater model, which certainly contributes to knowledge about the groundwater resource.

The table data and information relating to how AM was applied can be presented in the following ‘heat map’ (Figure 26, below):
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Figure 26. Heat map of AIA design principles for governance of groundwater in the Surat CMA
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On this analysis, the Queensland framework has significant weaknesses in terms of the overall design principles that have been recommended for governance of groundwater and aquifer injection, as noted in Chapter 2. The corresponding heat map clearly indicates areas of weakness in this governance framework, where aspects of the design principles are shaded as red. There were some aspects of the detailed designed principles that were evident (and therefore shaded amber), relating to: the boundaries of resource users, administrative rules for extracting groundwater and boundaries relating to the groundwater resource; rules for injection somewhat reflecting local conditions; monitoring of the extraction and resident groundwater resource; and graduated sanctions for non-compliance with aquifer injection requirements. In all other aspects, the detailed design principles were largely unmet.

Of note, the AM approach appears to have had positive influences in the governance arrangements for aquifer injection even though, at times, it was largely adopted voluntarily by certain operators. This context meant that the approach only had limited benefits. Whereas the adoption of a more authentic adaptive approach by OGIA is transforming knowledge about the boundaries of the resource. One can see how, over time, an adaptive approach could lead to more fulsome implementation of the design principles (thus changing the grading from red to amber to green in any case). These findings are discussed further in the next chapter, where a comparison with the Wyoming framework is provided.

(ii) Did success correlate with the AIA design principles in the Surat CMA?

I can now also answer the seventh research sub-question for the Surat CMA:

Did success (or ‘not success’) of the overall governance framework for groundwater and for extraction of CSG and injection correlate with the adoption (or absence) of the AIA design principles?

In Chapter 5, I concluded that the governance arrangements were not successful for the groundwater system generally, nor were they successful for the operational phases of CSG produced water extraction, and the governance arrangements for aquifer injection of CSG produced water were relatively unsuccessful. This correlates with the absence of most of Ostrom’s 8 design principles and the more detailed 21 AIA design principles.

In terms of the more detailed AIA design principles that relate to the governance of the entire groundwater system: 0 (zero) were fully present (green), 7 were partially present (amber) and 13 were absent (red); and one of the AIA design principles was unable to be graded due to a lack of
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information, but found likely to not be present (red). These findings are presented in Table 16 below:

<table>
<thead>
<tr>
<th>Sum of presence/partial presence/absence of AIA design principles</th>
<th>AIA design principles relating to governance of the groundwater system:</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (zero) are fully present (green)</td>
<td>Identity of groundwater users</td>
</tr>
<tr>
<td></td>
<td>Clarity of administrative boundaries to access the groundwater</td>
</tr>
<tr>
<td></td>
<td>Physical boundaries of the groundwater resource</td>
</tr>
<tr>
<td></td>
<td>Rules for injection that reflect local conditions</td>
</tr>
<tr>
<td></td>
<td>Monitoring of extraction</td>
</tr>
<tr>
<td></td>
<td>Monitoring of the resident groundwater resource</td>
</tr>
<tr>
<td></td>
<td>Sanctions relating to injection</td>
</tr>
<tr>
<td>7 are partially present (amber)</td>
<td>Clarity of administrative boundaries for aquifer injection</td>
</tr>
<tr>
<td></td>
<td>Appropriation rules that reflect local conditions for water extraction</td>
</tr>
<tr>
<td></td>
<td>Appropriators pay for the appropriate proportion of water extracted</td>
</tr>
<tr>
<td></td>
<td>Collective choice arrangements relating to extraction</td>
</tr>
<tr>
<td></td>
<td>Collective choice arrangements relating to injection</td>
</tr>
<tr>
<td></td>
<td>Monitoring of injection</td>
</tr>
<tr>
<td></td>
<td>Monitoring the monitors</td>
</tr>
<tr>
<td></td>
<td>Sanctions relating to extraction</td>
</tr>
<tr>
<td></td>
<td>Conflict resolution relating to extraction</td>
</tr>
<tr>
<td></td>
<td>Conflict resolution relating to injection</td>
</tr>
<tr>
<td></td>
<td>Rights to organise relating to extraction</td>
</tr>
<tr>
<td></td>
<td>Rights to organise relating to injection</td>
</tr>
<tr>
<td></td>
<td>Nested enterprises involving each of the regulators</td>
</tr>
<tr>
<td>13 are absent (red)</td>
<td>Economic benefit/costs of injection</td>
</tr>
<tr>
<td>1 is unable to be determined but likely to be absent</td>
<td></td>
</tr>
</tbody>
</table>

Table 16. Sum of presence/absence of AIA design principles for the governance of groundwater in Surat CMA

As with the analysis of the Wyoming framework, the governance of the separate operational phases of aquifer injection of CSG produced water can also be analysed in terms of the AIA design principles. For the 13 AIA design principles\footnote{Excluding the 8 AIA design principles that relate to injection activities.} that relate specifically to the extraction of CSG produced water: 0 (zero) are present (green), 4 are partially present (amber) and 9 are absent (red) (Table 17, below).

\footnote{Excluding the 8 AIA design principles that relate to injection activities.}
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<table>
<thead>
<tr>
<th>Sum of presence/partial presence/absence of AIA design principles</th>
<th>AIA design principles with respect to extraction of CSG produced water</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (zero) are present (green)</td>
<td>Identity of groundwater users</td>
</tr>
<tr>
<td>5 are partially present (amber)</td>
<td>Clarity of administrative boundaries to access the groundwater</td>
</tr>
<tr>
<td>8 are absent (red)</td>
<td>Physical boundaries of the groundwater resource</td>
</tr>
<tr>
<td>8 are absent (red)</td>
<td>Monitoring of extraction</td>
</tr>
<tr>
<td>8 are absent (red)</td>
<td>Monitoring of the resident groundwater resource</td>
</tr>
<tr>
<td>8 are absent (red)</td>
<td>Appropriation rules that reflect local conditions for water extraction</td>
</tr>
<tr>
<td>8 are absent (red)</td>
<td>Appropriators pay for the appropriate proportion of water extracted</td>
</tr>
<tr>
<td>8 are absent (red)</td>
<td>Collective choice arrangements relating to extraction</td>
</tr>
<tr>
<td>8 are absent (red)</td>
<td>Monitoring the monitors</td>
</tr>
<tr>
<td>8 are absent (red)</td>
<td>Sanctions relating to extraction</td>
</tr>
<tr>
<td>8 are absent (red)</td>
<td>Conflict resolution relating to extraction</td>
</tr>
<tr>
<td>8 are absent (red)</td>
<td>Rights to organise relating to extraction</td>
</tr>
<tr>
<td>8 are absent (red)</td>
<td>Monitoring the monitors</td>
</tr>
<tr>
<td>8 are absent (red)</td>
<td>Conflict resolution relating to extraction</td>
</tr>
<tr>
<td>8 are absent (red)</td>
<td>Rights to organise relating to extraction</td>
</tr>
<tr>
<td>8 are absent (red)</td>
<td>Nested enterprises involving each of the regulators</td>
</tr>
</tbody>
</table>

Table 17. Sum of presence/absence of AIA design principles relating to extraction in the Surat CMA

For the 13 AIA principles\textsuperscript{1195} that relate specifically to the governance of injection of CSG produced water: 0 (zero) are present (green), 5 are partially present, 7 are absent and 1 design principle was unable to graded but was likely to be absent (Table 18, below):

<table>
<thead>
<tr>
<th>Sum of presence/partial presence/absence of AIA design principles</th>
<th>AIA design principles with respect to injection of CSG produced water</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (zero) is fully present (green)</td>
<td>Identity of groundwater users</td>
</tr>
<tr>
<td>5 are partially present (amber)</td>
<td>Physical boundaries of the groundwater resource</td>
</tr>
<tr>
<td>7 are absent (red)</td>
<td>Rules for injection that reflect local conditions</td>
</tr>
<tr>
<td>7 are absent (red)</td>
<td>Monitoring of the resident groundwater resource</td>
</tr>
<tr>
<td>7 are absent (red)</td>
<td>Sanctions relating to injection</td>
</tr>
<tr>
<td>1 is unable to be determined but likely to be absent (red)</td>
<td>Clarity of administrative boundaries for aquifer injection</td>
</tr>
<tr>
<td>1 is unable to be determined but likely to be absent (red)</td>
<td>Collective choice arrangements relating to injection</td>
</tr>
<tr>
<td>1 is unable to be determined but likely to be absent (red)</td>
<td>Monitoring of injection</td>
</tr>
<tr>
<td>1 is unable to be determined but likely to be absent (red)</td>
<td>Monitoring the monitors</td>
</tr>
<tr>
<td>1 is unable to be determined but likely to be absent (red)</td>
<td>Conflict resolution relating to injection</td>
</tr>
<tr>
<td>1 is unable to be determined but likely to be absent (red)</td>
<td>Rights to organise relating to injection</td>
</tr>
<tr>
<td>1 is unable to be determined but likely to be absent (red)</td>
<td>Nested enterprises involving each of the regulators</td>
</tr>
</tbody>
</table>

Table 18. Sum of presence/absence of AIA design principles relating to injection in the Surat CMA

\textsuperscript{1195} Excluding the 8 AIA design principles that relate to extraction activities.
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The correlation between success or ‘not-success’ and the presence of the AIA design principles relating to the governance regimes for all activities impacting the groundwater system and the two operations phases is presented in Table 19, below.

<table>
<thead>
<tr>
<th>Governance of</th>
<th>Success or not-success?</th>
<th>Sum of presence/partial presence/absence of AIA design principles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater governance overall</td>
<td>Unsuccessful</td>
<td>Out of 21 overall AIA design principles: 0 (zero) are fully present (green) 7 are partially present (amber) 13 are absent (red) 1 design principle is likely to be absent (red).</td>
</tr>
<tr>
<td>Governance of extraction of CSG produced water</td>
<td>Unsuccessful due to continued deterioration of the overall groundwater resource and existing conflict and lack of trust</td>
<td>Out of 13 relevant AIA design principles: 0 (zero) are present (green) 5 are partially present (amber) 8 are absent (red)</td>
</tr>
<tr>
<td>Governance of injection process</td>
<td>Relatively unsuccessful due to the long delay and reluctance by other operators to adopt (despite the quantum injected)</td>
<td>Out of 13 relevant AIA design principles: 0 (zero) are fully present (green) 5 are partially present 7 are absent (red) 1 design principle is likely to be absent (red).</td>
</tr>
</tbody>
</table>

*Table 19. Correlation between success/not-success and presence of AIA design principles*

On the basis of these research findings, it appears that there is a correlation between an absence of the AIA design principles and the lack success of the governance arrangements relating to the groundwater system, as well as both operational phases: access to the CSG produced water and subsequent injection. The role of the absence or presence of the design principles in terms of the governance of aquifer injection using CSG produced water in the Surat CMA will be discussed in Chapter 7, where a comparison with the findings for the PRB is conducted.
PART D: DISCUSSION AND CONCLUSION

This part discusses the overall findings from the data synthesis and analysis chapters for both jurisdictions (chapters 4 and 6) in order to answer the overarching research question (Are there regulatory initiatives for aquifer injection and augmentation using CSG produced water that enable sustainable groundwater governance?).

Chapter 7 provides the overview and conclusions for the comparative study. Chapter 7 addresses the final two sub-research questions, relating to the importance of the AIA design principles and enabling and inhibiting features of the governance arrangements. Chapter 8 sums up the research by answering the overarching research question, and outlining initiatives that could be adopted. Chapter 8 also outlines areas for further research and presents reflections on this research prior to its conclusion.
CHAPTER 7: FINDINGS AND DISCUSSION

I have now canvassed the different regulatory frameworks and contexts for governing aquifer injection of CSG produced water (chapters 3 and 5). I have also put forward conclusions as to how successful those governance frameworks have been to date in achieving sustainable development of groundwater resources, extraction of CSG produced water and subsequent injection (chapters 3 and 5). I have detailed the presence or absence of the AIA design principles, and correlated these findings with the conclusions about success or not-success (chapters 4 and 6).

The findings from these earlier chapters are summarised and subsequently analysed in this chapter by comparing the findings for the two jurisdictions. The comparison reveals the importance of the various AIA design principles in terms of the governance frameworks for aquifer injection of CSG produced water in the Surat CMA and PRB. This chapter, therefore, addresses the final two research sub-questions, relating to the importance of the AIA design principles (sub-question 7) and enabling or inhibiting features in the governance arrangements (sub-question 8).

Through the comparison, I demonstrate that, overall, the AIA design principles are important for groundwater governance as well as governance of extraction and injection of CSG produced water. I demonstrate that an overall absence of the AIA design principles is an impediment to groundwater governance generally, and also for the governance of extraction of CSG produced water and subsequent injection. More specifically, for governance of aquifer injection, I demonstrate that a lack of clear and transparent rules for the injection process; a lack of rules that consider local geographic (and social) factors, and fragmentation between government agencies can be barriers to the activity. I also argue that, for the governance of the injection activity, a lack of formal collective choice mechanisms and rights to organise may not be as important for the operational phase of injection of CSG produced water. Nonetheless, informal or indirect avenues to influence decision-making may still be a positive feature for the injection process. In addition, I argue that unquantified benefits associated with injection may influence the process in some contexts. Finally, I conclude that transparency can more broadly enable or drive sustainable groundwater governance, as can adaptive management.
1. **The role of the various AIA design principles**

The comparative findings relating to the two jurisdictions are presented below, in heat maps placed side by side, which summarise the presence (or absence) of the AIA design principles in each jurisdiction (Figure 27, below). Table 20, below, summarises the research findings for the outcomes of the various governance arrangements (from chapters 3 and 5), and the presence, partial presence or absence of the AIA design principles (from chapters 4 and 6).
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Figure 27. Heat maps of the presence/absence of AIA design principles for both the PRB and Surat CMA
Aquifer injection in the coal seam gas context: Part D: Chapter 7: Findings and discussion

<table>
<thead>
<tr>
<th>Governance focus</th>
<th>Wyo/Qld</th>
<th>Success or not-success?</th>
<th>Presence/partial presence/absence of AIA design principles</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Groundwater</td>
<td>Wyo</td>
<td>Relatively successful</td>
<td>16 out of 21 overall AIA design principles present or partially present:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BUT not possible to definitively conclude either way due to truncated operations.</td>
<td>8 are fully present (green)</td>
</tr>
<tr>
<td></td>
<td>Qld</td>
<td>Unsuccessful</td>
<td>7 out of 21 overall AIA design principles are partially present:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0 (zero) are fully present (green), 7 are partially present (amber), 13 are absent (red)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 is likely to be absent.</td>
</tr>
<tr>
<td>b) Extraction of CSG produced water</td>
<td>Wyo</td>
<td>Relatively successful</td>
<td>11 out of 13 relevant AIA design principles present or partially present:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BUT not possible to definitively conclude either way due to truncated operations.</td>
<td>5 are present (green)</td>
</tr>
<tr>
<td></td>
<td>Qld</td>
<td>Unsuccessful</td>
<td>5 out of 13 relevant AIA design principles only partially present:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0 (zero) are present (green), 5 are partially present (amber) 8 are absent (red)</td>
</tr>
<tr>
<td>c) Injection of CSG produced water</td>
<td>Wyo</td>
<td>Successful</td>
<td>10 out of 13 relevant AIA design principles present or partially present:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(due to ready adoption of the process by many operators and the quantum injected over many years)</td>
<td>5 are present (green)</td>
</tr>
<tr>
<td></td>
<td>Qld</td>
<td>Relatively unsuccessful</td>
<td>5 out of 13 relevant AIA design principles only partially present:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(due to the long delay and reluctance by other operators to adopt (despite the quantum injected))</td>
<td>0 is present (green)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5 are partially present 7 are absent (red) 1 design principle is likely to be absent (red).</td>
</tr>
</tbody>
</table>

*Table 20. Table of comparative outcomes and presence/absence of AIA design principles*
It should be highlighted at the start of this exercise that is not possible to make a conclusive jot for jot comparison between the two jurisdictions, because of the truncation of CSG activities in Wyoming. Yet, it is possible and helpful to draw a finding of relative success in the PRB, for groundwater governance generally and also for the governance of CSG produced water extraction. This finding is based on the partial recovery of the groundwater system and because of the absence of residual trust issues and changes in decision-making, which occurred during conflict between the CSG industry and landholders in the PRB.1196

While keeping the above limitation in mind, a detailed study of the heat maps and comparison tables suggests that the presence of various design principles are important in both jurisdictions. In essence, it seems likely that the PRB framework would be more successful, in terms of sustainable governance, than the Surat CMA. We know that robust resource systems are characterised by most of Ostrom’s 8 design criteria (on which the AIA design principles are based) whereas the failures are not.1197 Which clusters of design principles are important in different contexts is now the subject of important research, including within this research project. Regardless, it must be noted that the design principles are not a cure-all. One may think of these design principles as ‘suggestions’ for CPR governance, depending on the context. Also, previous research posits that the more the design principles are present, the better, and clusters of design principles are important in different contexts.1198

Different factors will also be important for different resource systems and resource units. The relevant factors that are important in any particular case are revealed when analysing the frameworks and perhaps comparing them to other similar case studies, such as the rate of recharge of aquifers, competition for the resource and even other economic opportunities for landholders within the basins. No two case studies will be exactly alike, but they will hopefully be similar enough to be able to draw some conclusions about the design principles, while keeping in mind the distinctions.1199 Thinking about the incentives (and disincentives) that certain design features provide helps us understand enabling or inhibiting factors in the pursuit of sustainable outcomes. Both the PRB and Surat CMA frameworks can be analysed through this lens. The following analysis is intended

1196 These were discussed in chapter 3, above pp 89, 103 and 112-114.
1197 Cox, Arnold and Villamayor Tomas, above n 377; Babbitt, Burbach and Pennisi, above n 177; Baggio et al, above n 214; Ross and Martinez-Santos, above n 219.
1198 See chapter 2 section 3, above p 63–64: Babbitt, Burbach and Pennisi, above n 177; Baggio et al, above n 214.
1199 It is acknowledged, therefore, that the analysis will only ever be partial; a lifetime could be spent drilling down on the similarities and differences to determine the relevance and importance of various factors. This type of case-study based research which compares and contrasts variables and outcomes between broadly similar jurisdictions was adopted by Ross and Martinez-Santos, above n 219.
to determine the aspects of the design principles that were important in the two different jurisdictions for groundwater overall, and for extraction of groundwater in the CSG context and subsequent injection.

Another word of caution is warranted at the outset. While I am looking to establish a role for the AIA design principles, I must highlight that it is beyond the scope of this research to determine the specific degree of relative importance of any specific AIA design principle. That is, on analysis, I am able to assess whether a design principle is important, or not, based on the presence of various factors and outcomes. But I am not able to determine how much more or less important the design principle is by degree against any other. This will be highly contextual and would require exacting, targeted research. Nevertheless, by examining the congruence between the outcomes and the presence or absence of particular AIA design principles, and by considering the quantitative and qualitative data collected in this research, it is possible to reach conclusions as to their relevance and/or general importance. This will enable understanding about the relevant vulnerabilities or strengths of the two frameworks.

I conclude that the AIA design principles are, in fact, important in enabling sustainable governance of the groundwater systems, and also the separate operational phases of extraction of CSG produced water and subsequent injection of CSG produced water. Broadly, this is because they correlate with the relative success (or not) of the governance regimes in play (refer to Table 20, above). A more detailed discussion of this finding is warranted for the three related groundwater governance contexts (groundwater generally, extraction of CSG produced water and subsequent injection). Considering each context separately enables me to determine whether specific design principles are more important than others. The more detailed analysis presented here allows for a better understanding of the relevant strengths and weaknesses in each context.

a) Groundwater governance

(i) Surat CMA summary

The heat maps and the comparison tables indicate that the absence of AIA design principles may go some way to explaining the unsuccessful outcomes for the Surat CMA framework, in terms of overall governance of the groundwater system. As already mentioned, most of the AIA design principles were not present in the Surat CMA: out of 21 AIA design principles, none were fully adopted, only 7 were partially featured and 13 were entirely absent, with 1 sub-design principle likely to be absent.
Generally, my analysis found that, for the Surat CMA, there are issues relating to each of Ostrom’s design principles: fuzzy boundaries in terms of who is able to impact the resource and who is actually extracting or injecting into the resource (DP 1); rules that do not always reflect local circumstances and a lack of proportional cost-sharing for the resource (DP 2); an absence of collective input into rule-making (DP 3); weak monitoring (DP 4) and weak compliance measures (DP 5); minimal fora for conflict resolution (DP 6); no rights for the appropriators to organise themselves (DP 7); and fragmented agencies that are distanced from the appropriators (DP 8). These arrangements overall can contribute to a lack of collective decision-making, a lack of communal responsibility for the resource, incentives to pursue individual gain at the expense of the collective benefits, and the existence of free-riders and potentially rule-breakers.

Even though the current regulatory framework in Queensland aims to provide for the sustainable development of Queensland’s water resources,\(^\text{1200}\) there appears to be a problem in terms of both intra- and inter-generational equity. As mentioned in Chapter 5, many have argued that the system is unfair for different reasons, which may explain why there are continuing declining groundwater resources in some areas, why conflict exists between the users (especially between agriculture and the CSG industry), and why there is a lack of trust in the framework.\(^\text{1201}\) The declining groundwater levels in some parts of the Surat CMA\(^\text{1202}\) also indicate that future generations will not have the same opportunities as the current generation. For fossil aquifers, such as the GAB, there must be economic and social benefits that outweigh the consequent ecological impacts in the shorter and longer time-frames.\(^\text{1203}\) As discussed in Chapter 2,\(^\text{1204}\) ultimately, the sustainable limit for any groundwater resource will therefore be a function of political processes.\(^\text{1205}\) Robust political processes that engender trust and manage conflict will, therefore, be paramount in ensuring that the appropriate trade-offs (for the inevitable reduced aquifer levels) occur. They will also ensure consideration of local unintended consequences.

(ii) **Surat CMA: absence of DP 3 and DP 7**

Consequently, it is of broad concern that there appears to be weak collective choice arrangements (DP3) and rights of resource users to organise themselves (DP 7) to influence rules for extraction in the Surat CMA (injection is considered separately, below). Many participants,

\(^{1200}\) Water Act, s 2.

\(^{1201}\) Chapter 5, section 4(b), above p 183 - 184; Tan, George and Comino, above n 112; Tan et al, above n 978.

\(^{1202}\) Klohn Crippen Berger, above n 26.

\(^{1203}\) Foster and Loucks, above n 80; van der Gun and Lipponen, above n 214; see also chapter 2, section 1(a)(i), above p 40.

\(^{1204}\) Chapter 2, section 1(a)(i), above p 39–40.

particularly the landholders but also some representatives of government agencies, were unhappy about their perceived inability to influence the rules. I have already noted examples where landholders felt disempowered. A representative of local government also highlighted instances where he felt that he had an influence on the rules and, at other times, did not. Overall, he reflected that ‘whether there is an ability to influence the rules, depends on the political winds at the time.’

(iii) Surat CMA: absence of DP 8

The importance of nested arrangements (DP 8) where fossil groundwater is developed should not be overlooked. Nested enterprises generally tighten feedback loops between resource changes and response, and they also increase the proximity between knowledge of the resource, response capacity and decision-making. Therefore, in nested organisational structures, decision-makers are in closer proximity to the users. This not only provides information about the resource, it provides the stakeholders with an opportunity to know each other and build trust. Where collective choice arrangements (and rights to organise) are coordinated within a nested organisational structure, the higher-level agencies can protect against ‘elite’ local capture. The relatively smaller geographic footprint of the PRB versus the larger area of the Surat CMA would suggest that a less-nested organisational arrangement may be sufficient for the PRB context. Presumably a smaller area would enable local aspects to be more readily acknowledged. Yet, the opposite was implemented in that jurisdiction: the PRB governance arrangements feature more coordination, more collaboration and a decentralised model, as compared to the Surat governance arrangements. A more collaborative approach, as supported by CPR research, rather than the existing ‘command and control’, appears necessary for the Surat CMA. Landholder Participants Q10 and Q11 explained that:

government has a role to direct development sensibly. By treating the water as a ‘commons’, the government should be encouraging collaboration. It needs a truly bi-partisan or multi-partisan approach, whereby all of the political parties bring their own focuses together to deal with this issue collectively. Each of the parties have their own leaning – Labor in respect of people, the LNP focuses

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1206 See discussion in chapter 6 section 3(ii), above p 212–215.
1207 He felt that he had had success recently due to the current government coming into an election as opposed to in the past: Interview with Participant Q5 (Roma, Queensland, 26 October 2017).
1208 Interview with Participant Q5 (Roma, Queensland, 26 October 2017).
1209 Marshall, above at n 408.
1210 Ostrom, Understanding Institutional Diversity, above n 382, 268; see also Erik Mostert, ‘Water Management on the Island of IJsselmonde 1000 to 1953: Polycentric Governance, Adaptation, and Petrification’ (2012) 17(3) Ecology and Society 12, where the author describes how vested interests, a lack of leadership and path dependency resulted in a lack of flexibility and adaptability, despite polycentric arrangements.
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on money and the Greens the Environment. They all need to have an influence on the management of this resource. … when money is the underlying factor, things come unstuck.1211

(iv) Surat CMA: broader cultural context, and weak or absent DP 5, DP 3, DP 7 and DP 6

Moreover, there are indications that collective responsibility on the part of groundwater users may be weak in the Surat CMA. There are only a relatively small number of landholders voluntarily participating in the ‘citizen science’ initiatives relating to monitoring.1212 Some landholders have voluntarily contributed to the bore-capping program and, while this has benefited other users in the basin, it also undoubtedly benefits their own water security.1213 A lack of sanctions for landholders (DP 5), where over-extraction has occurred, encourages inefficiencies and does not support cultural change towards compliance or collective responsibility. The lack of any rights to organise (DP 7), coupled with a lack of collective choice arrangements (DP 3), may also contribute to this outcome.1214 The absence of the collective choice mechanisms and rights to organise should also be understood within the cultural legacy of the state-permitted riparianism and rule of absolute ownership of groundwater.1215 In Queensland, the regulator, in this case the Crown in right of the State legislature, permits water use without the constraints of a public trust doctrine,1216 or

1211 Interview with Participants Q10 and Q11 (Roma, Queensland, 24 April 2018).
1214 These themes are echoed by Bruce Lindsay, ‘Public Participation, Litigation and Adjudicative Procedure in Water Resources Management’ (2016) 33 Environmental Planning Law Journal 325 (with primary reference to NSW and Victoria).
1215 As Lee points out, ‘the institutions of property, privilege and authority that predate the recognition of interdependence are durable and likely to remain so’: Lee, above n 204, 12; Lindsay, above n 1214.
1216 Where the state holds the resource in trust for the public, the doctrine has not been adopted widely in Australia: Gardner et al, above n 441, [2.20] – [2.23], 32–33; Tim Bonyhady, ‘A Usable Past: The Public Trust in Australia’ (1995) 12(5) Environmental Planning Law Journal 329; Brian J Preston CJ, ‘Adapting to the Impacts of Climate Change: The Limits and Opportunities of Law in Conserving Biodiversity’ (2013) 30 Environmental Planning Law Journal 375. However, Fisher describes the legislative framework vesting rights in the Crown/State in Australia as an ‘inchoate public domain regime’, whereby ‘the exercise by the State of its [sovereign rights to “use” and “control”] … is accordingly an exercise of political power, in the sense that the rights are exercisable for the public benefit or in the public interest’, which are only restricted by the subject matter, scope and purpose of the enabling legislation, citing ICM Agriculture Pty Ltd v Commonwealth (2009)
correlative rights. Furthermore, historic approaches to groundwater extraction did not place limits on the activity based on impacts to the resource. Neither the government nor water users are accountable to other water users for over-extraction. This is in direct contrast to the transparency of landholder water rights and the ability to enforce priority in Wyoming.

Furthermore, there are adopted notions of privacy and confidentiality relating to water use in Queensland, which are based on individual concerns and do not reflect the communal nature of the groundwater resource. These factors in Queensland compound individualistic behaviours. Because the conflict resolution mechanisms (DP 6) between water users (including relating to CSG extraction) appear to be problematic, this can add to a lack of accountability and absence of responsibility for the common groundwater resource by individual water users. The context becomes akin to a prisoner’s dilemma, whereby incentives are present to maximise individual gains in the short term at the expense of the whole basin. This situation can contribute to the perception of a lack of communal ownership or responsibility for the common groundwater resource on the part of water users.

(v) Surat CMA: weak DP 4 and absent DP 5

Without measurement, one cannot easily manage a resource. The inability for monitoring the monitors (DP 4) in the Surat CMA, coupled with a lack of transparency with respect to


1217 Whereby surface water users are limited to a reasonable share of water resources: Embrey v Owen (1851) 6 EX 353; 155 ER 579.

1218 Such as the common-law rules relating to groundwater, whereby extraction was not curtailed by notions of ‘reasonable use’: Acton v Blundell (1843) 12 M & W 324; 152 ER 1223; Chasemore v Richards (1859) 7 HL Cas 349; 11 ER 140; Bradford v Pickles [1895] AC 587, 601.


1220 McKay and Gardner, above n 1125; see also Water Act 2007 (Cth), s 123.

1221 Skurray, above n 387.

1222 Ibid.

1223 As discussed by Ostrom, Governing the Commons, above n 145, 3–5.

1224 This point has been made by numerous commentators, see eg South Australia, Murray–Darling Basin Royal Commission Report (2019) <https://www.mdbrc.sa.gov.au/sites/default/files/murray-darling-basin-royal-
compliance activities (DP 5) and extraction data, has not provided policies of social encouragement in the past for QDNRME staff to address over-allocation and over-extraction in the GAB (which is, of course, their job). For example, large tranches of unallocated water were made available in 2014 out of the Hutton Sandstone and Evergreen Formation (totalling 785 ML). The release occurred despite the need to service the predicted ‘make good’ arrangements for impacted bores in the Walloon Coal Measures from the Hutton Sandstone. Participant Q12, a former DNRME representative, explained that, at the time, the release was politically advantageous.

The release in 2014 was also at odds with the current and historic declining status of that formation. Participants Q10 and Q11 explained that:

the baseline deficit, even before gas extraction, was certainly the elephant in the room in terms of management of the basin. Many people were concerned by the impacts of gas extraction but very few were concerned about the extraction by non-CSG water users. Most were very much concerned also about having gas wells outside their bedroom windows. If non-CSG water use is questioned, it was the cotton farmers and feedlots and irrigators that were considered the ‘baddies’. When the gas companies came in, they quickly became a very easy target.

(vi) Comparison with PRB

In contrast, the indications that the PRB framework was more relatively successful for groundwater governance, may be attributed to the presence of certain AIA design principles. Out of 21 overall design principles, 16 are either fully present (8) or partially present (8), and only 5 are totally absent. This contrasts clearly with the Surat CMA framework. Generally, there are clear boundaries for who can impact the resource (DP 1); rules that reflect local circumstances (DP 2); fairly transparent monitoring (DP 4); simple avenues for conflict resolution, relating to impacts of extraction for landholders (DP 6); and polycentric nested governing agencies, which display high degrees of coordination and collaboration (DP 8). In addition, transparency of information appears to be a hallmark of the framework: most permits, production and decisions of agencies are readily publicly available (even historic material relating to working groups). Also, many participants noted

1226 Interview with Participant Q12 (Toowoomba, Queensland, 25 July 2018).
1227 Klohn Crippen Berger, above n 26.
1228 Interview with Participants Q10 and Q11 (Roma, Queensland, 24 April 2018).
that they felt they had informal or indirect means of influencing the rules, despite a lack of formal fora.\textsuperscript{1229} Rules did, in fact, change as CSG development proceeded across the PRB.\textsuperscript{1230} In the PRB, social learning did occur through stakeholder working groups. These groups debated issues relating to CSG development, such as water-quality discharge limits. The process, as described by one participant,\textsuperscript{1231} was an example of Lee’s bounded conflict.\textsuperscript{1232} The parties vigorously debated issues, which led to a degree of social learning, including ‘second loop’ (involving quality limits about the CSG produced water) but perhaps not ‘third loop’ learning (involving questions about whether CSG activities ought to occur).

Even though the pressures of a booming CSG industry abated, the above-listed features of the Wyoming framework relating to groundwater governance reveal how the presence of the AIA design principles can have a positive influence on rules that protect the groundwater resource and may assist in resolving conflicts between resource users.

Research by other scholars has found that CPR governance frameworks are more likely to be unsuccessful where the following design principles are missing: congruence between local conditions and rules, investment/extraction proportionality (DP 2), accountability of the monitors (DP 4), and graduated sanctions (DP 5).\textsuperscript{1233} The Surat CMA governance framework does have more aspects of these design principles missing than the PRB. Although, neither the Surat CMA nor the PRB frameworks featured investment/extraction proportionality (DP 2) for the extraction of groundwater generally. Therefore, how the disproportionate costs paid by appropriators, for the proportion of water extracted, affects outcomes is uncertain in this context. The expectation of a ‘right’ to water\textsuperscript{1234} may contribute, to some extent, to the notion that appropriators ought to be able to

\begin{thebibliography}{99}
\bibitem{1229} Interview with Participants W1 and W2 (Cheyenne, Wyoming, 10 August 2017); Interview with Participant W3 (Casper, Wyoming, 11 August 2017); Interview with Participant W4 (Casper, Wyoming, 11 August 2017); Interview with Participants W5 and W6 (Sheridan, Wyoming, 14 August 2017); Interview with Participant W7 (Sheridan, Wyoming, 15 August 2017).
\bibitem{1230} The WSEO changed requirements relating to water production of CSG wells; some were shut down and an industry participant explained how water disposal requirements were debated and changed; see above at chapter 3, section 3(b)(ii), above p 103 relating to WSEO requirements; confirmed by: Interview with Participant W4 (Casper, Wyoming, 11 August 2017).
\bibitem{1231} As discussed at chapter 4, section 3(ii), above p 127–128, Participant W4 explained that, when the parties were not yelling at each other, they were able to gain each other’s perspective. Sometimes, they were able to reach agreement, but it was also an exercise in educating the other stakeholders. But where there were deep philosophical differences about the existence of the CSG industry, no amount of negotiations would affect the outcome: Interview with Participant W4 (Casper, Wyoming, 11 August 2017).
\bibitem{1232} Lee, above n 204.
\bibitem{1233} Baggio et al, above n 214, 428–429.
\bibitem{1234} For example, due to the now-replaced common law rights for groundwater, which allowed for unrestricted extraction of groundwater: \textit{Acton v Blundell} (1843) 12 M & W 324; 152 ER 1223; \textit{Chasemore v Richards} (1885) 11 ER 140; \textit{Bradford v Pickles} (1895) AC 587, 601; or perhaps the ‘human right’ to water, which is admittedly found in non-binding resolutions: United Nations, General Assembly, The Human Right to Water and Sanitation, above n 202; Human Rights Council, \textit{15/9 Human Rights Access to Safe Drinking Water and...
extract groundwater for minimal cost (or for free). This may suggest that this design principle is of less importance in the groundwater context, but without further research it is impossible to be sure.

This comparative analysis supports the conclusion that the AIA design principles are important for groundwater governance overall, because the absence of most AIA design principles appears to explain and coincides with opportunities for individualistic behaviours at the expense of the collective resource (as in the Surat CMA). Therefore, an absence of most of the AIA design principles appears to be an impediment to sustainable groundwater governance. Conversely, the presence of numerous AIA design principles may have been beneficial in the relatively successful PRB. In addition, transparency in terms of permits, extraction, monitoring, and decision-making and indirect or informal avenues to influence rule-making also appear to have promoted positive outcomes (in the PRB). Transparency and avenues to influence rule-making were notably absent in the Surat CMA. Finally, in the groundwater context, it is uncertain how important investment/extraction proportionality is.

b) Governance of extraction of groundwater in the CSG context

It is helpful to display the comparison heat maps because they relate only to the extraction of groundwater in the CSG context. These are displayed in Figure 28, below:
Figure 28. Presence/absence of AIA design principles relating to extraction in both the PRB and Surat CMA
Aquifer injection in the coal seam gas context: Part D: Chapter 7: Findings and discussion

Again, it is unwise to draw too many conclusions from the existence of various AIA design principles and the finding of relative success for the PRB. Nevertheless, the presence or partial presence of 11 of the 13 relevant AIA design principles suggests a connection. Conversely, an overall absence of the relevant AIA design principles (8 out of the 13 relevant), along with the relatively unsuccessful Surat CMA governance of extraction, supports the conclusion that the AIA design principles are important for that process. As mentioned in Chapter 1, competition over the groundwater resource has been the focus of much concern and conflict in respect of CSG activities in the Surat CMA.1235 The analysis of the governance of extraction of CSG produced water using the AIA design principles explains why that may be the case for the Surat CMA. The discussion above, relating to the lack of clarity around groundwater users and extraction data, an absence of collective choice mechanisms (DP 3) and rights to organise (DP 7) in the general groundwater context, similarly applies with respect to the governance of extraction by CSG activities. The absence of other AIA design principles also has significance where extraction of CSG produced water occurs.

(i) Surat CMA: weak DP 1(a)(ii) and DP 4(a)(i)

The weak boundaries relating to rules for extracting groundwater (DP 1(a)(ii)) in the Surat CMA (due to the extremely broad statutory authorisation) does not engender cooperation between users in the protection of the resource. Other scholars have highlighted the importance of appropriator support in defending the resource.1236 Appropriators are an integral part of successfully managing a CPR and, therefore, clarity is required in terms of who the appropriators are and exactly what they are permitted to appropriate. Transparent monitoring and reporting of extraction data (DP 4(a)(i)) could have assisted in groundwater appropriators’ understanding of the level of impact that is occurring individually, locally and collectively on the resource. But the lack of transparency in this regard in the Surat CMA casts a shroud over the management of the resource, especially where CSG activity is occurring.

(ii) Surat CMA: partially present DP 1(b) and AM

The partial presence of clarity around the physical boundaries of the groundwater resources (DP 1(b)) (the amber grading for this aspect of the AIA design principles) was common to both jurisdictions. It is likely that this would be usual for most groundwater systems, given the inherent uncertainty around the physical nature of the resource. A positive feature in the governance arrangements for the Surat CMA was the adoption of the AM approach by OGIA in the Surat CMA.

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1235 As opposed to the PRB, where surface impacts of the CSG produced water appeared to be the main concern: Interview with Participants W1 and W2 (Cheyenne, Wyoming, 10 August 2017); interview with Participant W3 (Casper, Wyoming, 11 August 2017).
1236 Ostrom, Understanding Institutional Diversity, above n 382, 262.
OGIA’s application of AM shows a helpful way to reduce the uncertainty in this regard. Over time, through a transparent AM approach, this AIA design principle may be able to transition from being partially present (amber) to being ‘present’ (green). Lee demonstrated that ‘without experimentation reliable knowledge accumulates slowly, and without reliable knowledge there can neither be social learning nor sustainable development.’ The approach applied by OGIA in the Surat CMA, and reported in annual reports and the updated UWIRs, presents reliable knowledge that facilitates social leaning about the impact of development in the Surat CMA. This reduces the uncertainty inherent in such a large ecosystem.

(iii) Surat CMA: absent DP 2(a)(i)

As mentioned in Chapter 6, a lack of congruence between local contexts (DP 2(a)(i)) and the broad statutory right to extract CSG produced water has also had negative impacts. Many have argued that the statutory right to extract water held by the gas operators in Queensland is unfair against other users. A recurring theme in the interviews conducted as part of this research related to the inherent inequity embedded in the framework, not just relating to access to the groundwater resource, but also with respect to the disproportionate costs borne by the CSG industry. Where the perception of ‘unfairness’ seems to be endemic, an absence of congruence between the rules and local contexts will be hazardous. This is because there will be less likely to be trust and cooperation, which will create incentives for rule-breaking or, at the very least, behaviour that feeds self-interest rather than collective interests.

(iv) Surat CMA: weak DP 4(a)(i) and absent DP 4(b)

In addition, there is a lack of transparency and accountability around extraction generally in the Surat CMA, but particularly for CSG produced water. Because most data around CSG activities in the Surat CMA are provided by CSG operators, rather than through the regulators, there are minimal opportunities to monitor the monitors (DP 4(b)). The ‘special’ rules for CSG activities, and a lack of transparency breeds distrust; recall, for example, the comments of Participant Q4, a

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1237 Lee, above n 204, 54.
1238 Refer to chapter 6, section 2(a)(i), above p 201 - 205.
1239 See: chapter 5, section 4(b), above p 183–186; chapter 6, section 3(i), above p 212–214; Agriculture, Resources and Environment Parliamentary Committee, Queensland, Water Reform and Other Legislation Amendment Bill 2014, Report No 52, above n 1107.
1240 Refer to chapter 5, section 4(b), above p 182–186.
1241 Hunter, above n 971; Nelson, above n 1156.
representative of local government, who argued that the department had essentially privatised monitoring and that this does not counter ‘conspiracy theorists’.\footnote{Noted in chapter 6, section 4(b), above p 220; Interview with Participant Q4 (Dalby, Queensland, 25 October 2017).}

(v) Surat CMA: absent DP 8 and DP 6(i)

The governance of extraction of CSG produced water is fragmented from the governance of the other groundwater users, due to the lack of coordination between QDES and QDNRMME (a lack of nested arrangements (DP 8)) and the designation of CSG produced water as a ‘waste’ in the legislation.\footnote{EP Act, s 13.} A landholder participant noted that, once extracted, the CSG operators are free to do whatever they decide with the CSG produced water, rather than it being required to be accounted for within the available pool in the basin. Speaking about an operator conducting activities on his land, one landholder complained that:

> the company … has just agreed with a local pastoral company to take all of the water. There has been no consultation at all about this and … [we] feel disappointed about that lack of consultation and the agreement made.\footnote{Interview with Participants Q10 and Q11 (Roma, Queensland, 24 April 2018).}

There is little that other groundwater users can do about this situation due to the lack of low-cost dispute resolution mechanisms (DP 6(i)); hence, the creation of activist organisations such as ‘Lock the Gate’.\footnote{As discussed in chapter 6, above at p 184 and 226.} The PRB framework featured these AIA design principles, and while there was certainly conflict, that conflict appeared to result in responsive changes to decision-making on the part of the WSEO\footnote{See chapter 4, section 3(i), above p 127.} rather than a stalemate.

This analysis explains why the AIA design principles are also important for governance of the extraction of CSG produced water. The absence of most AIA design principles provided some explanation as to why there has been continuing conflict and lack of trust relating to that process in the Surat CMA.

Furthermore, the clarity around the boundaries of the groundwater resource (DP 1(b)) will probably often be relatively uncertain, and therefore only ever partially present in most jurisdictions (amber at best). But this research shows that an AM approach can have a positive effect in providing increased clarity and reducing uncertainty of the physical boundaries of the resource. This research shows that, where it features monitoring, research, periodic evaluation and compliance measures, it can reduce uncertainty. As such, it would seem to be helpful in a wider context, not just where CSG activities occur.
c) Governance of injection of CSG produced water

Again, it is helpful to display the comparison heat maps because they relate to injection for this discussion (Figure 29, below):
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Figure 29. Presence/absence of AIA design principles relating to injection in the PRB and Surat CMA

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The comparison of the presence/absence of AIA design principles in the governance frameworks relating to injection in the two jurisdictions is on much firmer ground. However, it should be noted that there are likely to be other important factors that impact the adoption of aquifer injection in the CSG context, such as geological feasibility and even appetite for innovation and technological change relating to water. Nonetheless, due to the contrasting findings that the governance frameworks for injection were successful for the PRB and relatively unsuccessful for the Surat CMA (Table 20, above), it is possible to identify design sub-principles that were important. In the PRB, the governance framework was deemed to be successful due to the ready acceptance of the process by many operators from the relatively early days of CSG extraction activities and a lack of conflict in the process. In the PRB governance arrangements relating to injection, 10 out of 13 of the relevant AIA design principles were present (5) or partially present (5). Only 3 were absent. In contrast, in the Surat CMA, aquifer injection of CSG produced water has been a process avoided by most CSG operators. Despite the quantities of CSG water that have now been injected, there was a long delay between CSG extractive activities and the ultimate injection activities (at least 5 years). Furthermore, there appears to have been a reluctance by all other operators to adopt the process (despite thirsty, salty groundwater resources). These findings correlate with an overall absence of the AIA design principles. In the Surat CMA governance arrangements relating to injection, only 5 out of the 13 relevant AIA design principles were partially present, 7 were absent and 1 was likely to be absent.

(i) Surat CMA: absent DP 1(a)(iii) but AM present

The lack of clear rules around injection activities (DP 1(a)(iii)) in the Surat CMA meant that a staged approach was required by the Commonwealth Department of Environment and the QDES. A staged approach is useful in operations, but it is uncertain as to whether it must be embedded in the approval process. This makes the permitting arrangements uncertain, being dependent on the operator reverting to the regulator after every stage. This process involves AM, which necessitates a step-wise approach to permit arrangements and activities: the results of one stage being evaluated and feeding into the decision-making for the next stage. Ultimately, the AM approach applied did

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provide positive outcomes for injection, albeit after many years and only with respect to one operator.

Arguably, if the decision-making of the QDES and the Commonwealth Department of Environment had been more transparent, this would have provided more in terms of social learning (for all stakeholders) about the process. Not understanding decision-making by the QDES and the Commonwealth in this area provides fertile ground for doubts about the integrity of the departments’ decision-making, the operators and the rules associated with the process (when it will be required or not). It also precludes interested stakeholders, such as nearby landholders and the local government, who rely on the same groundwater formation, from having understanding and an input into the process. This is a conundrum: where there is a lack of permitting arrangements for new technical activities, AM can be helpful in devising appropriate permitting requirements, but will also necessarily involve inherent commercial risk (and added costs) for those first operators undertaking the activity.\(^\text{1249}\) This is especially the case where there is a lack of transparency around decision-making by the regulators.

(ii) Surat CMA: absent or weak DP 2(a)(ii)

Absent or weak locally tailored rules for injection in the Surat CMA (DP 2(a)(ii)) was reflected in the across-the-board policy adopted by the regulator for CSG operators to treat CSG produced water to a potable quality (a common condition in all approvals). This ignored the possibility of local target formations that may better match existing CSG produced water quality, which may save on treatment costs. To achieve this baseline expectation, operators require highly engineered centralised water treatment plants, which have the added costs of the water distribution network along with the high treatment costs. It also inevitably results in increased wastes from the treatment process, such as salts and brine that must be subsequently discarded. The centralised facilities are a large sunk cost and, when CSG development ceases, may become redundant (like the Gillette, Wyoming, ASR project)\(^\text{1250}\). The requirement means that the option of decentralised, simple injection wells that require less treatment, such as filtering and sanitising the CSG produced water, as used throughout the PRB, are not available. This less-sophisticated option could target formations closer to extraction, which would benefit water resources targeted by the affected landholders and reduce salt/brine production. This was considered a significant strength of the PRB framework by many of the participants in Wyoming.\(^\text{1251}\) Further scientific research will determine if this option is or is not

\(^{1249}\) The commercial risk may be balanced against the upside of being authorised to go ahead, when the alternative may have been refusal on precautionary grounds.

\(^{1250}\) Wester and Wetstein, above n 684.

\(^{1251}\) Interview with Participants W19 and W20 (Buffalo, Wyoming, 22 August 2017).
possible in Queensland, due to the quality of CSG produced water, the water quality in the resident aquifers and the relative transmissivity of the relevant aquifers. However, a blanket expectation of treating all CSG produced water to a certain standard, and necessarily in a centralised way, prevents innovative solutions that may be more environmentally, economically and socially beneficial.

(iii) Surat CMA: questionable DP 2(b)(ii)

There appeared to be negative consequences that flowed from the combination of the cost of injection activities and the inability to attribute benefits for the activity to the operator (DP 2(b)(ii)) in the Surat CMA. For example, the Maranoa Regional Council draws on groundwater from the Gubberamunda Sandstone aquifer for the town water of Roma. Figures 30 and 31, below, reveal the areas where the aquifer is showing declining trends. Figure 30 shows the declining water-level trends in the Gubberamunda Sandstone in the Surat CMA (the red circles are points where the aquifer has shown a decreasing trend; the size of the dot correlates with the size of the reductions). Similarly, Figure 31 shows the trends for a bore north-east of Roma.

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1252 The injection of CSG produced water is regulated under the EP Act as a waste and, therefore, the process is not directly acknowledged in water allocation and planning. Moreover, there is little acknowledgement of the value of water, as already discussed above regarding extraction of water.

1253 Davies, Gore and Khan, above n 47.
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Figure 30. Groundwater trends for the Gubberamunda Sandstone

1254 Taken from: Office of Groundwater Impact Assessment, above n 66, 352.
It seems a shame that the aquifer injection project by Santos did not proceed, at least for the citizens of Roma, Queensland. This is despite there being a need in the area for addressing declining water levels that were perhaps attributable to other users. As already mentioned, there are no available documents that indicate why the project did not proceed. Given the available supply of CSG produced water, and the existing need and demand on the part of groundwater users, it seems likely that, if the operator could have claimed some benefit from the project, negotiations between the parties may have facilitated injection. In January 2019, residents in Roma were forced to reduce water use to only essential needs, due to failing water infrastructure and inadequate funding from state and federal governments.\footnote{Warren Barnsley, Australian Associated Press, ‘Queensland Town Faces Water Shortage’ The Western Star (29 January 2019) <https://www.westernstarnews.com.au/news/queensland-town-faces-water-shortage/3633793/>.} If the cost of the project and the benefits that would have accrued to groundwater users and the community in that area could be openly acknowledged, this could facilitate negotiations between the parties that would result in more holistic and integrated groundwater management.

(iv) Surat CMA: absent DP 8

\footnote{Taken from, Office of Groundwater Impact Assessment, above n 66, 352, 353.}
The lack of nested arrangements (DP 8) in Queensland have also had negative impacts on the overall process of injection. Fragmentation has led to duplication of assessment so that both Queensland and Commonwealth approvals are required for the process and different reporting obligations exist.\textsuperscript{1257} Moreover, the fragmentation between the governance of groundwater generally (QDNRME) and the governance of injection of CSG produced water (QDES) means that the activities are not necessarily coordinated. As already noted, at present, the injected CSG produced water is not transparently accounted for in basin planning or made available to other users.

(v) PRB: present DP 8

In contrast, the organisational structure of the overall framework in the PRB is a nested polycentric structure (DP 8) and is a strength of the framework. Approval processes, such as with respect to injection, have been streamlined as between Wyoming and the US government (because Wyoming has delegated authority) and provides for the coordination between other Wyoming departments (the WOGCC, WSEO and WDEQ). There are numerous government agencies involved in the governance of CSG development, including aquifer injection of CSG produced water, but they appear to have a level of coordination and transparency in the PRB that is conducive to development rather than an impediment. Coordination was actively managed through the PRB Interagency Working Group (which included many stakeholders and representatives of the various government agencies).\textsuperscript{1258} Coordination was also facilitated by communication between departments and the public availability of most information (even the minutes of the working groups).

Participants representing the Wyoming regulators, the US BLM and industry considered this to be a strength, in that the different parties were able to build on and strengthen relationships in the PRB. For example, an operator representative reflected that the State government agencies enjoyed a high level of trust because they all have people who come from the area and know the landscape.\textsuperscript{1259} In contrast, he found the US BLM a bit more difficult to work with because their officers come from outside the region and are posted there for short periods.\textsuperscript{1260} Nonetheless, the US BLM participants concurred on the advantages of being locally situated. Nearly all participants in Wyoming reflected that there was a high level of trust between the stakeholders.\textsuperscript{1261} The one participant in Wyoming who did not share this view was an activist representing landholders who,

\textsuperscript{1257} As mentioned above for the application of the AM approach, required by the Qld and Cth EAs, chapter 6, section 1(a)(iii), above p 190.
\textsuperscript{1258} See chapter 4, section 8, above p 141.
\textsuperscript{1259} Interview with Participants W5 and W6 (Sheridan, Wyoming, 14 August 2017).
\textsuperscript{1260} Ibid.
\textsuperscript{1261} See chapter 3 section 4(b), above p 113; above n 661.
nevertheless, still considered that her efforts to influence the rules were successful.\textsuperscript{1262} In contrast, as mentioned above, most participants in Queensland felt that both trust and an ability to influence the rules were lacking.\textsuperscript{1263}

**(vi) PRB: absent DP 6(ii) but present DP 4(a)(ii) and DP 5(ii)**

The disposal of the large quantum of produced water was the impact that appeared to have the most wide-reaching consequences in the PRB, rather than competition for the resource.\textsuperscript{1264} Therefore, conflict resolution mechanisms (DP 6(ii)) relating to injection could be important, because landholders may have an interest in what happens to such large quantities of CSG produced water. Despite there being an absence of low-cost local arenas for conflict resolution relating to UIC wells, the lack of claims relating to impacts,\textsuperscript{1265} combined with an absence of negative outcomes in monitoring reports from the UIC wells, may indicate that, in this context, their absence did not have drastic outcomes. The transparency of the monitoring with respect to the UIC wells (DP 4(a)(ii)) is a design feature that aids in this context. There are graduated sanctions (DP 5(ii)) that have been readily applied by the WDEQ for injection activities; this aspect also assists in ensuring that the framework is fair and catches rule-breakers. It should be noted that the flaw in the graduated sanctions applied by the WDEQ relates to the historic bonding of UIC wells\textsuperscript{1266} and not in compliance activities relating to operations. From the publicly available record, it appears that most correspondence with operators with respect to UIC wells is published through its database.\textsuperscript{1267} This would assist interested landholders in determining whether the rules have been followed.

**(vii) Surat CMA and PRB: absent DP 3(ii) and DP 7(ii), but present DP 5(ii)**

A lack of formal rights to organise relating to the technical requirements for aquifer recharge (DP 7(ii)), and the relative absence of collective choice arrangements (DP 3(ii)) regarding the same, is worth noting. Such a highly technical activity where any negative impacts to the resource are difficult to determine is a context where there are significant incentives for rule-breaking on the part of the operators. The high costs of complying with permits, coupled with the difficulty in detecting negative impacts to the largely hidden groundwater resource, present an opportunity for operators to cut corners. Also, the technical aspects mean that there is not a ready public who may question

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\textsuperscript{1262} See chapter 3 section 4(b), above p 113 and n 661; Interview with Participant W4 (Casper, Wyoming, 11 August 2017); Jacquet, above n 727.

\textsuperscript{1263} See: chapter 6 section 3(i), above p 212–215.

\textsuperscript{1264} Interview with Participants W1 and W2 (Cheyenne, Wyoming, 10 August 2017); interview with Participant W3 (Casper, Wyoming, 11 August 2017).

\textsuperscript{1265} A representative of landholders confirmed that he was not aware of any landholder problems with UIC wells; interview with Participant W3 (Casper, Wyoming, 11 August 2017).

\textsuperscript{1266} Bills, Walsh and Haggerty, above n 152.

\textsuperscript{1267} This is because the correspondence record appears complete.
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activities. This also means that there could be a corporate ‘elite’, which may unduly influence rule-making in the absence of decision-makers above the level of the resource and operators. Ultimate control and oversight by a government agency would seem warranted in these circumstances (rather than collective management). The transparent monitoring information, and the transparent graduated sanctions applied by the WDEQ (DP 5(ii)), seem to reinforce a culture of rule adherence among the operators in the PRB. Injection (ultimately) occurred in both jurisdictions with minimal stakeholder participation in the rules for injection. This supports other research, which argues that where there is little disagreement about the environmental values or science (for example, drinking-water quality standards), a technocratic policy-making style with minimal participation and single-loop learning can be effective.

For the broader question about whether injection should be required, or should occur at all, this necessitates double-loop learning and differing degrees of participation are needed. The type of participation that would be beneficial in this regard depends on the rationale, the existing social and cultural context, and the institutional fit of potential participatory practices. For the Surat CMA, a lack of participation, in respect of whether aquifer injection of the CSG produced water ought to occur, arguably led to a missed opportunity for addressing thirsty aquifers and managing groundwater demand.

(viii) PRB: absent DP 2(b)(ii)

There does appear to be an anomaly in terms of the costs of injection (DP 2(b)(ii)), and the fact that it was adopted at all, in the PRB context. Recall that, in the PRB, injection was not required but was merely an available disposal option for operators. It is considered an expensive exercise, and there does not seem to be overtly quantified benefits that attribute to the CSG operators (such as some acknowledgement of the value of the augmentation of the aquifers). The other landholders, and the people of Wyoming, seem to be the broader beneficiaries of this process. Admittedly, there are streamlined processes for the permits and the authorised activities also dispense with unnecessary high treatment costs, where it is appropriate. Because operators can choose the

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1268 In the PRB, the rules are set largely by the US EPA, see chapter 3, sections 3(a)(iv), above p 98; section 3(b)(iii), above p 105; chapter 4 sections 3(ii), above p 127; chapter 4 section 7(ii), above p 140. It should be noted, however, that general and individual UIC applications are made available to the public, relevant landholders and various other government agencies for comment. In Australia, the requirements in the EAs were developed through the AM process post-approval and, unless changes to the EAs were considered ‘major amendments’, which is unlikely, they are not publicly notified: EP Act, ss 229, 232 and 240.
1269 Hurlbert and Gupta, above n 291.
1270 Ibid.
1271 Baker and Chapin, above n 294.
1272 See chapter 4 section 2(b)(ii), above p 125–126.
1273 See chapter 3, section 3(b)(iii), above p 105.
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most economically advantageous disposal mechanism (such as injection, infiltration ponds or disposal into rivers) within the framework of the regulations, the fact that aquifer injection occurred at all implies that there were some advantages, economic or otherwise, in those circumstances. Thus, the adoption of the process may be explained by unquantified benefits in the process. There was no evidence to suggest that the rules relating to UIC are considered ‘unfair’. Therefore, the associated cost-to-benefit ratio may actually have been appropriate, despite the obvious costs, in the circumstances. Other factors that may have afforded unquantified benefits could have been the benefits in being able to reinject at the point of extraction, or in avoiding the transaction costs of transporting the water to other locations, avoiding the costs of surface storage of the water, or even an absence of demand for the water on the surface. Without further targeted research, involving the operators who have undertaken the activity, it is now not possible to know.\textsuperscript{1274} The fact that the process was undertaken does suggest that other factors overcame the relative cost of the process, and this would minimise the downside of the otherwise red grading attributed.

(ix) Summary for AIA design principles and injection: DP 1, DP 2 and DP 8

In summary, this analysis explains why many of the AIA design principles are also important for governance of the injection of CSG produced water, because the absence of most AIA design principles correlated with a slow rate of adoption and reluctance to inject by other operators, which in turn, impacted the overall quantity of CSG produced water that could be returned to the groundwater system in the Surat CMA. Specifically, the absence of the following AIA design principles also explained why the process may not have been more widely adopted in the Surat CMA: clear and transparent rules for the injection process (DP 1); rules that consider local geographic (and social) factors, which provided economic incentives (DP 2); and nested government agencies (DP 8). These final design principles, incidentally, correspond with and confirm the recommendations made by scholars in the general MAR context: clear entitlements, economic incentives, unified assessments and that the process should be part of an integrated catchment management strategy.\textsuperscript{1275}

The role of collective choice mechanisms (DP 3) and rights to organise (DP 7) do not appear to be as important with respect to the technical aspects of injection, particularly where adequate sanctions (DP 5) and monitoring (DP 4) exist. But it should be noted that, in the PRB, there were some indications that there may have been informal avenues for relevant interested parties to influence decision-making. Certainly, if the Maranoa Shire Council and the local community around

\textsuperscript{1274} It is also unlikely that CSG operators would disclose this potentially commercially sensitive information about the quantification of actual benefits.

\textsuperscript{1275} For authorities, see discussion in chapter 1, section 2(b), above p 21–23.
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Roma accessing the Gubberamunda Sandstone aquifer could have some influence on rule-making, this may have facilitated integrated governance, so that the broader benefits from aquifer injection could be accounted for. Also, other factors such as the availability of other disposal options may also be important in this context (although, further research would be needed to determine this).

d) Seventh research question: importance of AIA design principles?

I can now answer the seventh research sub-question:

| What does the analysis suggest about the importance of the various aquifer injection and augmentation design principles for groundwater governance, and the separate operational phases of aquifer injection using CSG produced water? |

The analysis in this chapter reveals that the AIA design principles are important to groundwater governance overall, as well as the governance of the extraction of CSG produced water and subsequent injection of the CSG produced water.

The absence of most AIA design principles appears to act as an impediment to sustainable groundwater governance, especially regarding inter- and intra-generation equity. Conversely, the presence of numerous AIA design principles appears likely to be beneficial. In addition, transparency in terms of permits, extraction, monitoring, decision-making, and indirect or informal avenues to influence rule-making also appear to promote positive outcomes for governance of the groundwater system.

The AIA design principles are important for governance of the extraction of CSG produced water, because the absence of most AIA design principles correlated with existing conflict and lack of trust relating to the process in the Surat CMA. In addition, in the context of governance of the extraction of CSG produced water (and groundwater generally), AM assisted in reducing uncertainty about the physical boundaries of the groundwater resource and appears to be a useful method to transition to more positive design features.

The AIA design principles are also important for governance of the injection of CSG produced water, because the absence of most AIA design principles correlated with a slow rate of adoption and reluctance to inject by other operators, which in turn, impacted overall quantity of CSG produced water that could be returned to the groundwater system in the Surat CMA. Specifically, the absence of the following AIA design principles also explained why the process may not have been more widely adopted in the Surat CMA:
• A lack of clear and transparent rules for the injection process (DP 1);
• A lack of rules that consider local geographic (and social) factors, which provided economic incentives (DP 2); and
• Fragmentation between government agencies (DP 8).

Collective choice arrangements (DP 3) and rights to organise (DP 7) may not be as important, due to the highly technical nature of the process and the opportunity for corporate ‘elites’ to influence decision-making, especially if there is transparent monitoring of the injection (DP 4) and sanctions (DP 5). Furthermore, there may be unquantified benefits of the process that affect the economic benefit/cost ratio of the process (DP 2).

In addition, the adoption of AM can (but not always will) assist where there is a lack of permitting arrangements (DP 1), in that it can reduce uncertainty, but this depends on transparency particularly relating to decision-making. Where there is a lack of transparency around decision-making and AM is adopted, this can contribute to commercial risks for operators.

These findings will assist in answering the overarching research question, which will be considered in the next and final chapter. Prior to that discussion, I am now able to consider the final research sub-question, relating to features that enable or inhibit sustainable groundwater governance.

2. Enablers or inhibitors

The preceding section found that an overall lack of AIA design principles appears to have operated as an impediment to sustainable governance of the groundwater system and the two operational phases of aquifer injection using CSG produced water, at least for the Surat CMA. There also appear to be other factors that were relevant.

The analysis also highlighted that groundwater governance generally in the Surat CMA is unsuccessful. It seems likely that the pre-existing and continuing decline of some of the groundwater resource, caused by general over-extraction,1276 may also have had negative impacts on the governance relating to CSG extraction of groundwater. The two governance aspects (groundwater generally and CSG produced water extraction) overlap and suffer similar deficiencies in terms of the AIA design principles. It is not possible to know the extent to which deficiencies in governing the overall resource system have impacted the governance of CSG extraction. But it is an interesting

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1276 For the Hutton, Gubberamunda and Precipice Sandstone aquifers: Klohn Crippen Berger, above n 26, v; for the CCA: Office of Groundwater Impact Assessment, UWIR (2016), above n 26, 44. In contrast, the groundwater levels of the Walloon Coal Measures have remained relatively unchanged, which suggests an impediment to flow in that area, or low connectivity.
finding: the problems relating to governance in the Surat CMA may not be entirely related to CSG activities. They may also be a symptom of the problems relating to governance of the overall groundwater resource.

a) Transparency

The existence of a broad feature of transparency appears to have had a positive influence on understandings of the status of the resource and decision-making about the resource. In the PRB, in addition to the existence of many of the AIA design principles, transparency in terms of permits, extraction, monitoring and decision-making also appeared to promote positive outcomes. Unfortunately, a lack of transparency appeared to be a hallmark of the relatively unsuccessful Queensland governance frameworks. I mentioned in Chapter 1 with regards to my research methodology, that Queensland and Commonwealth government officers were reluctant to take part in this research.\(^{1277}\) This was in direct contrast to Wyoming.\(^{1278}\) The lack of openness by government departments was perplexing, given that the research involves questions of existing policy and could be helpful in that regard. There were many potential government participants for the Surat CMA, who either ignored communication or expressly refused to take part, despite the redaction of personal and identifying information. There were some officers who were interested to take part initially but, on seeking approval from superiors, were not given permission. Apart from the lack of response by the departments, there was obfuscation in terms of accountability of contacts. All contact details provided are to general emails or contact numbers that do not identify individuals. This makes it extremely hard to pin down individuals to make requests. In contrast, in the PRB, the names of individuals (and often phone numbers) associated with activities are included on publicly available documents, such as permits, monitoring reports and specific decisions.

This lack of openness in Queensland was noted by Participant Q7, who has experience in government as well as agriculture and industry. He stated that:

in respect of the environmental impacts, there is so much secrecy around the data and the science that people presume that there are environmental impacts. ... when one is dealing with environmental concerns, one is not dealing with apples and apples. The contextual debate can become lost and clouded by vested interests.\(^{1279}\)

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\(^{1277}\) No operators in Queensland agreed to take part formally, although informal discussions did take place. See also chapter 1, section 3(a)(iv), above p 32.

\(^{1278}\) Where every person contacted readily made themselves available. One government agency officer, on having the ethics process explained to him, responded that his department would take part in research and would talk to anyone, whether or not they had ethics approval, whether they had an appointment or simply walked through the door.

\(^{1279}\) Interview with Q7 (Brisbane, Australia, 1 November 2017).
The lack of transparency in the Surat CMA contributes to a lack of accountability, and this is also reflected in the governance arrangements. Groundwater users, apart from the CSG industry, are not accountable for their extraction; most information relating to permitting arrangements is difficult to obtain, and most general extraction is not measured or reported. Decisions and administrative actions by government agencies are not readily available to the public and must be inferred in many cases. This is directly in contrast to what is evident for the PRB context.

Higher levels of participation have been shown to positively impact levels of trust. Other research has highlighted that ‘transparency and trust-building are closely related,’ and that, to ‘build trust, increasing information flows and iterative processes of involvement are required.’ Increased transparency has also been a driver of trust in respect of the social acceptability, or the ‘social licence to operate’ of CSG operators. Legitimacy, credibility and trust are central components of a social licence to operate. Procedural fairness is one of the factors that has been found to impact levels of trust which, in turn, impacts the levels of acceptance and approval of the relevant extractive industry. Recent research on the responses of the public to industry and government initiatives for unconventional gas development argue for best-practice public participation strategies for not just industry but also government. While impacts to underground water resources continue to be the main concern of local residents, and trust in both the CSG industry and the state regulator is low, adopting a transparent approach to decision-making by the regulator appears to be needed. Indeed, this was one of the recommendations by 233

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1282 Hurlbert and Gupta, above n 291, 103, citing Pahl-Wostl, above n 280; Folke et al, Adaptive Governance, above n 29.
1284 Boutilier and Thomson, above n 1283; Boutilier, above n 1283.
1285 Moffat et al, above n 173, 62; although, it should be noted that factors that impact trust in this context have been found to be multifaceted and complex; Witt et al, above n 28, 425.
1287 Walton and McCrea, above n 173, 19.
stakeholders in the Surat CMA in recent research. The stakeholders in question considered that, in order to build or maintain trust in the regulators and government, greater transparency; education; public engagement; and more effective regulation, legislation, monitoring and compliance with enforcement actions was needed.

This level of transparency does not mean that the broad public must be included as final decision-makers, although collaborative strategies such as deliberation with stakeholders have proved helpful. Simple transparency relating to decision-making, particularly where it involves scientific uncertainty, is associated with increased social learning. Information about decision-making can improve understanding about the relative scarcity and importance of a resource, as well as the rationale for certain governance measures. This has been the impetus for the development of enduring collective governance in other jurisdictions.

Participant Q12, a former employee of QDNRM&E, highlighted the need to educate stakeholders about the status of the resource. He reflected on the situation of one particular landholder:

He was quite adamant that a bore was being impacted by the CSG industry. This landholder ... [had] been a strong critic of the CSG industry over the years. When [I] and another officer inspected his property and bore to determine the extent that it was not working, ... [we] were actually able to give the landholder monitoring data from a 40-year period that had been measured by the department. The data showed the water levels dropping consistently over that time, even though CSG development was relatively recent in the area. The landholder was aghast that he hadn’t known that this was occurring and realised that it could not have been CSG impacts. Rather, the impacts were due to general over-extraction. He asked, why hadn’t he been informed of this earlier ... of course, there are the impacts predicted by OGIA but not all falling bores are due to CSG impacts.

Therefore, information that clarifies the nature, behaviour and extent of the resource and impacts by water users is extremely important, especially where scarcity may exist. Certainly, the

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1288 The sample size was 233 participants: Nicole Gillespie and Morgana Lizzio-Wilson, ‘Stakeholder Trust in the Queensland CSG Industry: Overview and 2018 Survey Results’ Presentation to DNRME Social Impacts Research Forum, 9 April 2019.
1289 Gillespie and Lizzio-Wilson, above n 1288.
1290 There are certainly disadvantages in involving a heterogenous public in decision-making: National Research Council, Public Participation, above n 292; Glucker, above n 298, 109; Hurlbert and Gupta, above n 291; Baker and Chapin, above n 294.
1291 Tan et al, Deliberative Tools, above n 301.
1293 Baldwin et al, How Scientific Knowledge informs, above n 302.
1294 Ingold, above 467; Boone and Fragaszy, above n 389.
1295 Interview with Participant Q12 (Toowoomba, Queensland, 25 July 2018).
state has a significant role to play in the groundwater context. Communicating information to water users about decision-making, as well as information upon which decision-making is based, will be crucial in introducing new rules for managing that resource.

b) AM and adaptive governance

Where transparency was apparent, AM appeared to enable positive outcomes in terms of the management of the groundwater system. Unfortunately, the opposite was also true. The lack of transparency is particularly alarming in the context of AM, where it was applied to the governance of CSG produced water generally and especially relating to injection. As mentioned in Chapter 6, AM was applied at the operational level of projects as they proceeded by both the operators and the administrative officers in QDES and the Commonwealth Department of Environment. The process was factored into regulatory requirements, which included the drafting of management plans, monitoring and reporting by the operators. This is supposed to result in assessment by the regulator, a reduction of uncertainty and, possibly, a change to the management measures. Yet, while some of the steps taken by operators is documented in publicly available materials, much of it is not. There are no readily publicly available materials that relate to any decision-making by the regulators. As already noted, an authentic AM approach in Australia requires at the very least four stages (monitoring, research, periodic evaluation and compliance measures), and a reasonable assurance that uncertainty will be reduced and that the remaining risks can be adequately managed. Transparency relating to each stage is important to inform other relevant parties (for social learning) and to ensure legitimacy of and trust in decision-making.

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1296 Lopez-Gun and Cortina, above n 389; Schlager, Community Management of Groundwater, above n 388; Baldwin, above n 389; Ross and Martinez-Santos, above n 219; Theesfeld, above n 348; Wester, Sandoval Minero and Hoogesteger van Dijk, above n 302.


1298 Chapter 6, section 1(a)(iii), above p 190–197.

1299 This situation is not unique in Australia, see Slattery, above n 112, 439; Currell et al, above n 341, 681.

1300 An application can be made under the Right to Information Act 2009 (Qld), but this process takes time and effort and, depending on the attitude of the relevant operator who is the subject of the decision-making, there are various exemptions in the legislation that make the outcome of this process quite uncertain (see Right to Information Act 2009 (Qld) sch 4 pt 4, s 7: exemptions include information that ‘would disclose information ... concerning the business, professional, commercial or financial affairs of an agency or another person.’

1301 See chapter 2, section 2(c), above p 53–56.

1302 Unfortunately, the qualitative data revealed a lack of trust in the agencies, the operators and the overall governance framework in Queensland by some stakeholders: Interview with Participant Q3 (Telephone interview, 23 October 2017); Interview with Participant Q4 (Dalby, Queensland, 25 October 2017); Basin Sustainability Alliance, Submission No 97, to the Independent Review of the 2013 EPBC Act Amendment – Water Trigger, Undated <http://www.environment.gov.au/epbc/what-is-protected/water-resources/review>.
Even if AM is technically adequately applied, despite the lack of transparency,\textsuperscript{1303} the broader participatory and essentially flexible requirements of adaptive governance appear warranted in the context of groundwater in the Surat CMA. Recall that a lack of trust is an issue in the Surat CMA.\textsuperscript{1304} Without the participatory feature of Lee’s ‘bounded conflict’, the benefits of AM will be limited and there may be negative outcomes, such as increased issues of (dis)trust and lack of support for the process. These two outcomes appeared to take place in the Surat CMA context. The lack of authentic efforts to apply an adaptive approach by some operators may have been due to the lack of trust in legitimate decision-making based on firm policies. Although, without directly asking the operators this question, we cannot know. If the regulator does not set the example of transparency, there is no reason for operators to do so. In some senses, AM appeared to be an ‘empty ritual’ rather than affording real positive learning.\textsuperscript{1305} Without transparency, AM leaves the door open to reactionary decision-making influenced by politics (or commercial interests) rather than a rationally proactive and reactive process, incorporating legitimately unexpected environmental, social or economic outcomes. Also, where information about the entire process is widely available, this enables understanding to occur about the broader groundwater system, as opposed to the localised task-based learning that occurred at the project level. This research confirms how a lack of bounded conflict in the Surat CMA, for CSG produced water governance and injection, reduced the positive outcomes that could have been achieved through the AM process.

**c) Eighth research question: enabling or inhibiting features?**

I can now answer the eighth research sub-question:

> What features of a governance framework can enable or, alternatively, hinder aquifer injection and augmentation using CSG produced water?

In short, the following features can either enable or act as an impediment to the governance of groundwater, including extraction and injection of CSG produced water:

- An overall absence of AIA design principles appears to be an impediment to groundwater governance, and aquifer injection and augmentation of CSG produced water.

- For governance of the injection activity, a lack of clear and transparent rules for the injection process (DP 1), a lack of rules that consider local geographic (and social) factors (DP 2), and fragmentation between government agencies (DP 8) appear to be an impediment to the

\textsuperscript{1303} Such as was shown to occur in Allan and Watts, above n 302.
\textsuperscript{1304} See chapter 5, section 4(b), above p 183–186.
\textsuperscript{1305} The term ‘empty ritual’ is borrowed from Arnstein’s seminal work: Arnstein, above n 291.
governance of the activity. Also, the importance of collective choice arrangements (DP 3) and rights to organise (DP 7) are uncertain in respect of the governance of injection, particularly where monitoring (DP 4) and sanctions (DP 5) are present. Moreover, unquantified economic benefits of injection may also be relevant (DP 2).

- Transparency appears to enable sustainable groundwater governance, as well as aquifer injection and augmentation using CSG produced water, and a lack of transparency appears to be an impediment to sustainable groundwater governance, and aquifer injection and augmentation.

- AM can assist in reducing uncertainties and thereby enable aquifer injection and augmentation using CSG produced water, but a lack of transparency around decision-making can be an impediment to the process.

Of all of these, the most important appears to relate to transparency and AM because their presence can transform a governance framework, for better or worse. Transparency of reliable information, and an authentic, committed and broadly participatory AM approach, which views management as an experiment (in other words, adaptive governance), is the first step in transitioning towards a more sustainable governance framework for groundwater. These features ensure that social learning occurs, which can enable sustainable outcomes.

What these findings mean for either the PRB or Surat CMA governance frameworks is the subject of the final chapter in this thesis, which follows.
CHAPTER 8: INITIATIVES FOR REFORM

1. The research agenda and broad findings

I started this research looking for governance initiatives that may enable sustainable aquifer injection and augmentation using CSG produced water. The aim was to address, in part, a key issue for CSG activities, both in Queensland and internationally: the production of large amounts of groundwater along with the gas. I considered that it was likely there would be a permit or regulatory mechanism that could enable aquifer injection of CSG produced water to facilitate sustainable governance of groundwater. The existence of so many (class V UIC) injection wells for treated CSG produced water in Wyoming, a state much like Queensland, suggested this possibility. The key would be to consider what it may look like and how such a mechanism would fit into our framework.

In the search for appropriate mechanisms (such as a permit, licence or set of development conditions) for aquifer injection, I uncovered a much more pressing problem. This research demonstrates that there is, first and foremost, a problem with the governance of the groundwater system in Queensland, and not just within the context of CSG extraction (or mining activities). It is uncertain to what extent the problems relating to governance of groundwater in the Surat CMA are independent from or relate to CSG activities. Regardless, the research finding in respect of groundwater governance matters because it explains, in part, the heated conflict that we see relating broadly to groundwater and water resources generally in Australia. On reflection, the conflicts involving the CSG industry have parallels with, for example, continuing conflicts involving Adani’s Carmichael mine and, of course, the management of the Murray–Darling Basin. In both these latter cases, key decision-making materials have not been made available to the public. For the Carmichael mine, while Adani has extensive information, including its controversial groundwater management and monitoring report, voluntarily published on the internet, the Commonwealth Minister for the Environment has not made available her decision accepting that the plan is appropriate for the purposes of the mine’s ongoing management, other than through a media statement. In that case, a key issue, as mentioned above, relates to how groundwater will be

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1306 See chapter 7 section 2, above p 267–268.
monitored and managed going forward, and how the regulator requires suitably precautionary measures.\textsuperscript{1309} This is a key piece of information that would reassure the public that the appropriate balancing exercise had occurred and yet, the decision was made via a brief media statement, three days prior to a federal election.\textsuperscript{1310} QDES also notified the public of its approval of the same groundwater management and monitoring plan via a brief media statement, rather than releasing the actual decision.\textsuperscript{1311} The problem with this approach is that it focuses on decisions being newsworthy rather than establishing an ongoing public record of management actions. When apathy about the development ensues, decisions may not be openly debated or accountable. Similarly, unlike OGIA’s model for the Surat CMA, the model upon which the management of the Murray–Darling Basin is managed has not been made publicly available, and the overall transparency of the Murray–Darling Basin Authority has also been questioned.\textsuperscript{1312}

Like Hardin’s ‘Tragedy of the Commons’, many people argue that we need to either strengthen state control or continue with market reforms to resolve overuse of groundwater resources. At present, the Surat CMA governance is a highly centralised state ‘command and control’ model. Theoretically, the states should be able to manage groundwater. They should be able to refuse to issue permits or even ‘revise and rescind existing permits in order to realize a broad range of social values.’\textsuperscript{1313} But the experience to date in Queensland has shown that this is easier said than done.\textsuperscript{1314} Political and social resistance has meant that there have been calls for strengthening the state control of groundwater use since 1910 and yet, there is increased groundwater extraction. Groundwater levels in some important locations are continuing to decline. Like a broken record, we keep harping on about the same reforms: curtail and police extraction, cap bores, meter extraction. How do we reverse the habits and uses that have led to this situation?

\textsuperscript{1309} Refer to chapter 2, section 2(c), above p 54 in respect of Adani Mining Pty Ltd v Land Services of Coast and Country & Ors [2015] QLC 48 (15 December 2015).
\textsuperscript{1310} The 45th Parliament was dissolved on 11 April 2019: Australian Government, Proclamation - Prorogue the Parliament and dissolve the House of Reps - 11 April 2019, No, C2019G00344 (11 April 2019).
\textsuperscript{1312} South Australia, Murray–Darling Basin Royal Commission Report, above n 1224, 24 and ch 18.
\textsuperscript{1313} Schlager, above n 1219.
\textsuperscript{1314} Queensland, Parliamentary Debates, Legislative Assembly, Thursday 1 November 1910, 1786 (R Philp); 1790–94 (W Hamilton, D Gunn and JM Hunter); Queensland, Parliamentary Debates, Legislative Assembly, Tuesday 5 August 1930, 359 (W Forgan-Smith); Queensland Parliamentary Debates, Legislative Assembly, Wednesday 8 September 1954, p268 (GFR Nicklin).
Using Ostrom’s design principles for CPRs, I developed a more detailed set of design principles to be used where aquifer injection for groundwater recharge has taken place: the aquifer injection and augmentation design principles (AIA design principles). I also developed a corresponding heat map. The development of these tools is a unique contribution that can be used more widely in analysing governance frameworks for CPRs. These tools clearly revealed a correlation between negative governance outcomes and perceived weaknesses and strengths in the governance arrangements for groundwater, as well as extraction and injection of CSG produced water. This research is important because it provides an explanation as to why there may be continuing conflicts involving groundwater (and extraction of CSG produced water), and why groundwater users and the government might be predisposed to allow over-allocation and over-extraction of groundwater resources. It also reveals enabling features and impediments to groundwater governance and, more specifically, aquifer injection of CSG produced water. The research findings provide a pathway for reform that may assist in addressing the existing conflicts, as well as the current declining groundwater levels.

In Chapter 2, based on my analysis of the relevant literature, I adopted measures of sustainability against which I could evaluate the outcomes of both the Wyoming and Queensland governance arrangements for groundwater governance and aquifer injection of CSG produced water. The measures of sustainability adopted are a lack of continuing resource deterioration and a lack of conflict and trust issues. As already mentioned, I also developed the AIA design principles and a corresponding heat map, both of which served as the ‘yard stick’ against which I could analyse the governance frameworks. The AIA design principles are a more detailed version of Ostrom’s 8 design principles for CPRs, which include the additional aspects that are involved where aquifer injection of CSG produced water takes place. The AIA design principles include 21 sub-design principles. This is the first time that analysis has been conducted in such a detailed way. It is also the first time that governance of the GAB, including CSG activities, has been measured through the lens of Ostrom’s CPR theory. Using the detailed AIA design principles and heat map enabled an analysis of the different aspects of the overall groundwater governance – not only governance of the entire groundwater system, but also the aspects of extraction of CSG produced water and injection as separate activities. The corresponding heat map developed is a unique contribution that is a useful analytical tool, pictorially reflecting a governance framework based on CPR theory. It is a tool that can be further developed to educate stakeholders about overall CPR governance weaknesses and strengths, not just for groundwater but, perhaps, in other CPR contexts.

1315 See chapter 2, section 5(b), above p 76–80.
1316 See chapter 2, section 5(b), above p 81–84.
In parts B and C, I conducted the evaluation and analysis relating to both jurisdictions. A thorough doctrinal analysis of the regulatory frameworks was conducted. My research method also involved the collection of data from a wide number of permits and associated documents. A significant number of stakeholders were interviewed (with some notable exceptions for each jurisdiction). Triangulation between the doctrinal analysis, document analysis, and quantitative and qualitative data analyses provided me with confidence in the evaluation against the AIA design principles. Recall that a grading was attributed to each of the AIA design principles for both jurisdictions. Red, amber and green were used to reflect broadly the absence, practical presence or presence of a particular AIA design sub-principle. The attribution of gradings was necessarily subjective. Nevertheless, the utility of the three-colour grading system is that it provides clarity at either end of the spectrum: exactly where it is needed. Although amber gradings may be debateable, red and green gradings are unlikely to be because they indicate areas where the design principles are either clearly absent or present. This helpfully highlights weaknesses and strengths in the framework.

In chapters 3 and 4, I analysed the PRB Wyoming governance arrangements. From that analysis, I concluded that, in Wyoming, the governance of groundwater and of CSG produced water extraction was *relatively successful*, and that the governance of injection of treated CSG produced water was *successful*. This correlated with the presence and partial presence of a majority of the AIA design principles. In chapters 5 and 6, I analysed the Surat CMA Queensland governance framework in the same way and concluded that it was *unsuccessful* in terms of overall groundwater governance and of extraction of CSG produced water, and *relatively unsuccessful* in terms of injection of CSG produced water. These negative outcomes correlated with a general absence of the AIA design principles.

These research findings were compared and analysed in Chapter 7, where I concluded that an overall absence of the AIA design principles appears to be an impediment to groundwater governance and aquifer injection of CSG produced water. Moreover, I also concluded that transparency could be an important driver for sustainable groundwater governance, and also aquifer injection of CSG produced water, especially where AM is adopted. The heat map for the Surat CMA clearly showed where AM had been applied. I also demonstrated that AM could be helpful in transforming a governance framework, where it involves transparent monitoring, research, periodic evaluation and compliance measures.

This is another important contribution to natural resource management. The use of the heat map demonstrates how AM can transform particular aspects of a governance framework. This research shines a light on how AM has been used in the CSG context in Queensland. It also shows
how AM, or adaptive governance, could be used to transform specific areas of a governance framework, and how a balance between stability and flexibility in a governance framework may be achieved. Other scholars have criticised AM more broadly and from a theoretical perspective. But no other scholar has looked at the different empirical applications of AM, and the steps that have transparently taken place after approvals have been granted. This has been a fruitful area of research.

In Chapter 7, I also met the objective from the start of this research, arriving at conclusions specifically with respect to how governance of the injection of CSG produced water could enable sustainable groundwater resources. I concluded, using the AIA design principles and the outcomes from the PRB and Surat CMA case-studies, that clear entitlements, economic incentives and unified assessments positively correlate with successful outcomes for the injection of CSG produced water. I also concluded that positive outcomes align where the process is part of an integrated catchment management strategy. These are also important research findings in that they confirm that the recommendations by scholars for MAR generally also apply in the CSG context. Other specific findings relating to the governance of injection of CSG produced water are that a lack of formal collective choice mechanisms (DP 3) and rights to organise (DP 7) may not be important for the operational phase of injection of CSG produced water, although they may be helpful. In addition, I concluded that unquantified benefits associated with injection may also influence the process in some contexts. These findings provide the basis for pathways for reform of governance arrangements, which may support the use of aquifer injection of CSG produced water and enable positive outcomes for groundwater resources generally. This has been a fruitful area of research that contributes to the existing scholarship relating to MAR generally.

This chapter concludes this research project by answering the overarching research question below. I detail the three broad initiatives that I recommend should be adopted, on the basis of this research. To complete this research project, I then reflect on the remaining question, which was put to one side early on: whether entitlements to groundwater (and aquifer injection) are property rights and whether this issue matters, either way. The chapter ends with a description of some areas for further research.

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1317 The need for research that canvasses empirical evidence of administrative balancing of stability and flexibility was highlighted by Craig et al, above n 308.
2. Overarching research question: recommended initiatives

Based on the findings in Chapter 7, I can now answer the overarching research question:

Are there governance initiatives for aquifer injection and augmentation using CSG produced water that may enable or inhibit sustainable groundwater governance?

This chapter argues that there are three important initiatives for driving sustainable outcomes, not just for aquifer injection of CSG produced water but also wider groundwater governance. Because there has been a severe contraction in CSG extractive activity in Wyoming since 2010, it would be pointless to make recommendations for regulatory reform for that jurisdiction as a result of this analysis. However, on the basis of the comparison with the PRB framework, initiatives can be presented more specifically for the Surat CMA.

The two key initiatives for the governance of aquifer injection of CSG produced water, and groundwater generally, in the Surat CMA are first, transparency of reliable information; and second (and only if that is possible) adaptive governance. I also recommend that there should be a third initiative, which consists of broadly deliberating with stakeholders (including the public) on areas where the AIA design principles are missing. These three separate initiatives are discussed in sequence below.

b) Transparency

The most important initiative that results from this research is to start with transparency of reliable information. In this context, reliable information means information that relates to how the groundwater resource is already managed, and what we know about the status and behaviours of the resource. ‘Reliable information’ is, first of all, information that is held by government agencies and on which officers have made decisions, including the decisions themselves. Despite National Water Initiative provisions, which require openness and transparency, much of this information is

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1318 The most pressing regulatory issue for aquifer injection of CSG produced water raised by participants in the interview process as relating to the power of the WDEQ to require financial assurance for injection activities: Interview with Participants W8–18 (Sheridan, Wyoming, 16 August 2017); Interview with Participant W7 (Sheridan, Wyoming, 15 August 2017). That issue has now been addressed by legislative amendments passed in 2018, see chapter 3, section 3(b)(iii), above p 108.

1319 This level of transparency is broadly recommended as a key principle for effective participation in environmental management by the US National Research Council: National Research Council, Public Participation, above n 292.

1320 Commonwealth of Australia et al, Intergovernmental Agreement on a National Water Initiative, above n 247, cls 25(iii), 93.
not openly and readily available to the public in Queensland. For example, decisions on secondary environmental management plans and even water licences are not freely available. Often, it is the private parties, such as the CSG operators, that make it voluntarily available. But not always.

Information provided to government departments ought to be accessible by interested stakeholders without the need to make lengthy (or costly) applications. Just as importantly, the decisions that are made by government agencies ought to be freely available and easily located, for example, on the internet. Ironically, some operators have been voluntarily more transparent than the government departments. Government decision-making, in respect of water, relates to a public resource.\(^{1321}\) Therefore, the general public has a right to know, at the very least, how that resource is being managed. The importance of groundwater to the entire state, and not just the parties immediately affected, demands that decisions that impact the resource ought to be broadly, publicly accessible,\(^{1322}\) especially when there are indications that it is pressured. Considerations of ‘privacy’ or ‘commerciality’ of actions affecting a public resource, on which much of our economy and wellbeing rely, ought not to dictate how information relating to government agency decision-making is to be shared. The regulator must take the lead in this aspect. This will ensure that all groundwater users (landholders, agricultural enterprises, commercial operators and the broader public) are able to share in learning associated with the development. Without transparency, we cannot even begin to truly understand the resource as a collectively dependent social-ecological system, let alone try to manage it.

Similarly, information about the resource that scientists have collected really ought to be brought to the attention of all groundwater users, as well as the wider public. In the Surat CMA, the work of OGIA and the technical reports that support the GABORA water planning are readily available. Yet, it is uncertain as to how many landholders are aware of their findings. The recent efforts by QDNRME, in respect of the digital platform ‘Groundwater Net Digital Report 2018’,\(^{1323}\) is a positive initiative that addresses this issue.

To some, this call for transparency may be confronting, or even naïve. Some may point to the bits and pieces of information that are scattered throughout the public domain and argue that we already have transparency, to a certain degree. Regardless, if the broad level of transparency recommended in this thesis is not possible in the current political climate in the Surat CMA, would it not be better to try to understand why that is the case and address that issue? Why cannot we, as the public and interested stakeholders, be privy to decisions on injection management plans, CSG

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\(^{1321}\) *ICM Agriculture Pty Ltd v Commonwealth* (2009) 240 CLR 140, [147].

\(^{1322}\) National Research Council, Public Participation, above n 292.

\(^{1323}\) See chapter 6, section 4(a)(iii), above p 218 and 219.
water management and monitoring plans, annual returns for environmentally relevant activities, water licence applications, and all compliance activities? Why cannot monitoring data and permit and licence materials be displayed in a central publicly available repository? After all, this is largely the level of transparency that is displayed in the PRB framework.

Certainly, this first step would be best addressed before embarking on any further initiatives that require a degree of openness. Research that seeks to understand why a lack of transparency may be entrenched in Queensland, and the influence of political factors, would be useful in seeking to transition to a more adaptive governance model. Therefore, the first initiative is a call for transparency of reliable information. If that is not possible, I consider that research seeking to understand why transparency is difficult, or unwanted, is acutely necessary.

b) Adaptive governance

The second initiative proposed as part of this research relates to AM and the more expansive concept of adaptive governance. AM is a legitimate tool for applying the precautionary principle: it is a precautionary measure used where there is a threat of serious or irreversible environmental damage, and a lack of full scientific certainty.1324 As already noted, AM has been broadly adopted to address issues of uncertainty relating to CSG development.1325 It is important to note that AM is not expressly adopted in legislation although, as mentioned above, it is implicitly adopted in the way that CSG operators are required to report on CSG produced water management.1326 The context in which AM is applied is in the application of the precautionary principle, just one of a number of criteria that are relevant to decisions on EAs authorising CSG development.1327 Decisions relating to subsidiary management documents, such as a CSG produced water management plan or an injection management plan, do not need to comply with legislative criteria but they ought to be made in pursuance of ecologically sustainable development.1328 They ought to apply a precautionary approach and, where they incorporate AM, have the indicia established in caselaw – monitoring,

1324 See chapter 2 section 1(a)(ii), above p 40. There are other measures adopted by the Queensland government that appear to contribute to a ‘precautionary’ approach to CSG development (and other resource extractive industries). Legislative reform includes the introduction of the ‘make good’ framework in chapter 3 of the Water Act; the Regional Planning Interests Act 2014 (Qld); and the introduction and changes to the government’s CSG Water Management Policy in 2008, 2010 and December 2012: see chapter 1 section 1(b), above p 11–12; chapter 5 section 3(b)(ii), above p 167 and 168. However, the statutory right that authorises extraction of CSG produced water has not been revisited other than to broaden the statutory exemption to mining activities: see chapter 6 section 3(i), above p 212–213; Tan and Robertson, above n 982.
1325 See chapter 2 section 2, above p 44, above n 247 and n 248.
1326 See chapter 5 section 3(b)(ii), above p 169; chapter 6, section 1(a)(iii), above p 191-194.
1327 See chapter 5 section 3(b)(ii), above p 168.
1328 See chapter 5 section 3(b)(iii), above p 168.
research, evaluation and compliance – and sufficiently diminish the risks and uncertainty.\textsuperscript{1329} Where performance targets are required, these should be set so that the appropriate evaluation can be made in pursuance of the objective of sustainability.\textsuperscript{1330}

As seen through my earlier analysis in chapter 6 and 7, AM has been used in several ways. The heat map for the Surat CMA clearly showed where AM had been applied relevantly in respect of groundwater governance. First, AM has been used quite successfully by OGIA in relation to the physical boundaries and status of the groundwater resource, and the cumulative predicted impacts of CSG activities.\textsuperscript{1331} As noted, significant research has been and is being conducted into the physical status of the groundwater resources in the Surat CMA.\textsuperscript{1332} The use of an adaptive approach by OGIA has reduced uncertainty in respect of the impacts that can be expected. We now know that there are areas that have declining water levels.\textsuperscript{1333} Also, this research has shown that there is a very real concern that some landholders (and consequently the environment) may suffer impacts that are unable to be remedied by the ‘make good’ arrangements.\textsuperscript{1334} It could now be argued that, with the decreasing uncertainty about certain negative impacts, the rationale and operation of the legislative provisions that authorise such development ought to be revisited, and adequate preventative measures ought to be adopted. For example, a preventative and precautionary measure could now include requiring CSG activities to have a water licence. Another measure might be to ensure that landholders, who are reasonably predicted to be irreparably impacted, have immediate priority alternative access to other groundwater resources within water planning and allocation.

The other application of AM has been in respect of the management of CSG produced water and aquifer injection activities. The application of AM in this context has been flawed, in that decision-making by the regulator is not obvious or transparent. The legislative scheme in this context provides the regulator with extensive discretion. Recall that the legislative requirements for annual returns whereby an evaluation of the operator’s CSG produced water management are vague. All that is technically necessary is for the operator to provide an ‘evaluation’ of whether the CSG produced water management has been effective.\textsuperscript{1335} The requirements for other subsidiary management plans, such as injection management plans, are triggered by the EA conditions rather than specified in the legislation. Therefore, the regulator has a broad discretion in accepting these

\begin{enumerate}
\item \textsuperscript{1329} See chapter 2 section 2(c), above p 53–57.
\item \textsuperscript{1330} See chapter 6 section 1(a)(iii), above pp 194-195, discussing examples of performance targets set by operators relating to CSG produced water management.
\item \textsuperscript{1331} Discussed in chapter 6 section 1(b), above p 200.
\item \textsuperscript{1332} See chapter 6, section 1(b), above p 198–199.
\item \textsuperscript{1333} See chapter 1, section 1, above p 2: Klohn Crippen Berger, above n 26.
\item \textsuperscript{1334} See chapter 6, section 2(a)(i), above p 201–205.
\item \textsuperscript{1335} See chapter 6, section 1(a)(iii), above p 193–195.
\end{enumerate}
various documents as being sufficient for the purposes of the legislation and the EA conditions. However, arguably, this discretion ought to be exercised in pursuance of the objects of the Act and be suitably ‘precautionary’. There are indications that suggest that the decision-maker may not have exercised decision-making discretion at times.\textsuperscript{1336} Decision-making at this level is not required by the legislation to be transparent: there are no legislative provisions requiring publication of decisions on these subsidiary management plans.

Yet, without understanding the decision-making that has occurred, it is impossible to evaluate. Decision-making may be absent. Alternatively, a decision may have been made but is either inappropriate or, in fact, appropriate. This point is important, because this research shows that a requirement that the regulator approve certain documents will not necessarily ensure that adequate precautionary measures will be or are being adopted. McDonald P justified a decision upholding the AM approach proposed in respect of the Carmichael mine on these grounds.\textsuperscript{1337} Earlier, Doyle CJ of the South Australian Supreme Court had also reflected a cautious judicial approach,\textsuperscript{1338} arguing that it is not appropriate to assume in advance that an agency would avoid an authentic AM approach ‘at least and until there is evidence indicating that he might well do so.’\textsuperscript{1339}

After analysing the different standards accepted by QDES in respect of annual returns and evaluations of CSG produced water management, I am not reassured that simply requiring the regulator to approve plans at a later date \textit{without transparency} will ensure that an ‘adaptive’ approach applied in the future will be suitably precautionary. This is because there has been an absence of transparent decision-making but also decision-making thresholds,\textsuperscript{1340} which would trigger the cessation of extractive activities in certain locations. There is no assurance that an authentic AM approach has been adopted that ensured the residual risks have been minimised. It very much appears as though the process was adopted voluntarily by some operators to varying extents. This leaves the real possibility that impacts to groundwater levels may eventuate in some areas that are irreparable. If the test for whether an AM approach is appropriate depends on ‘the extent of risk and uncertainty remaining and the gravity of the consequences if the risk is realised’,\textsuperscript{1341} a re-evaluation

\textsuperscript{1336} See chapter 6 section 1(a)(iii), above p 194.
\textsuperscript{1337} See chapter 2 section 2(c), above p 54: \textit{Adani Mining Pty Ltd v Land Services of Coast and Country & Ors}(2015) QLC 48 (15 December 2015), [271].
\textsuperscript{1339} See chapter 2 section 2(d), above p 54: \textit{Tuna Boat Owners Association of SA v Development Assessment Commission} (2000) 77 SASR 369; 110 LGERA 1 [54].
\textsuperscript{1340} Such as when CSG produced water management is ineffective or inappropriate, or where there are likely to be irreversible impacts.
\textsuperscript{1341} See chapter 2, section 2(c), above p 55: \textit{Davidson Family Trust v Marlborough District Council} [2017] NZHC 52 (31 January 2017), [53].
of how AM is applied in Queensland is arguably necessary. Certainly, there will always be negative impacts of development and precautionary measures ought not go beyond what is appropriate.\textsuperscript{1342} However, the gravity of future irreparable impacts to the Great Artesian Basin, a national treasure and resource upon which most of Queensland relies, ought now to be properly evaluated.\textsuperscript{1343}

Where an AM approach that has been applied is arguably ultra vires,\textsuperscript{1344} a judicial review of the agency decision-making would normally revert the decision to the relevant decision-maker to be exercised again. Therefore, any argument that the AM approach applied by the QDES in the context of CSG water management is flawed does not necessarily provide any substantive outcome for anyone. Nonetheless, this research provides a basis for questioning whether the AM approach that has been adopted in Queensland to date is suitably precautionary. This research finding supports the argument that, without transparent decision-making and evaluation, the AM approach adopted in Queensland is not a suitable precautionary measure for development that may otherwise be prohibited due to the uncertainty of future environmental impacts. Work to rectify this in Queensland is warranted, because this research also demonstrated that AM can be transformative where it is applied legitimately and transparently.

This research has revealed that AM can be a powerful tool, but not always. The aim of an AM approach is to learn, so that uncertainty is reduced and management is improved. This research shares similarities with other research in the Edward Wakool system in the southern Murray–Darling Basin, Australia, which demonstrates that, where learning is limited or spread across multiple stakeholders and actors, it will not be immediately obvious without explicit documentation.\textsuperscript{1345} AM has been used in a positive way in Queensland; for example, to reduce uncertainty relating to the groundwater resource. It can also be used, in a limited way, in the development of new regulatory mechanisms for activities such as aquifer injection of CSG produced water. Arguably, the lacklustre attempt at AM, as revealed in some operators CSG water management reporting,\textsuperscript{1346} demonstrate the dangers of an opaque application of this approach. It also could be used more broadly, in the sense of adaptive governance, where broader social learning institutes changes on a whole raft of levels, particularly on values and norms. In other words, it has been both a lone drum echoing across the regulatory landscape as well as a small band of voluntary minstrels. It could be, with practice, an orchestra. There is a large caveat on its potential usefulness: without transparency in decision-

\textsuperscript{1342} See chapter 2 section 1(a)(ii), above p 42, n 235.
\textsuperscript{1343} As required by the Intergovernmental Agreement on the Environment: Commonwealth of Australia et al, Intergovernmental Agreement on the Environment, above n 195; see chapter 2 section 1(a)(ii), above p 41.
\textsuperscript{1344} See chapter 2, section 2(c), above p 54; in Australia, the test is ‘stringent’, see: Ulan Coal Mines Limited v Minister for Planning (2008) 160 LGERA 20, [100].
\textsuperscript{1345} See chapter 2 section 2(b), above p 49–50; Allan and Watts, above n 302.
\textsuperscript{1346} See chapter 6, section 1(a)(iii), above p 192–195.
making, its use will be limited and can even be hazardous, especially where there is existing conflict and lack of trust in the governance arrangements.

Therefore, the second broad initiative that I recommend depends on whether the reliable information that government agencies already possess can be placed in the public domain and whether government agencies can courageously adopt this type of transparency. This is especially true for agency decision-making. Why not open up the administrative process by publishing the various decisions (and reasons) that relate to EAs and water licensing? For example, the WDEQ includes all of the information relating to UIC permits for injection wells in its GEM database.\textsuperscript{1347} By checking through the materials relating to specific injection wells, anybody can see details about WDEQ inspections, operator non-compliances, and steps undertaken to address non-compliances and decisions by the WDEQ, indicating that the matters are resolved. The provision of this information enables interested stakeholders to reassure themselves that the regulator is doing its job. It also provides reassurance as to the nature of the common issues and, therefore, educates the interested stakeholder about the relative risks associated with the development. Only if these circumstances are possible, I recommend the efforts to adopt a transparent AM approach, which does not avoid robust discussion between relevant stakeholders. Therefore, on the basis of the research findings in this thesis, I recommend initiatives that would enable conditions for what may be termed ‘adaptive governance’.\textsuperscript{1348}

I am not alone in championing the need for more collaborative and transparent decision-making in Queensland.\textsuperscript{1349} Yet, in the Surat CMA, and Queensland generally, there appears to be a reluctance to allow true participation in policy development. Existing participatory mechanisms, such as the consultation undertaken in water planning and allocation, and even relating to resources projects generally, appear tokenistic. Communication that is merely one-way can have detrimental effects, breeding resentment and apathy.\textsuperscript{1350} Ironically, transparency around decision-making by the government agencies can go a long way to facilitate two-way communication on policy. This will

\textsuperscript{1347} See chapter 3, section 3(b)(iii), above p 108: Wyoming Department of Environmental Quality, Login (GEM) <http://deq.wyoming.gov/wqd/underground-injection-control/resources/gem-login/>.\textsuperscript{1348} A valuable research agenda could incorporate deliberations on the candidate legal and design principles, suggested by Daniel De Caro et al, ‘Theory and Research to Study the Legal and Institutional Foundations of Adaptive Governance’ in B Cosens and L Gunderson (Eds) \textit{Practical Panarchy for Adaptive Water Governance: Linking Law to Social-Ecological Resilience} (Springer, 2018).\textsuperscript{1349} See chapter 6, section 3(i), above p 212–215.\textsuperscript{1350} See discussion in chapter 6, section 3(i), above p 212–215, and also the comments of participants Q8 and Q9, who stated that, ‘What the companies do is come out and present what they will be doing; that is, explain what the company plans to do. There is no consultation, just “telling”. So often landholders won’t bother to go to these meetings because the consultation process is useless.’ see Interview with Participants Q8 and Q9 (Roma, Queensland, 22 April 2017); Arnstein, above n 291; Hurlbert and Gupta, above n 291.
facilitate social learning about not only appropriate governance arrangements but also the groundwater resource, and the respective interests of stakeholders and the wider society.

It is understandable that government agencies and other parties, such as CSG operators and other large users of groundwater, may be reluctant to openly engage with other stakeholders and the public. As already mentioned, two-way communication can be costly, unpredictable and can erode existing power bases. For transparent engagement to be adopted, the costs of producing and distributing the information, and the potential negative consequences of transparency, must be less than the future benefits of social learning and, perhaps, achieving consensus. Where the object of the governance is sustainable development of water resources, on which life, development and prosperity depends, the long-term benefits are surely considerable. Further, the adoption of a strategy of open engagement is sensible, where implementation of reform has been difficult in the past. In addition, where we are faced with continuing declining levels of the resource, and continuing conflict and a lack of trust, changing the current strategy of closed decision-making holds promise. Doing the same thing (or doing nothing) and expecting different results is nonsensical. The only option is to embrace uncertainty, courageously and transparently, as an opportunity and to share that opportunity so that stakeholders can participate in that journey.

c) Deliberative reform involving the AIA design principles

If we can be armed with better information, and an open and flexible environment to discuss existing governance and future reform measures, this research also highlights a third initiative that should be considered. The third initiative recommends an open deliberative process of enquiry that relates to specific areas of weakness in the Queensland framework highlighted by the AIA design principles. These recommendations accord with the research of Lebel et al described above, where the authors found that adaptive governance, and the capacity to manage resilience, requires attributes of good governance, which include participation and deliberation. A reform agenda could relate to first, broad deliberation on the governance of the groundwater system, including the governance of CSG produced water; and second, deliberation on the governance mechanisms of injection activities.

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1351 See chapter 2, section 2(b), above p 49: Hurlbert and Gupta, above n 291; Baker and Chapin, above n 294.
1352 See chapter 2 section 2(b), above p 49: This type of engagement will no doubt increase decision-making costs but will, ultimately, decrease the costs of implementation of policy: Schlager and Blomquist, above n 289, ch4.
1353 See chapter 2, section 3, under heading ‘AM, adaptive governance and Ostrom’s design criteria for CPRs’, above p 64.
1354 As well as polycentric and multi-layered institutions, and accountable and just authority: Lebel et al, above n 301, Cosens and Gunderson, above n 29.
The initiative of deliberating on whether (and how) to incorporate specific AIA design principles within the legislative framework could be adopted independently of the first two initiatives relating to transparency and adaptive governance: that is, as top-down rule changes. It is extremely tempting to tinker directly where there are obvious governance weaknesses. This is because, at the very least, it is extremely unlikely that resource users will independently work collectively to manage groundwater resources sustainably in the Surat CMA. Resource users are unlikely to be able to do it alone. Not only is this due to the existing strong state ‘command and control’ approach already applied, but the attributes of the resource, and the resource users, also contribute to this context. There are no obvious reasons (yet) that, in acting collectively, there will be feasible improvement in the resource. This is because the behaviour of the resource and impacts of extraction are highly uncertain and occur over very long timeframes; there are as yet no cost-effective, widely accessible, reliable and valid indicators of the status of the resource; the entire resource system is extremely large and, therefore, it is difficult for groundwater users to cooperate; the groundwater users are heterogeneous actors, some of which have low discount rates (the farmers) and some are likely to have higher discount rates (arguably, the CSG operators); and there appears to be an existing lack of trust between resource users (landholders versus CSG operators and perhaps other users, such as pastoralists versus cotton farmers or feedlot operators). The costs, benefits and likely success of rule changes must acknowledge this context.

Consequently, an open and collaborative process supported and instigated by the regulator, which can deliberate on these factors, ought to support any proposed reform efforts. This research has shown how an AM approach applied to areas of weakness can transform one set of arrangements to another that is conducive to cooperation, collective responsibility and action, and (hopefully) an absence of free-riders. However, without a commitment to monitoring any adopted initiatives going forward and communicating the results with the wider resource users, it may be difficult to (incrementally) improve governance arrangements.

This third initiative is framed as a set of questions that could start debate about the perceived weaknesses of the Queensland framework. The questions could be the subject of targeted workshops or even conversations with stakeholders. The questions are divided into two groups and tabled below (see Tables 21 and 22). The first group or table (Table 21) relates to areas of perceived weakness in respect of the wider groundwater governance, including governance of extraction of

\[1355\] See chapter 5, section 4(b), above p 183; Gillespie et al, above n 173, Gillespie and Lizzio-Wilson, above n 1288.

\[1356\] These are the opposite of attributes that are known to facilitate collective rule development, see: chapter 2, section 3, above p 61–62; Ostrom, Understanding Institutional Diversity, above n 382, 244–245.
CSG produced water. The second group and table (Table 22) relates to the governance of injection activities. Some of the discreet questions posed deserve further elaboration, and that discussion is presented directly after the relevant tables, below.

While some of the questions may overlap, I have deliberately separated the issues into two groups: first, issues that relate to the groundwater system and extraction; and second, issues that relate to injection activities. This is because, even though the topics are inextricably linked, there is likely to be different sets of stakeholders that relate to the two different topics. It also allows for the issues to be broken down into manageable units, which are conceptually and practically easier to tackle. It also means that stakeholders who are ideologically opposed to specific issues may, nonetheless, remain engaged where other discreet issues are considered. It is hoped that dividing the issues in this way may contribute to starting a conversation, which may lead to small successes even if holistic and broad reform is difficult.

It should be also highlighted that the list of questions has been developed as part of this research. Therefore, they are necessarily limited by not having been able to engage openly with the relevant departments or operators in Queensland, and certainly not all landholders in that jurisdiction. Nonetheless, as such, they present a fresh perspective on the Surat CMA governance framework.

(i) Initiatives for the governance of groundwater and extraction of CSG produced water

In Chapter 7, I found that the AIA design principles appeared to be important, in that their general absence correlated with unsustainable outcomes for groundwater governance in the Surat CMA. As already highlighted, the absence of various design principles enables the policy analyst to consider where underlying weaknesses may contribute to certain vulnerabilities. For reform of groundwater governance generally, as well as governance of extraction of CSG produced water, I recommend deliberating on the following questions (Table 21, below), which focus on the absent or weak missing AIA design principles in the Surat CMA. A conversation about reform, rather than ‘proposals for reforms’, reminds us that the context of any specific issue (clarity of boundaries, reality of monitoring, adequacy of sanctions, etc.) is extremely relevant and different in each case. The first and second columns in Table 21, below, indicate a specific design principle, following Ostrom’s general list of 8 principles, where weakness was perceived in the Surat CMA context. The third column provides a corresponding research question that may address the absence of the

1357 See chapter 2, section 3, above p 63; Ostrom, Understanding Institutional Diversity, above n 382, 270.
design principle. The fourth column includes more detailed questions along the same lines, specific to the Surat CMA context. Some questions may yield negative answers immediately by relevant knowledgeable stakeholders, who are already aware of the likely negative consequences of potential rule changes. Nonetheless, at the very least, if some of the questions are considered broadly by stakeholders and government, and implemented in an adaptive way, with open dialogue and transparent monitoring, this approach ought to transform understanding, if not outcomes.
<table>
<thead>
<tr>
<th>DP</th>
<th>Description</th>
<th>Topics to consider for governance of groundwater and extraction of CSG produced water in the Surat CMA</th>
<th>Potential areas for reform?</th>
</tr>
</thead>
<tbody>
<tr>
<td>DP1</td>
<td>Clear boundaries (users, rules and the resource)</td>
<td>How can we improve the definition of the boundaries of the resource as well as the resource users?</td>
<td>Upload all relevant materials relating to licences, permits, EAs and subsidiary management plans and compliance information?</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Consolidate monitoring and extraction data on a single web-page?</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Increase metering and reporting requirements (including non-CSG extractors and CSG extractors alike), which would then be publicly available?</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Amend the definition of ‘waste’ in the EP Act, so that CSG produced water of a certain quality can be managed as ‘water’?</td>
</tr>
<tr>
<td>DP2</td>
<td>Congruence between rules and local conditions</td>
<td>How can we improve local tailoring of rules for water extraction?</td>
<td>Reassess existing exemptions to water licencing to incorporate local context?</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Reservation of certain groundwater resources for future access by landholders that have been or are predicted to be impacted by CSG operations?</td>
</tr>
<tr>
<td>DP2</td>
<td>Cost/benefit proportionality</td>
<td>Should the costs of governing the resource be shared in a way that better reflects the proportion of water extracted by various users?</td>
<td>Reassess fees for extraction of water, such as some commercial operations?</td>
</tr>
<tr>
<td>DP3 and DP7</td>
<td>Collective choice arrangements</td>
<td>How can we enhance the ability for groundwater users to have input into decision-making?</td>
<td>Divide the groundwater resources further and allow smaller discreet groups of users to coordinate together with each other and the regulator?</td>
</tr>
<tr>
<td></td>
<td>Rights to organise</td>
<td></td>
<td>Establish regular working groups, open to any interested parties, that publish a transparent agenda and meeting notes?</td>
</tr>
<tr>
<td>DP4</td>
<td>Monitoring (users, extraction and the physical resource)</td>
<td>How can we improve the presentation of monitoring data to improve knowledge about the resource as well as accountability of the monitors?</td>
<td>Consolidate monitoring and extraction data on a single web-page?</td>
</tr>
</tbody>
</table>
Aquifer injection in the coal seam gas context: Part D: Chapter 8: Initiatives for reform

<table>
<thead>
<tr>
<th>DP</th>
<th>Description</th>
<th>Topics to consider for governance of groundwater and extraction of CSG produced water in the Surat CMA</th>
<th>Potential areas for reform?</th>
</tr>
</thead>
<tbody>
<tr>
<td>DP5</td>
<td>Graduated sanctions</td>
<td>How can we deal more transparently with rule infractions so that graduated sanctions are apparent?</td>
<td>Publicly report all compliance activities, along with other information about specific water users?</td>
</tr>
<tr>
<td>DP6</td>
<td>Conflict resolution mechanisms</td>
<td>How can we improve conflict resolution mechanisms for impacts to groundwater resources generally?</td>
<td>Establish low-cost conflict resolution mechanisms that could result in a cessation of extraction, where impacts are irreversible? Reserve alternative groundwater resources where there are predicted negative impacts in the short and longer term?</td>
</tr>
<tr>
<td>DP8</td>
<td>Nested enterprises</td>
<td>How can we improve collaboration between government agencies, and how can we provide a local connection with agencies?</td>
<td>Establish regular working groups, open to any interested parties, with a transparent agenda and meeting notes? Decentralise regulatory agency operations, so that agencies can be staffed by locals in more regional contexts (e.g. Roma, Dalby, Miles)? Make decision-making transparent between regulatory agencies so that coordination appears to be and is facilitated? Reconsider the need for an approval’s bilateral agreement between the Commonwealth and Queensland?</td>
</tr>
</tbody>
</table>

Table 21. Topics to consider and potential areas for reform in governance of groundwater generally and extraction of CSG produced water
Aquifer injection in the coal seam gas context: Part D: Chapter 8: Initiatives for reform

Suggested topics to consider for DP 1, DP 4 and DP 5

One of Ostrom’s key criteria is certainty with respect to the boundaries of the resource (DP 1). There does not appear to be any reason why relevant material relating to licences, permits, EAs and subsidiary management plans that relate to groundwater are not made publicly available by the regulator. This could include compliance activities that relate to permitted uses (DP 5). These are the materials that relate to a government agency’s management of a state-controlled resource pursuant to legislative powers. To ensure effective administrative action, it would seem sensible to start with transparency around these actions.

The requirement for certainty also includes quantification of extraction. Neither the Wyoming framework nor the Queensland framework require reporting of extraction by all water users. In the Laramie County Control Area in Wyoming, stock and domestic users do not have to meter water extraction. But large users, such as irrigation, municipal, industrial and miscellaneous users, are required to meter and report data in that area of Wyoming. Given the downward trends for some aquifers in Queensland, this would appear to be a reasonable requirement for Queensland as well. As to whether stock and domestic bores should also be metered and the data reported is more problematic. Some may argue that this exception to metering requirements is reasonable. The financial and administrative costs of metering are not insignificant and other users, such as feedlots, irrigators for agriculture and local government, actually extract proportionally more water.\footnote{Refer to proportions of water extracted, see chapter 5, section 3(b)(iii), above p 179.}

Further, there are natural limits on the quantum of water that is necessary to water stock, due to the carrying capacity of the land. However, recall that most land use controls on domestic or pastoral uses do not require a consideration of the availability of water.\footnote{See chapter 5, section 3(b)(iii), above p 179.} Once a domestic and pastoral use of land is established, the right to access groundwater is available. Depending on the status of the groundwater resources, and the quantum extracted cumulatively by stock and domestic users, it may be necessary to rethink this approach.

As mentioned in Chapter 7, there is a lot of monitoring data (DP 4) already available about the groundwater resource, but it is disaggregated. Landholders that have CSG activities on their land have access to a high quality and quantity of data, which is unavailable to the public and other landholders. Providing this information to be reported in a uniform way and requiring it to be uploaded onto a publicly available website would educate all interested parties about the resource, as well as ensure that there is monitoring of the monitors. The information need not be uploaded on a continual basis. In Wyoming, this information tended to be reported quarterly. Efforts to provide
more uniform access would assist educational efforts as well as confidence in the framework. As already highlighted above, QDNRME’s ‘Groundwater Net Digital Report 2018’\textsuperscript{1360} is laudable and ought to be supported and further developed.

Because CSG produced water is defined as a ‘waste’ in Queensland, CSG produced water falls outside of all transparent and direct accounting and planning: it is not included in the overall water use within a basin. It may be considered indirect and ‘off the books’ by QDNRME, but it is not obviously presented as part of the water-planning arrangements. The further use of CSG produced water for other beneficial uses, such as stock watering and crop irrigation, is also not included in the water planning for the basin. This compounds the criticisms of the independent review conducted in 2018, which suggested that a fit-for-purpose water accounting system be implemented.\textsuperscript{1361} These arrangements are contrary to the Wyoming framework, where water extracted by CSG activities requires licences for any further subsequent beneficial reuse. Defining produced water as a waste, when it is effectively the same water drawn from an aquifer governed by the GAB Water plan, seems nonsensical. It leads to numerous perverse outcomes. For example, spills from a CSG well are treated with caution under the environmental protection framework; however, spills from overflowing bores accessing the same aquifer/hydrocarbon resource are not.\textsuperscript{1362} If the definition of waste was amended to exclude water of a certain quality, this would enable CSG produced water of that quality to be accounted for within the basin. It may even provide a framework whereby some incentive could be provided to CSG operators to ensure that the water is not wasted. Not only would Ostrom’s criteria relating to certainty of the boundaries of the resource be strengthened but it would also provide a more integrated approach.

**Suggested topics to consider for DP 2**

Congruence between local conditions and extraction rules could be aligned if the existing exemptions could be reassessed. Perhaps it is time to rethink the exemption for domestic and stock use, or even the statutory authorisation held by the resources industry. These exemptions make it difficult to incorporate local conditions where extraction takes place within these contexts. At the very least, reserving groundwater where it is reasonably possible to predict future authorised extraction would seem sensible.

Admittedly, the disproportionate cost-sharing for the resource and quantum of extraction is a difficult issue to resolve. As noted in Chapter 6, non-CSG water users extract most of the

\begin{flushleft}
\begin{footnotesize}
\textsuperscript{1360} See chapter 6, section 4(a)(iii), above p 217.
\textsuperscript{1361} Waldron, Tan and Johnson, above n 992, 36.
\textsuperscript{1362} Because CSG produced water is defined in the legislation as a ‘waste’, see chapter 5, section 3(b)(ii), above p 166.
\end{footnotesize}
\end{flushleft}
groundwater but do not contribute to the governance of the resource in equal measure. Most would agree that agricultural and pastoral activities provide important cultural, social, tourism and economic benefits to Queensland. They also provide us with food security, which is in no way an insignificant contribution to state. Ultimately, all Queenslanders benefit from these activities. While the economic and cultural benefits are difficult to quantify, they ought to be included in the analysis of cost-sharing. Ultimately, any shortfall in fees recouped from water users is met by the government and, consequently, the people of Queensland. If it was considered necessary to increase water licence fees to account for the lack of congruence, further targeted research in this area ought to be conducted.

**Suggested topics to consider for DP 3 and DP 7**

There are weak collective action arrangements or rights to organise in respect of groundwater governance (and injection activities). Collaboration can be present even where the participants are not the final decision-makers.\(^\text{1363}\) Because each aquifer in the Surat CMA extends over a large geographic area and any broader impacts are delayed, collaboration with an external government agent is necessary (rather than local communal determination).\(^\text{1364}\) However, local and subregional factors have more influence on groundwater levels at the local level where the aquifer is large.\(^\text{1365}\) This is because groundwater flow is very slow, which means that local measures can have an impact locally within a shorter timeframe. Therefore, where the aquifer is large, this ought not to preclude collaboration between users at a more local level. On the contrary, it is of the utmost importance that water users consider themselves part of a collective at the local level because their behaviours impact each other in the short term. Education and collaboration at a local level ought to provide changes in attitudes and behaviours that will impact short-term outcomes. Therefore, facilitating local groups, which could coordinate with the regulator (such as the citizen science initiatives by QDNRME)\(^\text{1366}\) would seem truly warranted and ought to be supported and developed. Working groups with transparent agendas and meeting notes that are open to all would encourage education efforts and buy-in by other landholders, and discourage elite-capture by the local groups. Similarly, nested organisational arrangements that capture local efforts as part of a broader strategy addressing long-term objectives will support these initiatives.

\(^{1363}\) See chapter 2, section 2(b), above p 48.

\(^{1364}\) See chapter 2, section 3, above p 63; Ross and Martinez-Santos, above n 219; Schlager, above n 388.

\(^{1365}\) Klohn Crippen Berger, above n 26, 99.

\(^{1366}\) See chapter 6, section 4(a)(iii), above p 217.
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Suggested topics to consider for DP 6

If it was possible to introduce low-cost conflict resolution mechanisms that contemplate the cessation of extraction where impacts are irreversible, this would alleviate some of the negative impacts around the existing regulatory framework. For example, the aquifer interference policy in the PRB appears to be quite successful. In addition, as mentioned above, reserving groundwater that is reasonably predicted to be extracted pursuant to exiting permits or EAs would also seem like a sensible proactive step in avoiding future unnecessary conflict.

Suggested topics to consider for DP 8

I have already mentioned that facilitating regular working groups at the local level that publish transparently their agenda and meeting notes would be helpful in terms of encouraging local buy-in and collective responsibility. However, if these groups are supported by the regulator, this would strengthen a nested organisational structure. If regulatory agencies can be decentralised by being situated in local areas and staffed by locals, particularly branches of the QDES, this would support education efforts at the local level. If decision-making was transparent, this could support administrative efforts to coordinate between departments, which are otherwise not acknowledged or understood by groundwater users and the public. If decision-making was transparent, perhaps it would also be appropriate to reconsider an approval’s bilateral agreement between the Commonwealth and Queensland so as to reduce approvals duplication.

(ii) Initiatives for injection of CSG produced water

For aquifer injection of CSG produced water, I concluded in Chapter 7 that (at least) three AIA design principles explained the reluctance to adopt that process in the Surat CMA, as compared to the PRB. The weakness in the Surat CMA framework appears to relate to a lack of clear and transparent rules for the injection process (DP1); a lack of rules that consider local geographic (and social) factors, which can provide for economic incentives (DP2); and fragmentation between government agencies (DP8). As noted above in Chapter 7, the role of collective choice mechanisms (DP3) and rights to organise (DP7) do not appear to be as important in respect of the technical aspects of the process. Nonetheless, if the local government and local users were able to have some input, even if it is in an indirect or informal way, the broader benefits that flow from the process may be able to be offset against the costs borne by the CSG operators.

Therefore, initiatives that could enable aquifer injection of CSG produced water would involve considering the following areas for reform (Table 22, below). Again, I have posited the

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1367 See chapter 4, section 6(i), above p 137.
general topics to consider as questions (third column) alongside the Surat CMA context-specific questions (fourth column). This approach highlights that the following initiatives ought to be, again, considered as areas that warrant further debate as part of a transparent adaptive approach, rather than proffering ‘one shot’ recommendations:
### Topics to consider for injection of CSG produced water in the Surat CMA

<table>
<thead>
<tr>
<th>DP</th>
<th>Description</th>
<th>Potential areas for reform?</th>
</tr>
</thead>
<tbody>
<tr>
<td>DP1</td>
<td>Clear boundaries (users, rules and the resource)</td>
<td>Could a stand-alone permit, like the UIC permit in the PRB, be appropriate in the Surat CMA context?</td>
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<tr>
<td></td>
<td>Is there a legislative mechanism, such as a permit, licence or group of</td>
<td>Within the existing EP Act framework, would designating aquifer injection as a prescribed ‘environmentally relevant activity’ be appropriate, so that standard conditions could be drafted for the Surat CMA and other Queensland contexts?</td>
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<tr>
<td></td>
<td>conditions in an approval that can streamline authorisation for injection</td>
<td>Could standard EA conditions, like the permits by rule or the general UIC permits in the PRB, be drafted, which would adequately regulate the activity in the Surat CMA?</td>
</tr>
<tr>
<td></td>
<td>activities?</td>
<td>Remove the requirement for a staged approach in permitting arrangements, replacing with more outcomes-based or prescriptive requirements?</td>
</tr>
<tr>
<td>DP2</td>
<td>Congruence between rules and local conditions</td>
<td>Could the EPP Water be amended to provide for gradings or classes of groundwater formations, like the PRB framework, so that the environmental values can be defined generally by reference to a range of characteristics?</td>
</tr>
<tr>
<td></td>
<td>How can local aspects be better integrated in approval mechanisms for</td>
<td>If the CSG produced water was not considered a ‘waste’, could it be included in environmental offset arrangements?</td>
</tr>
<tr>
<td></td>
<td>injection?</td>
<td>Are there ways to facilitate coordination between QDNRME, QDES, local government and local groundwater users so that injection requirements can meet areas of need in water allocation and provision?</td>
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</tbody>
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1368 Refer to chapter 5, section 3(b)(ii), above p 166 and n 881, which briefly details how ‘environmentally relevant activities’ are governed in Queensland.

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Table 22. Topics to consider and potential areas for reform for injection of CSG produced water

<table>
<thead>
<tr>
<th>DP</th>
<th>Description</th>
<th>Topics to consider for injection of CSG produced water in the Surat CMA</th>
<th>Potential areas for reform?</th>
</tr>
</thead>
<tbody>
<tr>
<td>DP2</td>
<td>Cost/benefit proportionality</td>
<td>How can congruence between costs and benefits of the process be better aligned?</td>
<td>Why not allow for CSG produced water to be injected into lower-quality aquifers if the transmissivity and storage capacity were appropriate?</td>
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<td></td>
<td>How can the value of returned CSG produced water be attributed to operators that recharge aquifers?</td>
</tr>
<tr>
<td>DP3 and DP7</td>
<td>Collective choice arrangements Rights to organise</td>
<td>Are there ways that can facilitate input into rule-making by local stakeholders?</td>
<td>Are there ways to facilitate coordination between QDNRME, QDES, local government and local groundwater users so that injection requirements can meet areas of need in water allocation and provision?</td>
</tr>
<tr>
<td>DP8</td>
<td>Nested enterprises</td>
<td>How can injection be integrated and coordinated with other groundwater activities?</td>
<td>Can injection of CSG produced water be accounted for in water planning and allocation?</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Are there ways to facilitate coordination between QDNRME, QDES, local government and local groundwater users so that injection requirements can meet areas of need in water allocation and provision?</td>
</tr>
</tbody>
</table>
The above lists of questions and topics provide the final initiative (see Table 22, above). I propose these topics for deliberations that could enable more sustainable outcomes for the Surat CMA, both in terms of increasing groundwater levels (while protecting resident water quality) and reducing conflict between water users. They are discussed in more detail below.

**Suggested topics to consider for DP 1**

It appears that certainty in terms of the entitlement or authorisation to inject is necessary. This was affirmed in the Wyoming context. The existence of both general and individual UIC permits was seen as a strength by both operators and the environmental regulator, and was corroborated by the existence of hundreds of class V UIC wells that injected CSG produced water (even where the aquifer was not pressured). It provided certainty with respect to projects as to what could be done with the excess CSG produced water and this was perceived as enabling these activities, where it was geologically and socially appropriate. In respect of Queensland, perhaps a stand-alone permit for injection activities would now be appropriate. A suite of conditions in the EAs have been developed through the AM process in Queensland. Given the success of the injection facilities currently operating, and the apparent lack of negative environmental impacts both in Queensland and Wyoming, the process could be prescribed as an ‘environmentally relevant activity’ under the EP Act and EP Reg. 1369 This is the method already used in Queensland for regulating sewage and water treatment. 1370 By prescribing the process as an environmentally relevant activity in its own right, this would also enable recharge activities outside of the CSG context. Perhaps a suite of standard conditions could be incorporated into EAs for the resources industry? Furthermore, if transparency around these permits was adopted, the opportunity to educate other groundwater users about the process would be available.

The question ought to be asked whether it is necessary to embed a staged approach in the actual permits. Undertaking a staged approach is sensible commercially, and reduces operational and commercial risks, but may not necessarily need to be prescribed in the actual permits. The current staged approach requires the operator to revert to the regulator at certain stages for further approvals, and this increases the administrative burden and uncertainty for operators. Perhaps these requirements could simply be replaced by prescriptive standard conditions.

1369 There could even be standard conditions for EAs for the process: refer to chapter 5, section 3(b)(ii), above p 166 and n 881, which briefly detail how ‘environmentally relevant activities’ are governed in Queensland.

1370 See EP Reg, sch 2.
Suggested topics to consider for DP 2

There may be several reasons why the approvals that allow for injection of CSG produced water contemplate water-quality parameters that are essentially potable. As noted in Chapter 1, the water quality in the Walloon Coal Measures has a mean salinity that is greater than the other aquifers above and below it. Therefore, it will need to be treated to some extent to preclude negative impacts to the resident water quality following injection. Requirements to treat the CSG produced water to a potable standard result in CSG operators not just replacing what they have extracted but, instead, producing a new resource. There seem to be advantages to this approach in terms of the quality of the groundwater resource. However, when a regulator makes an activity overly punitive, it can ultimately act as a deterrent for the activity and the benefits that would have accrued are lost. Perhaps the benefits of augmenting our highest quality aquifer justify requiring this standard. Or it may be that the reduced pumping costs, due to the transmissivity of the Precipice Sandstone,\textsuperscript{1371} outweighed the costs of treatment. However, the negative outcome of the salt and brine from the higher treatment remains. The Wyoming experience suggests that it is possible, and perhaps even worthwhile, to recharge other aquifers that have different water-quality parameters. It enables simple decentralised injection wells that require minimal water treatment, which produces minimal brine and salts.

There is nothing in the Queensland legislation that prevents this from occurring. As mentioned in Chapter 7, there were two EAs (where injection was ultimately not undertaken) that did authorised injection of treated CSG produced water that was within the 95th percentile of the water-quality parameters of the target formations. Nonetheless, some regulatory changes could be helpful. For example, the EP Reg provides that injection activities involving a ‘waste’ must not detrimentally impact resident groundwater qualities.\textsuperscript{1372} Putting aside the issue relating to the definition of ‘waste’, resident groundwater environmental values are not currently prescribed in the EPP Water.\textsuperscript{1373} On the basis of the broad definitions of the offence provisions in the EP Act,\textsuperscript{1374} the exact quality in the aquifer must not be impacted, even for a short term. This is a very high bar for operators. If the EPP Water was updated with a provision that enabled aquifers to be categorised by reference to broad categories, as the Wyoming regime provides, this would enable some latitude in terms of injectate quality and reduce overly punitive regulatory provisions for an activity that has fairly low environmental risks and positively addresses declining aquifers. This would streamline

\textsuperscript{1371} For the mean transmissivity of the various formations, see Office of Groundwater Impact Assessment, above n 66, Table 15-1, 204–206; see also chapter 6, section 2(a)(ii), above p 206.
\textsuperscript{1372} See chapter 5, section 3(b)(ii), above p 166; EP Reg, s 41.
\textsuperscript{1373} See chapter 5 section 3(b)(ii), above p 170-171.
\textsuperscript{1374} See chapter 6 section 6(ii), above p 225.
operator requirements, reduce salt production and associated costs, and therefore positively impact the business case for the process. This, in turn, addresses the issue of economic incentives for injection.

In addition to reducing the costs of injection, it would be helpful if there was some way to account for the quantum of water injected into aquifers. If operators were able to be accredited for water reinjected, this would directly and appropriately reflect the benefit of that activity, and may provide an incentive for the process. Moreover, transparently accounting for water reinjected into aquifers may provide the opportunity for the activity to be included in environmental offset arrangements. This would also provide an incentive to operators for the activity.

**Suggested topics to consider for DP 3, DP 7 and DP 8**

If there was some way of facilitating coordination among stakeholders, such as QDNRME, QDES, local government and local groundwater users, injection activities may be able to address local issues more appropriately. This would assist in strengthening collective choice arrangements (DP 3) and rights to organise (DP 7). If injection activities were accounted for appropriately in basin planning, and there was transparent coordination between stakeholders, these measures would strengthen a nested organisational structure.

Before concluding this thesis, I must return to consider an important residual topic that had been set aside early in the research: the question of property rights for access to water and injection. This is the last topic in the research, which is discussed below.

**3. Property rights**

Early in this research, I put aside the question whether or not the entitlements for accessing groundwater and injection should be ‘property’ rights. Recall that the impetus for the characterisation as a private property right was so as to encourage an effective market.\(^{1375}\)

According to Coase, efficient use of resources and a reduction of pollution can be achieved through well-defined and allocated property rights, in a market where there is perfect pricing and minimal transaction costs.\(^{1376}\) However, there are a number of reasons why Coase’s theorem may not hold true in the groundwater context. Deleterious impacts to groundwater are usually delayed by many years. This means that these impacts are not reflected in current pricing of production. It is also difficult to attribute impacts to specific activities by a particular water user. These are often cumulative impacts by many users across time and space. This means that the negotiations between

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\(^{1375}\) See chapter 2 section 4(d), above p 71.

\(^{1376}\) See chapter 2 section 3, above p 57: Coase, The Problem of Social Cost, above n 351.
individual neighbours, on which Coase based his theorem, rarely occur. Furthermore, there are substantial transaction costs that are unavoidable, many unquantified externalities, as well as imperfect information associated with groundwater extraction. In the Surat CMA, the resource is open to continued exploitation: new water users can still obtain licenses, many existing users can access the resource without a licence and extraction is mostly unmetered. Even if the uncapped nature of the resource was addressed, the efficiencies of a market approach may still be elusive in the groundwater context. Uncertainty around the potential advantages of a market, in a groundwater context, impacts on the argument as to whether water-access rights ought to be ‘private’ property.

For this research, it was first necessary to establish whether there are clear entitlements for the relevant operational phases of aquifer injection (access to source water and injection) and what influence certainty of these entitlements might have on the activity of aquifer injection. As already stated, this research suggests that clear entitlements are a precursor for effective recharge activities which, in turn, can result in sustainable outcomes for groundwater. What is important seems to be that there is some certainty around the authorisation to access source water and to inject, not the proprietary status of the authorisation or entitlement.

Is there now a need to determine whether the entitlements (to groundwater access rights and injection) should or should not be property rights? From the Wyoming analysis, we know that individual water rights in that jurisdiction are considered to be property rights but the entitlement to inject is not. The lack of a property right for the injection process in no way seemed to hamper that activity. Arguably then, it can be presumed to be unnecessary for that entitlement when seeking to enable sustainable outcomes.

However, what about the rights to extract groundwater? Ought they be individual property rights in Queensland as they are in Wyoming? As mentioned in Chapter 2, in Australia, whether a water licence or allocation under the current legislative framework is a property right and, if so, what type of property right, is not settled law. This research has highlighted that there are very real concerns about the protection being afforded to the broader groundwater resource system: the CPR. There can be competing private and communal interests in a CPR in the short term. The competing interests and resource users both focussing on individual gain is what appears to lead to the deterioration of the resource. My analysis showed that there are aspects of the Queensland

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1377 See chapter 2, section 3, above p 59; Abildtrup, Jensen and Dubgaard, above n 368; Hahnel and Sheeran, above n 351.
1378 See chapter 3 section 3(b)(ii), above p 102.
1379 See chapter 3 section 3(b)(iii), above p 108.
1380 See chapter 2, section 4(d), above p 72.
regime that drive individual incentives towards favouring increased extraction of groundwater at a cost to the overall CPR. Because individual property rights are enforceable against the world, subject to environmental protection and impacts on neighbours, if these latter protections are weak, strengthening individual interests will be at the expense of these latter interests.\textsuperscript{1381} Once established as a property right, they are difficult to expunge. The experience in the Murray–Darling Basin, where the conversion of existing rights to tradeable property resulted in an increase in overall extraction, due to the conversion of ‘sleeper’ and ‘dozer’ licences, ought to be kept firmly in mind.\textsuperscript{1382} The current governance framework in Queensland appears to be inadequate in guarding against deterioration of the resource. Strengthening the individual interests at this time may therefore compound this situation and be very hard to reverse.

Ostrom argued that when the 8 design principles are largely present, individual resource users’ interests can align so as to protect the underlying resource system. The issue of coordination problems and free-riders are minimised. In this research, where most of Ostrom’s design principles are not present and where the resource system is showing deterioration in Queensland, a logical and sensible step would be to strengthen some of Ostrom’s criteria, rather than strengthening private interests. Some of these criteria, such as the adequacy of monitoring, clarity around the boundaries of the resource system, and water users and compliance arrangements, are foundational requirements for any type of management of the resource, be it a market, state or a communal governance arrangement.

Clarifying and strengthening the individual rights with respect to access to the groundwater, by defining licences as private property, places individual interests above notions of communal responsibility and ownership. This could have grave results in areas where the groundwater system is showing signs of continued deterioration and legislative reform has been difficult to implement. On the basis of this research project, I conclude that defining water licences as ‘private property’ could have unintended negative consequences at a time when the groundwater resource requires our collective protection. Conversely, clarifying the nature of how the groundwater resource system is held, rather than the resource units, may ultimately lead to measures that could assist in guarding against further deterioration.

\textsuperscript{1381} See chapter 2, section 4(d), above p 74-75.\textsuperscript{1382} Tan and Quiggin, above n 439, 290; Connell notes that the promotion of ‘water markets and making water a valuable trading commodity has almost certainly increased the overall volume diverted for production [in the Murray Darling Basin]’; Connell, above n 369, 203.
4. Further research

This analysis of the governance arrangements for aquifer injection of CSG produced water has uncovered a rich landscape for further research that appears to be acutely necessary. Apart from the third initiative already detailed, which recommends deliberations on the specific areas that have been targeted in Tables 21 and 22, above, there are other broad research areas that appear warranted.

Generally, repeating the analysis conducted in this research with a broader number of participants would further develop the research findings. Specifically, further qualitative data from more representatives from the regulatory agencies for the Surat CMA and operators, and from more landholders in the PRB, Wyoming, would be helpful. Similarly, a more extensive stakeholder analysis that explores the role of the relationships between stakeholders\(^{1383}\) would assist in understanding how the regulatory frameworks and administrative action operates in practice.

Further testing of the AIA design principles against the governance arrangements in other geographic areas where CSG activities occur, would also provide triangulation of the research finding that the AIA design principles are important. Research that seeks to determine groundwater governance weaknesses and strengths in areas unaffected by CSG activities (or mining) would provide a comparison with the Surat CMA, and may explain the impact of the CSG industry on conflicts between users and issues of trust relating to the governance arrangements.

Research into institutional and, perhaps, cultural and cognitive\(^ {1384}\) barriers to transparency for government and the broader community, including corporate operators in Queensland, would also be helpful. Research that considers groundwater appropriators’ attitudes to the value of groundwater, their rights to extract and any notions of communal responsibility (absent or otherwise) would assist reforms relating to not only proportional cost-sharing but also more participatory governance. Further economic research on the value of non-CSG water extraction, calculated against the benefits to the society that flow from that groundwater use, ought to be conducted. Research that determines the direct benefits and detriments of further metering of non-CSG water extraction in the Surat CMA ought also to be considered to ensure that new metering policies have the intended consequences.

\(^{1383}\) As described by Reed et al, above n 186.

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There are also further research avenues worth exploring to develop the research findings relating to adaptive management and adaptive governance. Research that seeks to document existing decision-making to better reveal how AM (or adaptive governance) has been applied would go a long way to educating other natural resource managers and the public as to the current processes being undertaken. Such research would highlight success stories, as well as provide cautionary tales, which would be useful. Research that seeks to determine positive ways of more broad and inclusive engagement with stakeholders also appears necessary. A parallel assessment of the resilience, adaptability and transformability of the relevant SESs would provide guidance in how best to affect governance change, in addition to the initiatives recommended in this thesis.\textsuperscript{1385}

Specifically, in respect of aquifer injection, research is needed that can quantify benefits and/or determine the relevance of various other disposal options on the process. Research that can determine the importance, benefits and detriments of either direct or indirect avenues for the various stakeholders to influence decision-making for injection would also appear to be relevant.

These further research topics could assist in addressing conflict and lack of trust within the Surat CMA, relating to groundwater governance as well as CSG activities. It also would have application in respect of aquifer injection in the CSG context, and perhaps in other contexts such as mining and general conjunctive water management. It would also further our understanding of how best to proceed along the difficult journey of sustainable natural resource management.

5. Conclusion

This research confirms that there is never only ‘one’ way to manage a resource system. While the PRB governance framework included many positive features, the Surat CMA included different ones. The need to find a silver bullet is certainly seductive, but this blinkers our vision of where we are, where we have been, as well as what the future may hold. It also does not acknowledge that groundwater governance is the sum of a large number of moving parts, which vary over time and place. When I reflect on the genesis of this project, and the common questions I have faced by interested members of the public (such as, is fracking good or bad? Is the CSG industry good or bad? And now, is Adani good or bad?), there is a shared misconception. Certainty is seductive and comforting, but an illusion with respect natural resource management, especially water.

\textsuperscript{1385}The many chapters on this topic in Cosens and Gunderson, above n 29, would be a useful starting point.
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This research supports other research, which has posited that management is always an experiment, whether it is intended as such or not. An original example from this research of the need for governance arrangements to evolve has been the development of EA conditions for aquifer injection to inject treated CSG produced water into a GAB aquifer in the Surat CMA. Similarly, the rise and fall of the CSG industry in the PRB, and the changing water permit conditions and disposal requirements in that jurisdiction also demonstrate the need for flexible arrangements, which can react to changing information and circumstances. We can never know in advance which policies will yield optimal results, because resource systems as well as social, economic and political contexts are always changing. It is clear that, both as a society and as individuals, we are still learning how to govern effectively. Sustainable governance must, therefore, be a process. If the subject of that governance is a CPR, as is the case with groundwater, that process needs to be inclusive if we are to avoid the coordination problems associated with Hardin’s ‘Tragedy of the Commons’.

This research journey started with a search for a permit or legislative mechanism that could enable sustainable aquifer injection of CSG produced water. The research did, indeed, uncover possible avenues for reform that could meet this objective. Based on the empirical data from this research, a stand-alone permit (or EA) that is integrated with other groundwater governance could, and probably should, be developed in the Queensland context for aquifer injection of CSG produced water and, perhaps, for other types of excess water. The thesis also uncovered a rich vein of research relating to CPR theory in the groundwater context. In short, I have demonstrated that Ostrom’s design principles are relevant to groundwater governance, even where CSG activities are present. The presence of Ostrom’s design principles, and my more detailed AIA design principles, explain and correlate with successful outcomes of groundwater governance and aquifer injection using CSG produced water. The opposite was also true: a lack of the design principles correlated with unsuccessful outcomes.

Just as importantly, for the first time, a more fulsome understanding of how adaptive management has been applied in Queensland in the CSG context: sometimes effectively and, at other times, in a patchy way. At times, there has been a lone drummer, at other times, a small voluntary band of minstrels. What we need is practice at being the orchestra. Blaming the drummer for the lack of music is pointless if we do not participate. At the same time, we should not expect to

1386 Ostrom, Understanding Institutional Diversity, above n 382.
1387 Ibid, 255.
1388 Peel, above n 231, 208–210; or as Lee states, ‘sustainable development is not a goal, not a condition likely to be attained on earth as we know it. Rather, it is more like freedom or justice, a direction in which we strive’: Lee, above n 204, 200.
1389 See chapter 2 section 3, above p 58.
play like the Chicago Symphony or Sydney Symphony orchestras, without the same dedicated years of practice, vulnerable to harsh critics. After all, it is the public nature of the performance that often drives learning. A commitment to transparency and embracing uncertainty as an opportunity for learning will no doubt improve the performance.

Finding discreet answers to discreet problems in groundwater governance, like the governance of aquifer injection of CSG produced water, may be possible for the short term. However, this research reveals that there are deeper, more intractable issues that have far more wide-ranging effects, which are worthy of our attention. Issues involving transparency and regulatory agency commitments to adaptive management ought to be first addressed as a matter of priority, prior to tinkering with the regulatory landscape. This thesis has demonstrated that the prospects of reform in the discreet area of governance of aquifer injection of CSG produced water, and perhaps even for the broader topic of groundwater governance, will likely depend upon how these two issues are addressed in the future.
APPENDIX 1: RESEARCH ETHICS APPROVAL AND SEMI-STRUCTURED INTERVIEW MATERIALS
To Whom It May Concern

Human Research Ethics Approval
"The governance of Aquifer Injection using Coal Seam Gas/Coal Bed Methane Produced Water"
(Ref: 2017/237)

I am pleased to advise that this research has approval to commence from the Griffith University Human Research Ethics Committee, a committee established and operating in accordance with the standards and principles of the Australian National Statement on Ethical Conduct in Human Research (2007) and Griffith University policy.

The decision to approve is dated 11 April 2017 and covers the period 11 April 2017 to 14 February 2019.

For any queries regarding this ethical approval please contact the Committee Secretary on tel: 07 3735 4375 or research-ethics@griffith.edu.au.

Yours sincerely,

Dr Amanda Fernie
Secretary to the Griffith University Human Research Ethics Committee and Manager, Research Ethics and Integrity
Office for Research
Griffith University
Nathan Qld 4111 Australia

18 May 2018
Draft email to potential participants

Subject line for email: Research in respect of permit mechanisms relating aquifer injection of coal seam gas (CSG) or coal bed methane (CBM) produced water (GU Ref No: 2017/237)

Dear #,

As discussed in our recent telephone call, I am conducting research as part of my PhD candidature in respect of the regulatory mechanisms for aquifer injection of CSG/CBM produced (associated) water. I would like to invite you to be a part of this project through a semi-structured interview conducted by me, either in person or via a telephone or skype call. The interview should take no longer than one hour and take place during a time that is convenient for you.

I have attached an information package that sets out why the research is being conducted, what you would be asked to do, the basis you were selected, the expected benefits of the research as well as any risks to you and confidentiality. I have also included a list of key questions or topics that would form the basis of the semi-structured interview for you to consider.

A consent form is also included. If you consent to be a part of this research, I would appreciate you letting me know by email and completing and returning to me a signed consent form. I will then be in touch with you to arrange a time and method that is convenient to you for conducting the interview.

This research project has been approved by the Griffith University Office for Research in accordance with the Australian National Statement on Ethical Conduct in Human Research and a copy of that approval is also attached to this email for your reference.

I look forward to hearing from you in respect of this research.

Regards,

Jacqui Robertson
PhD Candidate
Griffith Law School
Ph: 0403 053 174
Why is the research being conducted?
This research is being conducted in respect of part of the PhD Candidature of Jacqui Robertson at Griffith University. It involves evaluating the nature and extent of the implementation of the legal mechanisms used in Queensland and Wyoming to regulate aquifer injection of Coal Seam Gas (CSG) or Coal Bed Methane (CBM) produced water. The intentional recharge of aquifers for subsequent recovery or environmental gain is a relatively new technological advance that is evolving with respect to water regulatory frameworks. Aquifer injection projects involving produced water from CSG (CBM) projects are seen as a first priority disposal technique for CSG (CBM) produced water in Queensland. However, the governance arrangements for this new technique are undeveloped. In contrast, aquifer injection of CSG (CBM) produced water has been occurring in Wyoming for decades.

Despite there being recommendations for the adoption of aquifer injection to address the environmental impacts of CSG (CBM) projects, how the process itself should be governed has never been reviewed. There are recommendations by current scholars in respect of other types of waste water that entitlements should be put in place in respect of access to the waste water, the injection process, aquifer storage and perhaps later recovery. Both Queensland and Wyoming have put in place different legal mechanisms for governing the aquifer injection process with respect to CSG (CBM) produced water. Specifically, the phases that are regulated relate to access to groundwater during gas extraction and the process of injection. No regulation has yet been adopted that relates to the rights to aquifer space or retrieval of the stored water. The relative advantages and disadvantages of the different mechanisms that have been put in place for this process in Queensland and Wyoming will inform wider research relating to environmental protection and water security.
What you will be asked to do
As part of this project, the challenges and experiences in using these mechanisms (environmental approvals, licences or permits), from the point of view of regulators, operators and other third parties will be considered. You are being invited to take part in a semi-structured interview due to your direct experience with the regulatory framework in either Queensland or Wyoming. The semi-structured interview will be conducted by Jacqui Robertson, either in person or via a telephone or skype call. The interview should take no longer than one hour and take place during a time that is convenient for you.

The basis by which participants will be selected or screened
Participants have generally been identified through relevant permits that are in the public domain as well as organisational websites on the internet or through word of mouth. The categories of participants that will be invited to take part in this research project are representatives of:

- the relevant government departments that regulate the process;
- the local government authority;
- peak industry, agriculture, landholder and environmental groups;
- project operators;
- relevant landholders; and
- representatives of the local community.

Landholders that have been involved in litigation with CSG (CBM) operators or the relevant regulator will be excluded from this study.

You will have first been approached by telephone so that the researcher could introduce herself, explain to you how you were specifically identified and to generally explain the purpose of this research. An email with this information package follows that first contact to more fully explain the research project and seek your consent to participate.

The expected benefits of the research
A goal for this research is the formulation of a set of general principles and specific recommendations which could be considered in respect of the regulatory framework relating to both the CSG(CBM) industry as well as water resources generally. It is therefore hoped that a review of the regulatory mechanisms governing this process may address current issues relating to environmental protection as well as water and energy security such as:

- A reduction in the regulatory burden faced the regulator as well as by CSG(CBM) projects and therefore a reduction in governance costs;
- A reduction in the environmental impact of the production of vast quantities of ‘waste water’ (by reducing the aquifer depletion and surface release of treated and untreated produced water), thus addressing community concerns around water security.
- An increase in the available water supply in a water basin for potable, agricultural or environmental uses thus addressing water security issues.

Although, until the research is conducted, it is uncertain whether these anticipated benefits will be realised.
Risks to you
It is anticipated that there are minimal risks to you in this research. Questions about particular projects will be restricted to information that is already in the public arena or held by government agencies. The researcher will not ask questions relating to any activities that may have been environmental offences that are not already on the public record. The researcher will also not ask for information that may be commercially sensitive. The subject of the interviews will be limited to discussion around existing publicly available documents and data (from permits, environmental assessments, environmental authorities, environmental management plans, water plans and monitoring data) as well as experiences and impressions of the regulatory process in general. A list of key focus questions that would form the basis of the interview is attached to this information package for your reference.

Your confidentiality
The conduct of this research involves the collection, access and/or use of your identified personal information. The information collected is confidential and will not be disclosed to third parties without your consent, except to meet government, legal or other regulatory authority requirements. A de-identified copy of this data may be used for other research purposes. However, your anonymity will at all times be safeguarded. For further information consult the University’s Privacy Plan at http://www.griffith.edu.au/about-griffith/plans-publications/griffith-university-privacy-plan or telephone (07) 3735 4375.

Identifiable data from the semi-structured interviews will have personal and corporate identifying material redacted so that only the broad category of organisation will be noted: government department, operator, peak representative body or landholder. If you consent to participate, your name or any identifying information which would identify you will not be published in any research publications or Jacqui Robertson’s PhD thesis. There are multiple operators, teams of employees within the relevant government agencies as well as many landholders that are within the pool of potential participants for this research project.

However, there is a risk that the identification of certain corporate operators, although their identity is not named, may be able to be inferred. This may occur where only a limited number of operators have conducted this process in a region.

Jacqui Robertson will take notes of the semi-structured interviews and following the interview, a summary of the interview will be made available to you for your approval. The information obtained will be retained in Griffith University’s secure storage facilities for five years. Only Jacqui Robertson will have access to these original summaries. The information will be used in the research for the purposes of journal articles, a conference paper and the thesis for Jacqui Robertson’s PhD candidature.

Your participation is voluntary
Your participation in this research is voluntary. You can withdraw your consent at any time prior to analysis of the information being completed. If you were to withdraw your consent, any information you have provided will not be used in any publication.
Questions / further information
Please feel free to contact Jacqui Robertson by telephone or email (as noted above) at any time about this research project about any issues that may concern you.

The ethical conduct of this research
Griffith University conducts research in accordance with the National Statement on Ethical Conduct in Human Research. If you have any concerns or complaints about the ethical conduct of the research project please contact the Manager, Research Ethics on 3735 4375 or research-ethics@griffith.edu.au

Feedback to you
Once the research is completed, if you indicate that you would like to receive information about the outcomes of this research, Jacqui Robertson will provide you with a summary of the overall findings and results of her research as well as any resultant publications.
The Governance of Aquifer Injection using Coal Seam Gas / Coal Bed Methane Produced Water (GU Ref No: 2017/237)
CONSENT FORM

Research Team  Professor Poh-Ling Tan; Professor Don Anton and
Jacqui Robertson
Griffith Law School
Contact details:
Professor Tan:
Phone: 07 3735 4182
Email: p.tan@griffith.edu.au
Jacqui Robertson:
Phone: 0403 053 174
Contact Email:
Jacqui.Robertson@Griffithuni.edu.au

By signing below, I confirm that I have read and understood the information package and in particular:

☐ I understand that my involvement in this research will include a semi-structured interview with Jacqui Robertson;

☐ I have had any questions answered to my satisfaction;

☐ I understand the risks involved;

☐ I understand that there will be no direct benefit to me from my participation in this research;

☐ I understand that my participation in this research is voluntary;

☐ I understand that if I have any additional questions I can contact the research team;

☐ I understand that I am free to withdraw at any time, without explanation or penalty;

☐ I understand that my name and other personal information that could identify me will be removed or de-identified in publications or presentations resulting from this research;

☐ I understand that I can contact the Manager, Research Ethics, at Griffith University Human Research Ethics Committee on 3735 4375 (or research.ethics@griffith.edu.au) if I have any concerns about the ethical conduct of the project; and

☐ I agree to participate in the project.

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<th>Name</th>
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<td>Signature</td>
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Questions to be addressed in semi-structured interviews

<table>
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<tr>
<th>Participants</th>
<th>General questions:</th>
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<tr>
<td>All participants where relevant</td>
<td>Are there certain advantages or disadvantages in the current framework controlling water extraction for CSG/CBM production? If so, can you please explain them?</td>
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<td>Are there any economic, social or environmental issues (either negative or positive) that you perceive directly relate to the extraction of water by CSG/CBM projects in your area? Again, if so, could you please explain them?</td>
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<td>Are there certain advantages or disadvantages in the current framework controlling aquifer injection of CSG/CBM produced water? If so, can you please explain them?</td>
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<td>Are there any economic, social or environmental issues (either negative or positive) that you perceive directly relate to the process or framework controlling aquifer injection of CSG/CBM produced water in your area? Again, if so, could you please explain them?</td>
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<td>Have there been certain factors that have been recurring issues (either technical, practical, economic or social issues) or problems relating to extraction of water from CSG/CBM projects?</td>
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<td></td>
<td>Have there been certain factors that have been recurring issues (either ecological, technical, practical, economic or social issues) or problems in the aquifer injection process?</td>
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<td>Have there been any surprises in respect of extraction of water by CSG/CBM projects or aquifer injection?</td>
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<td>Where legal requirements for aquifer injection for particular projects have been changed as a project has progressed, how and why did this occur? Were there factors or circumstances which made this difficult?</td>
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<td>What changes, if at all, would you like to see to improve decision-making? Why?</td>
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**Additional questions for certain categories of participant:**

**Queensland:**

| | How does the DNRM generally account and then plan for water extracted as part of mining, petroleum and gas activities generally? |
| | Do you consider that there are difficulties in balancing the demands of different water users in the basin and what, in your opinion, are the key issues that need to be addressed? |
| | If water extraction in respect of resources industries was to be licenced and the subsequent quantity of produced water was to be included in the available pool of resource, what would you think would be the likely advantages or disadvantages of this change? |

<p>| | What, in your opinion are the advantages or disadvantages in having DEHP and the Commonwealth Department of Environment control the mechanism for aquifer injection? |</p>
<table>
<thead>
<tr>
<th>(DEHP), Petroleum and Gas Compliance Unit AND Representative of the Department of Environment (Cth)</th>
<th>How does the DNRM account and then plan for water extracted as part of mining, petroleum and gas activities generally? How will the DNRM include water extracted as part of mining, petroleum and gas activities in the GAB water plan? What are the perceived difficulties in balancing the demands of different water users in the GAB basin? If water extraction in respect of resources industries, but in particular CSG extraction, was to be licenced and the subsequent quantity of produced water was to be included in the available pool of resource, what would you think would be the likely advantages or disadvantages of this change?</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Great Artesian Basin (GAB) Coordinator, Department of Natural Resources and Mines</td>
<td>Representatives of gas project operators which have undertaken water disposal via aquifer injection And Landholders that have had operators conducting water disposal via aquifer injection on their land And Landholders that rely on water from aquifers that are targeted by aquifer injection And Representatives of the local community</td>
</tr>
<tr>
<td>Representatives of the Wyoming State Engineer’s Office (WSEO)</td>
<td>Are there specific factors that impact on the SEO’s decision to grant a water permit as part of gas extraction such as volumetric limits, adjudication, and the determination of the public interest? How often are water permit conditions changed in response to unexpected outcomes?</td>
</tr>
<tr>
<td>Representative of the Ground Pollution Control program and Underground Injection Control, Wyoming Department of Environmental Quality (WDEQ)</td>
<td>What are the reasons for excluding gas projects from aquifer storage and retrieval injection projects? Were the aquifer injection projects undertaken in the height of gas extraction within the basin perceived as being successful?</td>
</tr>
</tbody>
</table>
| Representatives of **gas project operators** which have undertaken water disposal via aquifer injection And **Landholders** that have had operators conducting water disposal via aquifer injection on their land And **Representatives of the local community** | What is your understanding of the treatment options for CBM produced water and are there any which you consider are more appropriate?  
Are you concerned about water security and has a lack of water impacted your use of your land?  
What is your main concern about water security going forward?  
Have there been any positive or negative impacts of aquifer injection that you would like to mention? |
APPENDIX 2: GEOLOGICAL AND HYDROGEOLOGICAL SETTINGS

a) Powder River Basin geology and hydrogeology

The PRB, shown in Figure 32 below, contains the 'largest resources of low-sulfur, low-ash, subbituminous coal in the United States'.\textsuperscript{1390} The PRB is an elongated, north-northwest-trending sedimentary and structural basin that forms a broad asymmetric syncline (depression) with a gently dipping east limb and a steeply dipping west limb.\textsuperscript{1391} Production of CBM in the Wyoming PRB has been occurring since the 1980s, predominantly from the Wyodak-Anderson coal zone of the Tongue River Member of the Fort Union Formation (Smith, Anderson and Canyon coal beds).\textsuperscript{1392}

\textsuperscript{1390} Luppens et al, above n 37; Jones, above n 37.
\textsuperscript{1391} Luppens et al, above n 37.
\textsuperscript{1392} Ibid; Flores, above n 54.
Aquifer injection in the coal seam gas context: Appendix 2: Geological and hydrogeological settings:

De Bruin et al explain that the coal beds of the PRB are too shallow (less than 3000 feet deep) to contain much thermogenic gas; however, it does contain large quantities of biogenic gas. There are other Cretaceous and some Tertiary coal beds that are deeper, which are considered to contain large volumes of thermogenic gas.

The CBM resource in the Wyoming PRB is estimated to be 37 trillion cubic feet, assuming 65 cubic feet of CBM per ton of in-place coal. It has been estimated that the production life of

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1391 Flores, above n 54, 2.
1394 De Bruin et al, above n 52.
1395 Ibid, 3.
1396 Ibid, 11.
Aquifer injection in the coal seam gas context: Appendix 2: Geological and hydrogeological settings:

CBM wells is about 10–12 years. If the wells access multiple beds, this can extend the life of the well by an additional 10–30 years.\textsuperscript{1397}

The coal basins in the Rocky Mountain States developed during the Late Cretaceous–early Tertiary periods during the Laramide Orogeny;\textsuperscript{1398} during this time, mountains were formed in North-Western America due to subduction of tectonic plates under the North American tectonic plate. The Western Interior Cretaceous Seaway (a seaway that split the North American continent in two) was located in the area that connected the Gulf of Mexico with the Arctic. During the Laramide Orogeny, the seaway was pushed to the north-east\textsuperscript{1399} and the basin was shaped through down-warping while the surrounding mountains were formed by up-warping.\textsuperscript{1400} During the Paleocene Epoch, wetlands developed in flood plains and fluvial corridors at or near sea level.\textsuperscript{1401} The accumulation of organic material from these areas produced peat, which became the coal resources today.

The coal seams in the Upper Fort Union Basin (see figures 33 and 34 below), as well as the sands of the overlying Wasatch Formation and the alluvium underlying surface drainages, were the focus of analysis undertaken in the 2003 FEIS for the PRB.\textsuperscript{1402} These are the hydrogeologic formations impacted by CBM development. The Wasatch Formation is exposed over most of the PRB CBM development area and consists of fine-grained sandstones, siltstones, claystones and coals (the coals are not generally economic for mining or CBM development).\textsuperscript{1403} The sandstones within the Wasatch Formation are used locally for water supply.\textsuperscript{1404} Jones explains that the ‘coal-bearing Tongue River Member is the upper-most member of the early Tertiary (Paleocene) Fort Union Formation in Wyoming’s PRB.\textsuperscript{1405} It is composed of fluvial, lacustrine and mire deposits,\textsuperscript{1406} consisting of interbedded shale, mudstone, claystone, siltstone and sandstone, alternating with carbonaceous shale and coal.\textsuperscript{1407} The coals vary in thickness and continuity.\textsuperscript{1408} The upper sequence of the Fort Union Formation is divided into four geologic groups, three that together are known as ‘Big George’

\textsuperscript{1397} De Bruin et al, above n 52; Luppens et al, above n 37, 14-15.
\textsuperscript{1398} Biewick and Jones, above n 484.
\textsuperscript{1399} Ibid.
\textsuperscript{1400} Flores, above n 54.
\textsuperscript{1401} Biewick and Jones, above n 484.
\textsuperscript{1402} Buffalo Field Office, \textit{Final Environmental Impact Statement and Proposed Plan Amendment for the Powder River Basin Oil and Gas Project} (2003), above n 199, ch 4, 4-2.
\textsuperscript{1403} Ibid, 4-2.
\textsuperscript{1404} Ibid, 4-2.
\textsuperscript{1405} Jones, above n37.
\textsuperscript{1406} ‘Mire’ is the generic term for wetlands: swamps, marshes and bogs.
\textsuperscript{1407} Jones, above n 37.
\textsuperscript{1408} Buffalo Field Office, \textit{Final Environmental Impact Statement and Proposed Plan Amendment for the Powder River Basin Oil and Gas Project} (2003), above n 199, 4-2.
Aquifer injection in the coal seam gas context: Appendix 2: Geological and hydrogeological settings:

and one group that occurs in the south-eastern part of the PRB and is known as the 'Wyodak coal'.

While the Wasatch Formation contains partially confined groundwater resources, the Fort Union Formation is generally hydraulically confined (except near the land’s surface). The separation between the Upper Union Formation and the Wasatch Formation varies greatly over the PRB, but there is generally considered to be a thick claystone unit that provides a significant hydraulic barrier between the two formations. A small amount of leakage is known to occur. The groundwater in the zones below the coal zone aquifers has not been as extensively developed as those above and within the coal zones. High yields in the Tullock aquifer are attractive for municipal and industrial uses, and have been used for mine water-supply wells.

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1410 Ibid, 3-14.
1411 Ibid, 4-6.
1412 Ibid, 4-6.
1413 Ibid, 4-57.
1414 Ibid, 4-57.
Aquifer injection in the coal seam gas context: Appendix 2: Geological and hydrogeological settings:

Figure 33. Generalised stratigraphy of the PRB

1415 Flores, above n 54, 3 which was modified from Laudon et al., *Geology and Energy Resources of the Powder River Basin: 28th Annual Field Conference Guidebook* (Wyoming Geological Association, September 1976).
Recharge generally occurs in the PRB through infiltration into the more permeable surface geologic units, particularly in creek valleys, which recharge the underlying alluvium and shallow bedrock aquifers. Recharge from precipitation is estimated at only 0.2 inches/year with a general flow to the north and north-east. The Wyodak-Anderson coal zone of the Fort Union Formation is reported as being the most continuous hydrogeological unit in the PRB and the recharge occurs along the eastern margins. Clinkers (orange-coloured rocks baked and melted by burning coal beds due to spontaneous combustion and lightning strikes) and the coal beds act as vertical recharge.

1416 Flores, above n 54, 16.
1417 Buffalo Field Office, Final Environmental Impact Statement and Proposed Plan Amendment for the Powder River Basin Oil and Gas Project (2003), above n 199, 4-3.
1419 Flores, above n 54, 7.
Aquifer injection in the coal seam gas context: Appendix 2: Geological and hydrogeological settings:

Flores explains that much of the CBM produced in the coal beds is biogenic, created by bacterial activity. The influx of oxygenated water through the clinkers ‘allowed for renewed bacterial activity in the coal beds for methane generation’. There are also ‘sandstone beds inter-bedded with mud-stone, siltstone, and carbonaceous shale beds [that] serve as aquifers ... but [they] are not as continuous as the coalbed aquifers’.

There are two differing groundwater quality systems within the PRB: the shallower chemically dynamic system, which is generally 200–500 feet deep and exhibits localised flow, and the deeper chemically static system, which exhibits regional flow generally northwards. The shallower system has a mixed composition of ions, containing ‘calcium, magnesium, and lesser amounts of sodium as cations (positively charged ions) and bicarbonate or sulfate as the dominant anion (negatively charged ion)’. The deeper system contains sodium and bicarbonate dominant ions. Data obtained by the US Geological Survey shows a wide range between wells in the various parameters and TDS.

b) Surat geology and hydrogeology

The Surat CMA covers parts of three geologic basins: the southern Bowen Basin, the northern portion of the Surat Basin and the western Clarence Moreton Basins. The Bowen Basin is the oldest and, therefore, the deepest of the basins, which was formed through sedimentation in the early Permian to Triassic periods. The CSG-producing coal measures in the Bowen Basin are the Bandanna and deeper Cattle Creek Formations. The overlying Surat Basin ‘comprises a mainly Jurassic to Cretaceous age sequence of alternating layers of sandstones, siltstones and mudstones’. It overlies the Bowen Basin, having been formed later through sedimentation processes during the Jurassic to Cretaceous periods. The Clarence Moreton Basin lies in the south-east of the other basins. Unconsolidated alluvial sediments and volcanics overly all of the

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1420 Flores, above n 54, 7.
1421 Ibid.
1422 Ibid.
1424 Ibid.
1425 Ibid.
1426 Ibid.
1429 Ibid.
Aquifer injection in the coal seam gas context: Appendix 2: Geological and hydrogeological settings:

basins. The Condamine Alluvium is one such accumulation, which was deposited during the Cenozoic Era (which began 65 million years ago and continues to the present).

The stratigraphy of the Surat CMA is shown in Figure 35, below, and the geologic basins are shown in Figures 36, 37 and 38, below.

1432 Ibid, 25.
Aquifer injection in the coal seam gas context: Appendix 2: Geological and hydrogeological settings:

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<tr>
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<th>Clarence-Moreton Basin</th>
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<tr>
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<td>Kimberlina Beds</td>
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<td>Alluvium (Condamine)</td>
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Figure 35. Regional hydro-stratigraphy of the Surat Basin\textsuperscript{1433}

\textsuperscript{1433} Office of Groundwater Impact Assessment, UWIR (2016), above n 26, 38.
Aquifer injection in the coal seam gas context: Appendix 2: Geological and hydrogeological settings:

Figure 36. Geological basins in the Surat CMA\textsuperscript{1434}

Aquifer injection in the coal seam gas context: Appendix 2: Geological and hydrogeological settings:

Figure 37. Geological cross-section through the Surat and Bowen Basins

Figure 38. Geological model visualisation

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1436 Ibid, 32.
The hydrogeology of the Surat CMA includes part of the GAB. This part of the GAB includes the Surat Basin, parts of the Clarence Moreton Basin and the uppermost sequences of the Bowen Basin. A number of aquifers that are used for water supplies occur within these basins, and the unconsolidated Condamine Alluvium, which is also a major water source for agriculture, lies above the basins. The Walloon Coal Measures contain usable quantities of water, ‘particularly where the formation is at a shallow depth, where it is more readily recharged and water is of a better quality’. In most of the aquifers in the GAB, the water quality salinity averages about 1,900 mg/L and is suitable for stock watering. The water quality in the Walloon Coal Measures varies greatly, from about 150 mg/L to more than 18,000 mg/L with an average of 3,000 mg/L. The hydrogeology of the Walloon Coal measures is complex because it is largely made up of thin discontinuous layers of alternating aquitards and aquifers. The actual coal thickness is only about 10% of the measures and the coal seams comprise ‘numerous thin non-continuous stringers or lenses’. See Figure 39 below for a diagram of the stratigraphy of the Walloon Coal Measures.

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1438 Ibid.
1439 Ibid, 35.
1440 Ibid, 35.
1441 Ibid, 40.
Aquifer injection in the coal seam gas context: Appendix 2: Geological and hydrogeological settings:

Figure 39. Stratigraphy of the Walloon Coal Measures\(^{1442}\)

\(^{1442}\) Office of Groundwater Impact Assessment, UWIR (2016), above n 26, 41.
APPENDIX 3: WYOMING DOCUMENTS

All WDEQ UIC permits are available online through:

Wyoming Department of Environmental Quality, Login (GEM)

All WOGCC API Permits are available through:


All WSEO water permits can be accessed through:


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<th>CSG Operator permits and documents</th>
<th>Anadarko Petroleum</th>
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<td><strong>WDEQ UIC permits</strong></td>
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<td>61</td>
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<td>UIC permit 5C5-2, WYS-005-00558 (Mahalo)</td>
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**WOGCC API permits – gas wells producing water associated with EOG Y Resources’ LX Bar Fed#20 UIC permit 5C5-1, WYS-005-00453**

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102. API 558251 – LX BAR CS FEDERAL#13
103. API 558253 – LX BAR CS FEDERAL#14
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105. API 557810 – LX BAR CS FEDERAL#17
106. API 557811 – LX BAR CS FEDERAL#19
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109. API 557885 – LX BAR CS FEDERAL#15
110. API 557812 – LX BAR CS FEDERAL#18

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| 133. UIC permit 5C5-1, WYS-005-189 (Stones Throw) |
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<td>UIC permit 5C5-1, WYS-005-164 (West)</td>
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High Plains Gas LLC

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**WOGCC API permits – gas wells producing water associated with High Pains Gas LLC’s Creswell UIC facilities**

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**WSEO water permit – water permits for the gas wells producing water associated with High Pains Gas LLC’s Creswell UIC facilities**

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APPENDIX 4: QUEENSLAND DOCUMENTS

All current Qld EAs are available through:
Queensland Government, Environmental Authority Register (July 2019)

All Commonwealth EAs are available through:

### CSG Operator permits and documents

**AP LNG**

Some documents and reports available through:

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<td>2.  EPBC 2017/7881 (Cth) referral decision</td>
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<td>3.  EPBC 2017/7902 (Cth) referral decision</td>
<td>24.04.17</td>
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<td>4.  EPPG00885313 (Spring Gully) (Qld)</td>
<td>08.02.17</td>
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<td>5.  EPPG00853213 (Combabula/Reedy Creek) (Qld)</td>
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<td>6.  EPPG00853013 (Condabri) (Qld)</td>
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<td>7.  EPPG00968013 (Walloons) (Qld)</td>
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<td>8.  Amendment to EPPG00853213 (Reedy Creek), EPPG00853013 (Condabri) and EPPG00968013 (Walloons) (Qld)</td>
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### CSG water monitoring and management plans

9.  Stage 1 CSG Water Monitoring and Management Plan Q-LNG01-95-MP-0147                     | Undated    |
10. Stage 2 CSG Water Monitoring and Management Plan Q-LNG01-15-MP-2105                     | 11.03.14   
This includes:
- 2013 Groundwater Assessment
- Groundwater Monitoring Plan
- Aquifer Injection Feasibility Studies
- Groundwater Mitigation Plan
- Surface Water Monitoring and Management
- Fracture Stimulation and Ecotoxicology

13. Spring Gully Coal Seam Gas Water Management Plan (CDN:12369206)                       | 08.02.17   |
14. Spring Gully Aquifer Injection Management Plan                                        | 06.07.17   |
15. Spring Gully Injection Management Plan Q-8200-95-MP-1008                               | 05.11.15   |
17. Reedy Creek Aquifer Injection Management Plan– Precipice Sandstone (Q-4255-5-MP-004) | 08.05.17   |

### Groundwater assessment reports

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<td>2014–2015 Groundwater Assessment Report Q-1000-75-RP-001</td>
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<td>2015–2016 Groundwater Assessment Report QLD-1000-E75-RPT</td>
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**Environmental and social reports**

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<td>Jan to June 2012 Environmental and Social Report</td>
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**Independent CSIRO report on responses to injection activities**

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**Qld annual returns** (only available through specific request to QDES)

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**Commonwealth annual environmental returns**

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**Commonwealth required third-party audit**

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<td>51.</td>
<td>2017 Third Party Review for the purposes of an extension application of the project and separate Cth approval application. Eco Logical Australia</td>
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**IESC advice on Spring Gully extension application EPBC 2017/7881**

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Aquifer injection in the coal seam gas context: Appendix 4: Queensland documents

### SANTOS

**Some documents and reports available through:**
Santos, *GLNG Environmental Documentation and Plans*  

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<td>56. EPPG00928713 (Fairview Arcadia) (Targets the Bandanna formation) (Qld)</td>
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<td>57. Ch5 minor amendment application to EPPG00928713 (Fairview Arcadia)- Application to amend EPPG00928713 to release to Dawson River (Qld)</td>
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<td>59. Roma Shallow Gas Project Area Coal Seam Gas Water Management Plan</td>
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<tr>
<td>68. Coordinator-General’s evaluation report on the EIS for the Santos GLNG project December 2015</td>
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<td>69. Coordinator General’s evaluation report on the EIS for the Gladstone LNG project May 2010 (the export facility)</td>
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<td>70. IESC, Advice to Decision Maker on Coal Seam Gas Project, IESC 2014-061: Santos GLNG Gas Fields Development Project (EPBC 2012/6615) – Expansion</td>
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**CSG water monitoring and management plans**

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<td>Surat North Development Water Resource Monitoring and Management Plan</td>
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**Coal seam gas water monitoring and management annual reports**

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**Queensland annual returns (only available through specific request to QDES)**

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**Cth third-party audits**

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<td>88</td>
<td>Deloitte, Independent Compliance Audit of EPBC Upstream Approval (EPBC 2008/4398) – specified conditions relating to water management</td>
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**Arrow**

**Environmental authorities**

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**CSG water monitoring and management plans**

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## Commonwealth Senate Inquiry – Water Use by the Extractive Industry

*Submissions available at Parliament of Australia, *Water Use by the Extractive Industry*  
<https://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Environment_and_Communications/WaterUseGovernance>*

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### Independent Review of the 2013 EPBC Act Amendment – Water Trigger

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APPENDIX 5: OTHER QUEENSLAND APPROVALS FOR CSG PROJECTS

Other relevant approvals for CSG projects include:

- satisfaction of the minimum requirements of the Land Access Code and a negotiated Conduct and Compensation Agreement with landholders;
- a cultural heritage plan under the Aboriginal Cultural Heritage Act 2003 (Qld) and an Indigenous Land Use Agreement under the Native Title Act 1993 (Cth);
- water licences under the Water Act 2000 (Qld) for taking or interfering with water not associated with petroleum production or off-tenement;
- development permits under the Planning Act 2016 (Qld) and Building Act 1975 (Qld), and local government planning and other regulation, such as for structures that are not incidental to the extraction such as offices as well as for building works, heritage issues and vegetation clearing under local laws;
- permits under the Nature Conservation Act 1992 (Qld) for fauna and flora movement or destruction;
- permits under the Vegetation Management Act 1999 (Qld) to clear native vegetation outside the petroleum lease area;
- permits under the Land Act 1994 (Qld) for occupying state land and, perhaps, works on local roads;
- permits under the Transport Infrastructure Act 1994 (Qld) for works on a State road; and
- general work safety requirements for operating plants in the P&G Act, and the Work Health Safety Act 2011 (Qld) to the extent that it applies; and
- End of Waste Approvals under the Waste Reduction and Recycling Act 2011 (Qld) (see Note below).

NOTE: CSG produced water generally and the brine or salt that is the result of treatment processes are ‘wastes’ within the meaning of the EP Act. Where the CSG produced water has a pH of between 6 and 10.5 and an electrical conductivity of less than 15,000 micro-siemens per centimetre, it will be governed by the Waste Reduction and Recycling Act 2011 (Qld) (Waste Act) rather than as a ‘regulated waste’ under the Environmental Protection Regulation 2019 (Qld). Under the Waste Act, certain wastes can be approved as a resource so that, rather than disposal, the by-

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1443 EP Act, s 13, because it is an unwanted by-product of the extraction process.
product can put to further beneficial use. Individual end of waste or beneficial use approvals 1444 (EOW/BUAs) can be obtained through Chapter 8 of the Waste Act. There are two existing general BUAs that relate to CSG produced water, so that it can be further used either on-tenement or off-tenement without the need for further approvals. (An EA under the EP Act can only authorise the use of the CSG produced water on-tenement but not off-tenement.) The two existing EOW/BUAs that apply to CSG produced water relate to use for irrigation, 1445 and the other relates to its general use in aquaculture, coal washing, dust suppression, construction, landscaping and revegetation, industrial and manufacturing operations, research and development, domestic, stock, stock intensive, and incidental land management. 1446 Without a beneficial re-use approval or end of waste approval, the CSG water is subject to the offence provisions in the Waste Act 1447 and the EP Act. 1448

Worse-quality CSG produced water, or the brine and salt that is produced from the treatment of the CSG produced water, is considered ‘regulated waste’ and is subject to tracking, transport and disposal requirements in the EP Reg. 1449

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1444 Beneficial Use Approval (BUA) was the term used in earlier iterations of the framework and existing BUAs are transitioned pending expiry.
1447 Waste Act, ch 5 pt 1.
1448 EP Act, ch 8.
APPENDIX 6: EXAMPLE OF RELEVANT EA CONDITIONS FOR AP LNG’S COMBABULA PROJECT

Example of conditions in a current EA

It is the Queensland EA that usually sets out the detailed operational requirements for aquifer injection trials or commercial applications. While there may be a requirement to undertake a pilot study in the federal approval, for example, as is the case for AP LNG’s federal approval for 2009/4974, it will usually be the corresponding State approval that sets out the detailed requirements.

For example, the historic EPPG00853213 (18 February 2016) (Qld) for AP LNG’s Combabula project required AP LNG to conduct fluid injection in accordance with the ‘Australia Pacific LNG Upstream Phase 1 – Reedy Creek Aquifer Injection Management Plan – Precipice Sandstone’ (ref Q-4255-95-MP004). This plan is required to include details about:

- estimated volumes and rates of water to be injected, as well as a thorough description of the water quality of the injectate;
- how when and where the injectate will be produced, and its treatment and the compatibility of the injectate with the target aquifer;
- the regional characteristics of the receiving environment;
- identification of the water-quality impact zone and hydraulic impact zone;
- identification of injection wells and existing bores, springs, etc.;
- identification of the water-quality values of the receiving environment, in accordance with the EPP Water and Queensland Water Quality Guidelines;
- the potential migration of the injectate, a risk assessment and methods to monitor activities and control measures;
- the procedures that will be adopted to review monitoring and reporting procedures; and
- procedures to prevent environmental harm and to respond to accidents.  

1450 Condition B59.
1451 Condition B60.
A fluid injection monitoring program must be implemented.\textsuperscript{1452}

An operation fluid injection report must be provided with each annual return.\textsuperscript{1453}

There are also conditions relating to fluid injection well closure and a fluid injection cessation report.\textsuperscript{1454}

Injection of fluids is only authorised for 21 wells (whose locations are provided) into the Precipice Sandstone aquifer.\textsuperscript{1455} The water quality of the injectate must not exceed 500 pb of dissolved oxygen, 1000 mS/cm electrical conductivity, total dissolved solids 600 mg/L, and a minimum pH of 6.5 and maximum of 9.4.\textsuperscript{1456}

\textsuperscript{1452} Condition B61.
\textsuperscript{1453} Conditions B62 and 63.
\textsuperscript{1454} Conditions B64–69.
\textsuperscript{1455} Condition B52.
\textsuperscript{1456} Condition B58.
APPENDIX 7: SUMMARY OF MONITORING ACTIVITIES AS REPORTED BY QUEENSLAND OPERATORS

AP LNG

AP LNG’s Groundwater Monitoring Plan CDN/ID 11788517, dated 7 April 2017, lists approximately 200 monitoring wells measuring general impacts: groundwater levels are recorded at a minimum of 12 hourly intervals (p 19) and water quality is tested six-monthly. The water quality parameters measured are extensive. As a minimum, all groundwater samples are analysed for the water-quality parameter suite defined in the UWIR (OGIA, 2016). This includes:

- physio-chemical parameters – pH, electrical conductivity (μS/cm @ 25°C), redox, temperature, free gas (methane) at wellhead;
- Total Dissolved Solids (TDS);
- major cations and major anions – calcium, magnesium, sodium, potassium, chloride, sulphate, bicarbonate, carbonate, total alkalinity and fluoride;
- metals (dissolved) – arsenic, barium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, strontium, and zinc; and
- dissolved methane.\(^{1457}\)

Reporting of raw data is made to the OGIA on a six monthly and annual basis. AP LNG allows the relevant landholders to login to access pressure and temperature data (p20). Water level and water quality data were (but are not now) available via two publicly accessible webpages.\(^{1458}\)

AP LNG’s historic Spring Gully Aquifer Injection Management Plan (5 November 2015) details the monitoring commitments to measure impacts of the injection activities. Ten monitoring bores record data at hourly, daily, quarterly, six-monthly and annual intervals (page 60). This data is included in the company’s annual returns but is also summarised in its annual

Aquifer injection in the coal seam gas context: Appendix 7: Summary of monitoring by Queensland operators

groundwater assessments, which are published on the internet.\textsuperscript{1459} AP LNG also has a farmer/community-based groundwater monitoring scheme to facilitate independent groundwater monitoring.\textsuperscript{1460}

AP LNG has readily made available results of third-party monitoring of their activities. For the results of monitoring of injection activities, AP LNG engaged independent third-party scientists from CSIRO to report on the geochemical responses to the injection activities and published the report on the internet.\textsuperscript{1461} It has also made available on the internet the independent audit of compliance with its federal obligations for its gas field activities.\textsuperscript{1462}

Santos

Santos details its groundwater monitoring bores in its Environmental Monitoring Plan, dated February 2013.\textsuperscript{1463} That plan sets out the locations of approximately 150 bores in Appendix A as well as the frequency and suite of parameters measured in Appendices C and M. Water level measurements are taken daily by some wells and semi-annually for water quality characteristics. Water quality parameters measured are also extensive and include:

- major cations and anions- calcium, magnesium, sodium, potassium, chloride, fluoride, sulphate, nitrite and nitrate;
- sodium absorption ration (SAR), TDS, pH, conductivity and total alkalinity;
- total metals;
- total organic carbon and dissolved organic carbon; and
- total petroleum hydrocarbons and BTEX.\textsuperscript{1464}

Santos also has monitoring wells designed to measure impacts due to seepage, irrigation with CSG produced water and fracking activities (see Table C7 at p 15). It has an excellent water portal on its website, which shows the location of monitoring bores and data associated with

\textsuperscript{1461} Prommer et al, above n 970.
\textsuperscript{1462} Ibid.
\textsuperscript{1463} Santos, Stage 2 Revision 2 CSG Water and Monitoring and Management Plan, above n 1003.
\textsuperscript{1464} Ibid, App M (Laboratory Analytical Suites).
those bores. Water-quality parameters publicly reported via this webpage are limited to pH, electrical conductivity and total dissolved solids.

QGC
QGC’s 160-odd monitoring bores are noted in Appendix E 2.1 of its *Stage 3 CSG Water Monitoring and Management Plan*, which take measurements varying from continuously, hourly and daily, to six-monthly. The field suite of water-quality parameters measured are noted in Appendix G.1 to *Stage 2 Water Monitoring and Management Plan* as including odour, colour, temperature, electrical conductivity, pH, redox potential, dissolved oxygen, carbon dioxide, methane, hydrogen sulphide, oxygen, carbon monoxide, peak LEL and depth of water. QGC provides public access to data via a webpage (from 2014).  

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APPENDIX 8: CHAPTER 3 WATER ACT
QUEENSLAND, CONFLICT RESOLUTION
MECHANISMS

An underground water impact report (UWIR) must be prepared by either the petroleum tenure holder or the OGIA, generally 14 months after the start day of the petroleum tenure. The UWIR sets out relevant information such as estimates of predicted water extraction, identification, characterisation and analysis of relevant aquifers; identification on maps of areas where the water levels are predicted to decline (‘immediately affected areas’ (IAA) and ‘long term affected areas’ (LAA)); methodology used to obtain information and predictions; existing water bores; a description of existing and predicted future impacts to environmental values due to water extraction; water monitoring, which includes a baseline assessment program; spring impact monitoring strategies; and a program for reviewing the accuracy of the maps. The water monitoring strategy relates to bores in both the IAA and LAA.

The 2016 UWIR determined that there are 459 bores in the LAA and 91 bores (out of the 459) that are in the IAA (which all access the Walloon Coal Measures).

Bore assessments are required in order to determine whether bores in IAA are impaired or likely to have an impaired capacity. They must occur within 60 business days after the

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1467 If the petroleum tenure is within a cumulative management area (CMA), such as the Surat CMA, the Office of Groundwater Impact Assessment is the responsible entity for the production of the UWIR; Water Act, s 368.
1468 IAAs are areas that are predicted within 3 years to decline by more than the bore trigger threshold (5 m for consolidated aquifers and 2 m for unconsolidated aquifers) due to petroleum activities; Water Act, ss 362 (bore trigger thresholds), 376(1)(b)(iv) and 387.
1469 LAAs are areas that are predicted to experience a decline in water levels of more than the bore trigger threshold of the UWIR at any time; Water Act, ss 376(1)(b)(v) and 387.
1470 Water Act, s 376, and if the UWIR relates to the CMA, it must also identify the relevant tenure holders that are responsible for report obligations and make good obligations for bores in the IAA; Water Act, s 376(h).
1473 Also for bores in LAAs where a petroleum tenure is terminating: Water Act, s 438.
Aquifer injection in the coal seam gas context: Appendix 8: Chapter 3: Water Act Conflict Resolution
Mechanisms

UWIR\textsuperscript{1476} takes effect.\textsuperscript{1477} Impaired capacity for either new or existing bores\textsuperscript{1478} is when petroleum activities have caused a water level decline in the bore and, because of the decline, the bore can no longer provide a ‘reasonable quantity or quality of water for its authorised use or purpose’.\textsuperscript{1479} (Where the bore is a new bore, the decline must be more than the predicted decline in the relevant UWIR.) Also, if the bore is affected by free gas due to the petroleum activities, which has caused (or materially contributed to) damage to the bore; if it poses a health or safety risk; or if it can no longer provide a reasonable quantity or quality of water, this is also evidence of an impairment.\textsuperscript{1480} It is not necessary to prove causation of these impacts, merely that gas extraction is likely to cause or materially contribute to the impact.

Within 40 business days of the completed bore assessments, the petroleum tenure holder must use its ‘best endeavours’ to enter into a make good agreement with the bore owner.\textsuperscript{1481} The make good agreement sets out the outcomes of the bore assessments, whether the bore is impaired (or likely to be impaired) and intended make good measures such as agreeing to provide an alternative supply of water, continue to monitor bores, construct new bores or provide monetary compensation.\textsuperscript{1482} Make good measures are only required if the bore is impaired or likely to become impaired due to petroleum activities. If the parties cannot agree, they may seek a conference with QDES or independent alternative dispute resolution and, if that fails, they may apply to the Land Court.\textsuperscript{1483}

At the end of a petroleum tenure, if there are bores in the LAA, the make good obligations continue to apply to those bores as though they were bores in IAAs.\textsuperscript{1484}

**AM and the iterations of the UWIRs**

The production of a UWIR is the first step in the conflict resolution mechanisms in place in Queensland because it identifies the IAAs which, in turn, determine which bores require assessment.

\textsuperscript{1476} Or the final report if the petroleum tenure is terminating by either closure or surrender: Water Act, s 438.
\textsuperscript{1477} Water Act, s 417, or at a later time if agreed by the QDES. The QDES can also direct the petroleum operator to conduct bore assessments of bores that are not within the IAA, but have experienced declines or are otherwise impacted: Water Act, s 418.
\textsuperscript{1478} Existing bores are bores in existence before the first UWIR takes effect and new bores are bores constructed after that date: Water Act, s 412(5).
\textsuperscript{1479} Water Act, s 412
\textsuperscript{1480} Ibid, s 412(3).
\textsuperscript{1481} Ibid, s 423. The petroleum tenure holder must reimburse the bore owner for any accounting, hydrogeological, legal or valuation costs that are reasonably incurred: Water Act, s 423(3).
\textsuperscript{1482} Water Act, ss 420 and 421.
\textsuperscript{1483} Ibid, ch 3, pt 5, div 4.
\textsuperscript{1484} Ibid, ch 3, pt 6.
UWIRs must be prepared every three years.\textsuperscript{1485} For the Surat CMA, two UWIRs have been developed (in 2012 and 2016) and a consultation draft of the next is now available. Annual reports are also published that inform the public of updates.\textsuperscript{1486} For the Surat CMA, OGIA develops the hydrogeological model, relying on the monitoring and production data supplied by the operators. As more data is received, this allows OGIA to test and develop or refine this model. As production and development change, so too have the predicted impacts, so that each UWIR is the new iteration. Therefore, there is a step-wise approach applied by the OGIA in performing these functions, which attempt to clarify the predicted impacts as development progresses. This adaptive approach applied by the OGIA appears to be a positive factor in reducing uncertainty.

\textsuperscript{1485} Water Act, s 370, states that a UWIR must be given within 10 business days after each third anniversary of the day the first underground water impact report took effect, or if the chief executives agrees to a later day.\textsuperscript{1486} Available at Queensland Government, Business Queensland, \textit{Underground Water Impact Reports (UWIR) for the Surat CMA} (2019) <https://www.business.qld.gov.au/industries/mining-energy-water/resources/land-environment/surat-cma/uwir>.
APPENDIX 9: CHALLENGES FOR AM
### Theoretical:
- A lack of clarity of definition and how to apply it,
- A lack of success stories on which to build,

### Economic:
- The cost of implementing (especially with respect to active AM),
- Short term costs for long term gains are frequently discounted so that short term gains are favoured,

### Institutional and management:
- Management policy and funding paradigms that favour reactive rather than proactive approaches to natural resource management,
- Failure to recognise the potential for shifting objectives,
- The failure of overlapping management agencies to fully and clearly define their responsibilities for implementing AM plans,
- Where there is institutional reluctance to change or inflexibility,
- Where there is a complex legal environment,
- A lack of transparency and openness in respect of access to information,
- A risk averse institution,
- Difficulties in reconciling centralised coordination and decentralised implementation,
- The tension between long planning timeframes and short tenure of government decision makers,
- A lack of experience in collaboration on the part of management and stakeholders,
- The detachment of management agencies,
- The turnover of key personnel and stakeholder participants,
- The threat of unpredictable disruptions from changes in external political, budgetary, or other conditions.

### Scientific and ecological:
- There may be greater risks to the resource (especially with respect to active AM),
- Where the ecological system lacks resilience,
- The long time periods required for acquiring statistically valid field trial results,
- The difficulties in collecting enough information to evaluate progress and even a failure to monitor,
- The tendency of scientists to overstate their abilities to be able to measure complex functional relationships through experimentation ('spurious certitude'),
- Problems stemming from the model; disagreement, lack of faith or incorrect application or formulation of the scientific models used,
- Where there are technical challenges associated with designing experiments,
- Inadequate planning and design,
- The reluctance of technical experts to engage in political discourse,
- Resistance from agency scientists,
- Hijacking of management goals for research interests,
- The difficulties of experiments,
- Surprises are suppressed,

### Social:
- Failure to acknowledge the social source of uncertainty, and hence increased risk of surprise,
- The difficulty in addressing multiple needs of managers, scientists and stakeholders,
- A lack of emphasis or attention to the processes required for building shared understanding and shared decision making among diverse stakeholders,
- Inflexible social systems,
- Lack of trust resulting from the belief that certain stakeholders wield more power,
- Where certain stakeholders do hold more power this can result in intransigence
- The difficulty in understanding scientific method (models) and findings,
- The turnover of key personnel and stakeholder participants,
- A belief that confrontation and adversarial forms forums command attention,
Aquifer injection in the coal seam gas context: Appendix 9: Challenges for AM

Theoretical

- Lack of clarity of definition and how to apply it
- Lack of success stories on which to build

Institutional and management

- Management policy and funding paradigms that favour reactive rather than proactive approaches to natural resource management
- Failure to recognise the potential for shifting objectives
- Failure of overlapping management agencies to fully and clearly define their responsibilities for implementing AM plans
- Where there is institutional reluctance to change or inflexibility
- Where there is a complex legal environment
- Lack of transparency and openness in access to information
- Risk-averse institution
- Difficulties in reconciling centralised coordination and decentralised implementation
- Tension between long planning timeframes and short tenure of government decision-makers
- Lack of experience in collaboration on the part of management and stakeholders

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1487 Allen et al, above n 267, 1341–2.
1488 Ibid.
1489 Ibid.
1490 Ibid.
1493 Williams, Szaro and Shapiro, above n 249, 18
1496 McLain and Lee, above n 289, 443.
1497 Ibid; Shea et al, above n 1492, 932.
Aquifer injection in the coal seam gas context: Appendix 9: Challenges for AM

- Detachment of management agencies\textsuperscript{1499}
- Turnover of key personnel and stakeholder participants\textsuperscript{1500}
- Threat of unpredictable disruptions from changes in external political, budgetary, or other conditions\textsuperscript{1501}
- Inadequate planning and design\textsuperscript{1502}
- Inadequate implementation of plans\textsuperscript{1503}
- Inadequate institutional structures and stakeholder participation\textsuperscript{1504}
- Lack of commitment to monitoring, evaluating and reporting\textsuperscript{1505}
- Institutional ‘memory loss’ regarding what has been learned\textsuperscript{1506}
- The failure of decision-makers to understand why AM is needed and whether it works\textsuperscript{1507}
- Lack of leadership\textsuperscript{1508}
- Inaction used as a policy choice\textsuperscript{1509}
- Action rather than learning being valued\textsuperscript{1510}
- Difficulties in translating learning into practice or even a failure to learn\textsuperscript{1511}

Scientific and ecological

- There may be greater risks to the resource (especially with respect to active AM)\textsuperscript{1512}
- Where the ecological system lacks resilience\textsuperscript{1513}
- Long time periods required for acquiring statistically valid field trial results\textsuperscript{1514}

\textsuperscript{1499} Balint, above n 1498, 100.
\textsuperscript{1500} Ibid.
\textsuperscript{1501} Ibid.
\textsuperscript{1502} Schreiber et al, above n 1495, 180.
\textsuperscript{1503} Ibid, 180.
\textsuperscript{1504} Ibid, 180.
\textsuperscript{1505} Ibid, 180.
\textsuperscript{1506} Ibid.
\textsuperscript{1508} Ibid, 1380, citing Walters, above n 1507.
\textsuperscript{1509} Ibid, 1380, citing Walters, above n 284.
\textsuperscript{1510} Ibid, 1380.
\textsuperscript{1511} Ibid, 1380 and 1382.
\textsuperscript{1512} Gregory, Ohlson and Arvai, above n 1491, 2412–2413. The ethical dilemma that this creates is noted by Halbert, above n 265, 274; Walters, above n 284; Gunderson and Light, above n 289, 329.
\textsuperscript{1513} Gunderson, above n 284.
\textsuperscript{1514} Gregory, Ohlson and Arvai, above n 1491, 2413. For the requirement for management to remain committed for this period, see Williams, Szaro and Shapiro, above n 249, 18.
Aquifer injection in the coal seam gas context: Appendix 9: Challenges for AM

- Difficulties in collecting enough information to evaluate progress and even a failure to monitor\textsuperscript{1515}
- Tendency of scientists to overstate their abilities to be able to measure complex functional relationships through experimentation (‘spurious certitude’)\textsuperscript{1516}
- Problems stemming from the model: disagreement, lack of faith, or incorrect application or formulation of the scientific models used\textsuperscript{1517}
- Where there are technical challenges associated with designing experiments\textsuperscript{1518}
- Inadequate planning and design\textsuperscript{1519}
- Reluctance of technical experts to engage in political discourse\textsuperscript{1520}
- Resistance from agency scientists\textsuperscript{1521}
- Hijacking of management goals for research interests\textsuperscript{1522}
- Difficulties of experiments\textsuperscript{1523}
- Surprises are suppressed\textsuperscript{1524}

Social

- Failure to acknowledge the social source of uncertainty and, hence, increased risk of surprise\textsuperscript{1525}
- Difficulty in addressing multiple needs of managers, scientists and stakeholders\textsuperscript{1526}
- A lack of emphasis or attention to the processes required for building shared understanding and shared decision-making among diverse stakeholders\textsuperscript{1527}
- Inflexible social systems\textsuperscript{1528}

\textsuperscript{1515} Williams, Szaro and Shapiro, above n 249, 18; Shea et al, above n 1492, 932; Schreiber et al, above n 1495, 180.
\textsuperscript{1516} Gregory, Ohlson and Arvai, above n 1491, 2413; Schreiber et al, above n 1495, 180; Gunderson and Light, above n 289, 328; Allen and Gunderson, above n 1491, 1380.
\textsuperscript{1517} McLain and Lee, above n 289, 443; Walters, above n 285, Shea et al, above n 1492, 933.
\textsuperscript{1518} Gunderson, above n 285.
\textsuperscript{1519} Schreiber et al, above n 1495, 180.
\textsuperscript{1520} Balint, above n 1498, 100.
\textsuperscript{1521} Gunderson and Light, above n 289, 327.
\textsuperscript{1522} Allen and Gunderson, above n 1491, 1380, citing Walters, above n 284.
\textsuperscript{1523} Ibid, 1381.
\textsuperscript{1524} Ibid, 1381.
\textsuperscript{1525} Allen et al, above n 267, 1341–2.
\textsuperscript{1526} Ibid, 1341–2; Gregory, Ohlson and Arvai, above n 1491, 2413; Walters, above n 284; Gunderson and Light, above n 289; 327. Feldman notes that, where there is extreme conflict between stakeholders, AM is unlikely to succeed, in David Lewis Feldman, ‘Barriers to Adaptive Management: Lessons from the Apalachicola–Chattahoochee–Flint Compact’ (2008) 21(6) Society & Natural Resources 512, 522.
\textsuperscript{1527} Gregory, Ohlson and Arvai, above n 1491, 2413.
\textsuperscript{1528} Gunderson, above n 284.
Aquifer injection in the coal seam gas context: Appendix 9: Challenges for AM

- Lack of trust, resulting from the belief that certain stakeholders wield more power\textsuperscript{1529}
- Where certain stakeholders do hold more power, this can result in intransigence\textsuperscript{1530}
- Difficulty in understanding scientific method (models) and findings\textsuperscript{1531}
- Turnover of key personnel and stakeholder participants\textsuperscript{1532}
- Belief that confrontation and adversarial forms forums command attention\textsuperscript{1533}

**Economic**

- Cost of implementing (especially with respect to active AM)\textsuperscript{1534}
- Short-term costs for long-term gains are frequently discounted so that short-term gains are favoured\textsuperscript{1535}

\textsuperscript{1529} McLain and Lee, above n 289, 443; Gunderson and Light, above n 289, 329; Gunderson, above n 284, 329.\textsuperscript{1530} Barry Johnson, ‘The Role of Adaptive Management as an Operational Approach for Resource Management Agencies’ (1999) 3(2) Conservation Ecology 8; Balint, above n 1498, 100; Gunderson and Light, above n 289, 327; Fikret Berkes, ‘Evolution of Co-management: Role of Knowledge Generation, Bridging Organizations and Social Learning’ (2009) 90(5) Journal of Environmental Management 1692, 1698.\textsuperscript{1531} Balint, above n 1498, 100.\textsuperscript{1532} Ibid.\textsuperscript{1533} Gunderson and Light, above n 289, 330.\textsuperscript{1534} Gregory, Ohlson and Arvai, above n 1491, 2412; McLain and Lee, above n 289, 443; Walters, above n 284; Shea et al, above n 1492, 933; Holly Doremus et al, Making Good Use of Adaptive Management (Center for Progressive Reform, 2011), 5.\textsuperscript{1535} Shea et al, above n 1492, 933.
APPENDIX 10: ANALYSIS OF PRB PERMITS
Aquifer injection in the coal seam gas context, Appendix 10- PRB permits

Operator

Facility number

Anadarko

WYS-025-024
WYS-007-049
WYS-007-053
WYS-007-052
WYS-00-051
WYS-007-054
WYS-007-056
WYS-007-058
WYS-007-057
WYS-007-055
WYS-007-044
WYS-007-00161
WYS-007-00159
WYS-007-00165
WYS-007-00172
WYS-007-00165
WYS-007-039
WYS-007-040
WYS-007-041
WYS-007-043
WYS-007-030
WYS-007-042
WYS-007-00244 Stewart Draw fed
WYS-005-00562 Speck
WYS-005-014
KD CS Injector 1

Yates

EOG Y wells transferred
01.11.16

Name

Number of wells
Permit number permitted
05-231; 08-144
06-156
06-615
06-616
06-617
06-735
06-736
06-737
06-738
06-739
06-753
07-308
07-309
07-338
08-799
09-669
5C5
5C5
5C5
5C5
5C5
5C5
5C5
5C5-1
5C5-1

Administrative
action count
(Letter of Violation
(LOV)) not
Informal
including missing administrative
reports
action

Notifications of
exceedences
6
1
1
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10
8
44
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41
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Administrative action narration

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LOV 10.11.08, email 14.08.14
LOV 10.11.08
LOV 10.11.08
LOV 10.11.08

General notes
missing monitoring reports and bacteria exceedance==> resolved through meeting 15.12.08; email 14.08.14
querying quantum of injection data
missing monitoring reports and bacteria exceedance=> resolved through meeting 15.12.08, p&a 06.06.12
missing monitoring reports and bacteria exceedance=> resolved through meeting 15.12.08
missing monitoring reports and bacteria exceedance=> resolved through meeting 15.12.08

LOV 10.11.08
LOV 10.11.08
LOV 10.11.08
LOV 10.11.08
LOV 10.11.08
LOV 10.11.08
LOV 10.11.08
LOV 10.11.08
LOV 10.11.08

missing monitoring reports and bacteria exceedance=> resolved through meeting 15.12.08
missing monitoring reports and bacteria exceedance=> resolved through meeting 15.12.08
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missing monitoring reports and bacteria exceedance=> resolved through meeting 15.12.08
missing monitoring reports and bacteria exceedance=> resolved through meeting 15.12.08
missing monitoring reports and bacteria exceedance=> resolved through meeting 15.12.08

LOV 09.02.12

pH and pressure exceedance==> resolved 05.03.12

LOV 10.11.08
LOV 29.01.13

missing monitoring reports and bacteria exceedance=> resolved through meeting 15.12.08
monitoring reports missing==> resolved becaues permits requested to be cancelled

LOV 05.08.10

missing report ==> resolved 21.12.10 NEVER DRILLED
p&a 28.12.10
bacteria exceedance==> resolved 21.12.10; p&a 30.03.16; and some supporting info missing email 30.09.16; ltr
09.05.12 re general minor non-compliances
ltr 17.04.17 requesting info re land ownership/agreements; LOV 14.05.13 missing reports==>resolved 16.07.13;
04.10.10 request to cancel NEVER DRILLED
04.10.10 request to cancel NEVER DRILLED
04.10.10 request to cancel NEVER DRILLED
04.10.10 request to cancel NEVER DRILLED
missing reports ==> resolved 21.12.10 NEVER DRILLED
04.10.10 request to cancel NEVER DRILLED
04.10.10 request to cancel NEVER DRILLED
02.10.08 request to cancel NEVER DRILLED
missing reports ==> resolved 21.12.10 NEVER DRILLED; CANCELLED
missing reports ==> resolved 21.12.10 NEVER DRILLED
missing reports ==> resolved 21.12.10 NEVER DRILLED
missing reports ==> resolved 21.12.10 NEVER DRILLED
missing reports ==> resolved 21.12.10; LOV 08.04.14 missing monitoring reports; ltr 17.04.17 requesting info re
land ownership/agreements
02.10.08 request to cancel NEVER DRILLED

WYS-005-244

KD CS Injector 2

5C5-1

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LOV 05.08.10, email 30.09.16, ltr
2 09.05.12

WYS-005-258
WYS-005-259
WYS-005-260
WYS-005-280
WYS-005-00561
WYS-019-00222
WYS-019-00227
WYS-019-0029
WYS-033-115
WYS-033-116
WYS-033-117
WYS-033-118

Stripe POD 1
Stripe POD 2
Stripe POD 3
Crooked Creek
Afriqueen
Haunt
Dusk
Van Houten
Interceptor 9
Interceptor 10
Interceptor 11
Interceptor 12

5C5-1
5C5-1
5C5-1
5C5-1
5C5-1
5C5-2
5C5-2
5C5-3
5C5-3
5C5-3
5C5-3
5C5-3

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WYS-019-00235 Interceptor 13
WYS-019-00220 Relish No1

5C5-3
5C5-3

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WYS-005-00529 Bogie Draw
WYS-005-00530 Ucross

5C5-1
5C5-1

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WYS-005-00582 Deer Track S&R
WYS-005-257
Stripe POD

5C5-1
5C5-1

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WYS-005-277

Dejure

5C5-1

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WYS-005-279
WYS-005-278

Chatterbox
Worley Draw

5C5-1
5C5-1

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WYS-005-281

Fuels Injector 1

5C5-1

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2

ltr 17.04.17; LOV 14.05.13

LOV 05.08.10

LOV 05.08.10
LOV 05.08.10
LOV 05.08.10
LOV 05.08.10
LOV 05.08.10; LOV 08.04.14; ltr
1 17.04.17
0
0 LOV 05.08.10; LOV 20.07.12
0 LOV 05.08.10
ltr 17.04.17; LOV 14.05.13; LOV
1 14.05.13
0
LOV 05.08.10; ltr 09.05.12; ltr
2 17.04.17
1 ltr 17.04.17; LOV 14.05.13
2 ltr 09.05.12; ltr 17.04.17
LOV 05.08.10; ltr 09.05.12; ltr
2 17.04.17; LOV 14.05.13

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missing reports ==> resolved 21.12.10 NEVER DRILLED ; LOV 20.07.12 missing reports
missing reports ==> resolved 21.12.10 NEVER DRILLED
ltr 17.04.17 requesting info re land ownership/agreements; 14.05.13 pressure exceedances; LOV 14.05.13 missing
reports==>resolved 16.07.13
injection pressure exceedance ==> resolved 21.12.10; ltr 09.05.12 re general minor non-compliances; ltr 17.04.17
requesting info re land ownership/agreements
ltr 17.04.17 requesting info re land ownership/agreements; LOV 14.05.13 missing reports; ==>resolved 16.07.13;
NEVER DRILLED AT MAY 2012
ltr 09.05.12 re general minor non-compliances; ltr 17.04.17 requesting info re land ownership/agreements
bacteria==> resolved 21.12.10; ltr 09.05.12 re general minor non-compliances; ltr 17.04.17 requesting info re
land ownership/agreements; LOV 14.05.13 pressure exceedances==>resolved 16.07.13


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