THE UNIVERSITY OF QUEENSLAND

AUSTRALIA

Getting the Science Right: Queensland's Coal Seam Gas Development and the Engagement with Knowledge, Uncertainty and Environmental Risks

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Master of Arts (Hons) (Sociology & Anthropology)

A thesis submitted for the degree of Doctor of Philosophy at

The University of Queensland in 2017

School of Social Science

Abstract

Along with the current global 'gas revolution', Australia's natural gas industry grew rapidly over the last decade. As part of this growth, unconventional gas reserves in the coal basins underlying the State of Queensland have been developed at a large scale. These coal seam gas (CSG) projects are expected to involve the drilling of up to 20,000 gas wells in southern Queensland alone. On a small — but likely increasing — number of the existing 9,000 wells, CSG companies apply the controversial extraction technique of hydraulic fracturing ('fracking'). One hotspot of development is the rural Western Downs region where the CSG industry's rapid expansion and accompanying socio-cultural changes have intensified land use competition between agricultural and extractive industries, while also affecting non-agricultural landholders and regional residents. In this region and elsewhere, CSG extraction has sparked debates over associated risks, uncertainties and possible unknown environmental impacts.

Based on ethnographic research in the Western Downs, this thesis addresses the resulting environmental risk controversy by examining the 'problems of knowing' associated with CSG developments. My analysis focuses on how a variety of actors come to know CSG and its environmental risks as well as the ways in which uncertainties and unknowns are negotiated. I particularly attend to scientific knowledge claims regarding potential environmental and health impacts. The conceptual framework for this approach draws on anthropological and wider social scientific literature concerning knowledge and ignorance, late modern risks, and science. My understanding of these concepts generally follows a postconstructivist perspective that attends to the discursive and material practices of socially positioned actors.

I start the analysis with an outline of the Western Downs' resource history following European settlement. This outline situates the region as an intensively managed landscape that has already been shaped by significant techno-scientific developments. I subsequently examine the role of science in actors' sense-making of CSG and argue that knowing its risks requires scientific knowledge but also involves personal experience and phenomenological ways of knowing. For some actors, CSG-specific scientific research has remained uncertain and unable to answer significant questions regarding groundwater or health-related impacts. I therefore address how a variety of actors have responded to continuing problems of knowing, including critiques of scientific research. The deconstruction of these critiques demonstrates how scientific research can be understood as situated practices that themselves can become contested. These findings point towards the wider politics of knowledge and ignorance around CSG developments, which I examine in the final parts.

The analysis of the politics of science and knowledge offered here concludes that scientific knowledge is crucial for addressing CSG's potential environmental impacts. However, science is ultimately only one element of sense-making processes within actors' lifeworlds. For a variety of actors, scientific research findings often also remained uncertain and constrained by a diverse range of factors, some of which are examined in this thesis. Turning political and moral negotiations about CSG developments into scientific questions alone can thus adversely affect conflict resolution processes. Instead, this thesis demonstrates that it is important to appreciate the limits of scientific research and to find ways to bring scientific and other ways of knowing into dialogue. CSG risk debates and associated problems of knowing therefore manifest as socio-cultural phenomena that require social resolutions as well as techno-scientific solutions.

Declaration by author

This thesis is composed of my original work, and contains no material previously published or written by another person except where due reference has been made in the text. I have clearly stated the contribution by others to jointly-authored works that I have included in my thesis.

I have clearly stated the contribution of others to my thesis as a whole, including statistical assistance, survey design, data analysis, significant technical procedures, professional editorial advice, and any other original research work used or reported in my thesis. The content of my thesis is the result of work I have carried out since the commencement of my research higher degree candidature and does not include a substantial part of work that has been submitted to qualify for the award of any other degree or diploma in any university or other tertiary institution. I have clearly stated which parts of my thesis, if any, have been submitted to qualify for another award.

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Publications during candidature

Espig, M. & de Rijke, K. (2016a) "Unconventional Gas Developments and the Politics of Risk and Knowledge in Australia." *Energy Research & Social Science*, 20: 82–90.

Espig, M. & de Rijke, K. (2016b) "Navigating Coal Seam Gas Fields: Ethnographic Challenges in Queensland, Australia." *Practicing Anthropology*, 38 (3): 44–45.

Espig, M. (2015) "Politics of the (Un)Known: An Anthropological Perspective of Australia's Unconventional Gas Developments." *Proceedings ESRS Congress 2015*: 39–40.

Publications included in this thesis

No publications included.

Contributions by others to the thesis

No contributions by others.

Statement of parts of the thesis submitted to qualify for the award of another degree

None.

Acknowledgements

I have been extremely fortunate to receive guidance from three exceptional academic supervisors at the University of Queensland (UQ). They certainly attempted their best to direct my thinking towards an accessible and worthy thesis. This thesis would have been impossible without their support. At times, however, I was probably more stubborn than they preferred. Any factual errors, conceptual slippages or intellectual ambiguities are therefore entirely my own.

In the School of Social Science, Professor David Trigger readily agreed to principally supervise me on this ambitious project. It is in no small part due to David's intellectual challenges that my research progressed into a coherent thesis. My thinking and writing benefitted substantially from his constructive commentary and repeated calls for conceptual streamlining and scholarly clarity. I also learned a great deal more about anthropology as a life-long intellectual endeavour and applied practice beyond theoretical curiosities. For this, and David's senior oversight, steady guidance and approachability, I am deeply grateful.

As Dr. Kim de Rijke's first Ph.D. candidate, I hope the experience has been as rewarding for him as it was for me. Kim's insights from his own anthropological research into environmental conflicts and coal seam gas (CSG) were welcome points of orientation and I benefitted greatly from his practical advice and critical intellectual feedback. Many of the thoughts following our conversations, often held over extended coffee breaks, found their way into this thesis. As co-author, Kim helped me to navigate the challenges of my first academic publications. He also provided me with opportunities to tutor in his under- and postgraduate courses. All of this enriched the Ph.D. experience and, beyond completing a substantial thesis, contributed towards my professional development. I am thankful for Kim's encouragement as a co-supervisor and colleague.

Professor Will Rifkin, previously of the UQ's Centre for Coal Seam Gas (CCSG) and currently based at the University of Newcastle, took on the task to co-supervisor an anthropologist whose technical knowledge of CSG and natural resource developments was still somewhat limited. Through his invitations to attend CSG researcher networks, technical seminars and professional workshops, I gained crucial insights into the operation and challenges of the extractive industries. These insights and technical understandings allowed me to develop a more well-rounded perspective of CSG risk controversies and improved my skills as a social scientist. Will's repeated critical and highly constructive feedback on multiple drafts was invaluable in improving the thesis's structure and quality. I am grateful for Will's support and guidance.

Between the School of Social Science and CCSG, David Trigger and Will Rifkin arranged a generous co-funding agreement for my UQ International scholarships. In a climate of shrinking research funding, I hope my critical observations of CSG developments and scholarly contribution to anthropology justify the faith they paid forward some four years ago. The CCSG also funded a travel grant to attend my first international conference. I am indebted to Dr. Bruce Taylor of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) who supported a successful application for a three-year-long UQ/CSIRO Integrated Natural Resource Management top-up scholarship. The living stipend enabled me to focus on my project, while the generous research funding allowed for substantial fieldwork and — unachievable for most Australian Ph.D. candidates — to attend multiple international conferences. Bruce also provide welcome feedback over many shared coffees.

Much of the intellectual and conceptual breadth of this thesis is owed to the stimulating research of social scientists I encountered at various conference, workshops and seminars; too many to name here, but they are acknowledged where possible. At UQ's School of Social Science, numerous colleagues provided critical feedback on chapter drafts or working papers. The memberships within CCSG's Gasfield Social Scientists group, initiated by Will Rifkin, and the Water Researcher Network, organised by Helen Schultz, were invaluable. My friend and research colleague Mohammad Makki helped me to understand the peculiarities of CSG in the Western Downs. During busy times, Anna Weisse patiently transcribed most of my interviews. Deep personal and professional gratitude belongs to those who participated in these interviews — your contributions made this research possible. Please excuse any incorrect interpretations or misunderstandings.

I sincerely appreciated the collegial support and personal friendships of the School of Social Science's staff and entire Ph.D. cohort. Remaining committed to this project would have been impossible without them. My family was and continuous to be the safe haven in life's stormy seas. With all my heart and love, thank you. To Christoph, our late childhood friend, I spent most of the final days of this thesis with your memory in mind. No one fought harder for life despite unimaginable suffering — an inspiration and humbling reminder to appreciate what we are given. You are forever loved and dearly missed, but I am sure you found a beautiful place of peace and solace, with a black and yellow jersey and endless soccer balls!

Keywords

environmental anthropology, coal seam gas, fracking, risk, uncertainty, ignorance, non-knowledge, science, politics of knowledge

Australian and New Zealand Standard Research Classifications (ANZSRC)

ANZSRC code: 160104, Social and Cultural Anthropology, 80%

ANZSRC code: 160802, Environmental Sociology, 10%

ANZSRC code: 160808, Sociology and Social Studies of Science and Technology, 10%

Fields of Research (FoR) Classification

FoR code: 1601, Anthropology, 80%

FoR code: 1608, Sociology, 20%

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List of Abbreviations and Acronyms

AGM	Annual General Meeting
APLNG	Australia Pacific Liquefied Natural Gas
APPEA	Australian Petroleum Production & Exploration Association
ATSE	Australian Academy of Technological Sciences and Engineering
AUD	Australian Dollar
AWD	Advance Western Downs
BOM	Bureau of Meteorology
BSA	Basin Sustainability Alliance
BTEX	Benzene, Toluene, Ethylbenzene and Xylene
CBM	Coalbed Methane (i.e., CSG)
CMA	Cumulative Management Area
CCA	Conduct and Compensation Agreement
CSG	Coal Seam Gas
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EIS	Environmental Impact Statement
ERIC	Energy Resource Information Centre
ESD	Ecologically Sustainable Development
FLIR	Forward Looking Infrared
GAB	Great Artesian Basin
GISERA	Gas Industry Social and Environmental Research Alliance
HOMA	Houston Oil and Minerals Australia
IAA	Immediately Affected Area
IESC	Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development
LAA	Long-term Affected Area
LNG	Liquefied Natural Gas
LNGEU	Liquefied Natural Gas Enforcement Unit
MGA	Make Good Agreement
NGO	Non-governmental Organisation
NICNAS	National Industrial Chemicals Notification and Assessment Scheme
NIMBY	Not In My Backyard
OCE	Office of the Chief Economist
OGIA	Office of Groundwater Impact Assessment
QLD	Queensland
QRC	Queensland Resource Council
RGSQ	Royal Geographical Society of Queensland
RO	Reverse Osmosis
SLQ	State Library of Queensland
UCG	Underground Coal Gasification
UQ	University Of Queensland
UWIR	Underground Water Impact Report
VOC	Volatile Organic Compound
WDRC	Western Downs Regional Council

Preface

Embracing epistemic democratization does not mean a wholesale cheapening of technoscientific knowledge in the process.

(Sismondo 2017: 3)

[S]cience matters, and makes authoritative claims upon us, because of rather than despite its historical and cultural specificity. … Sciences are instead precarious and risky possibilities that only emerged in specific circumstances, and could disappear.

(Rouse 2014: 290–291, original emphasis omitted)

As I am putting the final touches to this thesis in mid-2017, it feels necessary to revise the initial, more personal preface that was written sometime in 2016. Since this project started in late 2013, a number of geopolitically important events occurred that appear to challenge some of the taken-for-granted pillars of our globalising world. Against a background of perpetual discourses of financial, refugee and climate crises, the citizens of the United Kingdom chose to leave the European Union despite many academic and professional experts strongly advising to the contrary. In the United States, Americans elected a presidential candidate who many political commentators — and probably international bystanders — for a long time dismissed with a sense of bewilderment. The incoming Trump administration has so far made headlines through its attempts to implement numerous problematic humanitarian, environmental and scientific research policies. Questionable 'factual' claims and, at best, selective statistics played a role in swaying public sentiments in both cases.

Regardless of whether one agrees with either of these democratic outcomes or not, they sparked debates over 'alternative facts' and 'fake news'. Some social researchers and political commentators therefore critically asked if we entered a "post-truth era" (Fuller 2016; Sismondo 2017). A mere generation after political scientist Fukuyama (1992) suggested the potential 'end of History', it appears that, instead, novel challenges are emerging. One of these challenges concerns the status and future of not just adequate science but legitimate knowledge generally. For Fukuyama (1992: 88), modern science "is so powerful, both for good and for evil, that it is very doubtful whether it can ever be forgotten or 'un-invented' under conditions other than the physical annihilation of the human race". Current debates over post-truth politics or besieged science would probably warrant this certainty to be reassessed.

To be sure, 'post-truth' debates are not unproblematic as they seem to presuppose a prior truth or factual era. Nonetheless, these debates allude to deeper-rooted developments in many industrialised societies and deserve brief commentary, especially before leading the reader into an analysis of

knowledge, uncertainty and risk. In this sense, I feel compelled to explicitly highlight that throughout the following critical analysis I do not intend to dismiss *per se* notions of science or rationality. I am certainly critical of particular characteristics of their historical constructions and contemporary arrangements within many contexts. However, to critique existing scientific practices and open spaces for imagining that "it could be otherwise" (Woolgar & Lezaun 2013: 322) is a long way from fundamentally disputing the merits and value of scientific knowledge and rational political debate — quite the opposite I would suggest. As historian Chakrabarty (2009: 211) argues, "in the era of the Anthropocene, we need the Enlightenment (that is, reason) even more than in the past". What constitutes reason, rationality and proper science is, of course, at the very heart of the debate. Beyond an analysis of these questions, however, we must acknowledge the historical specificity and fragility of scientific practices and rational, respectful debates (Rouse 2014; Stehr 2001). Like democratic structures, these precarious arrangements deserve critiquing but also to be defended.

Following these considerations, the tone and perhaps focus of this thesis may be somewhat different if I commenced a similar project now. As it were, this enquiry emerged initially from a curiosity with the notion of environmental risk in contemporary, late modern societies. In early 2011, I then became aware of coal seam gas (CSG) developments in Queensland. The gas boom was approaching its peak, as was the social controversy that had arisen around the potential impacts of these projects. Similar to many current disputes over the impacts and unintended consequences of the application of techno-scientific capabilities, this controversy included debates around perceptions of risks, sustainability, and concerns about uncertainties. I thus began an honours project based on a discourse analysis of risk and sustainability.

While that analysis allowed for some modest conclusions on the interplay between notions of risk and sustainability, much remained unanswered. I was particularly intrigued by how multiple parties' contradictory claims — usually referring to more or less credible scientific reports and studies for support — frequently included calls that one merely needed to understand the 'actual facts'. Likewise, where unknowns and uncertainty were at stake, settling the debate would simply require more scientific research. Calls to get the science right, therefore, appeared as the solution to the controversy over CSG's risks and impacts. An investigation of knowledge and uncertainties in this context was the logical step. Initially, I intended to focus primarily on the science of CSG and the original thesis title included the 'engagement with *scientific* knowledge'. Throughout this project, however, I became aware of the crucial, yet limited, role of scientific knowledge claims. The word 'scientific' is therefore now omitted from the title.

In a sense, I realised that the "rootedness of scientific inquiry in our habitation of the earth, its general messiness and incoherence, is something to be celebrated, not suppressed" (Ingold 2014a:

236). This somewhat shifted my focus and made me appreciate the epistemic diversity through which risk concerns emerge within lived experiences. So what began as an examination of science, morphed into a broader enquiry of knowledge *and* science (cf. Edwards *et al*. 2007: 1). I therefore also began to engage with a wider range of anthropological and other social scientific literature.

In retrospect, I am reminded of historian Le Roy Ladurie's suggestion that a divide exists among 'parachutist' historians who interpret a large segment of the world from afar, and 'truffle-hunters' who explore a small locality of that world by digging into its rich, situated history (Elliott 2012: 197). In bringing together a diverse body of literature and topics, my aim in this thesis has been to find middle ground between such approaches and to develop a perspective that allows studying 'up, down and sideways' (Nader 1972, 2013: 317). My modest proposition is that this combination and the study's resulting insights can make a contribution to anthropology's conceptual repertoire. Above all, however, I have attempted to adequately reflect and intellectually enrich the debates around Queensland's CSG developments. I sincerely hope that my research is informative and does justice to those who willingly shared their homes and offices, thoughts, and time with me over the last four years.

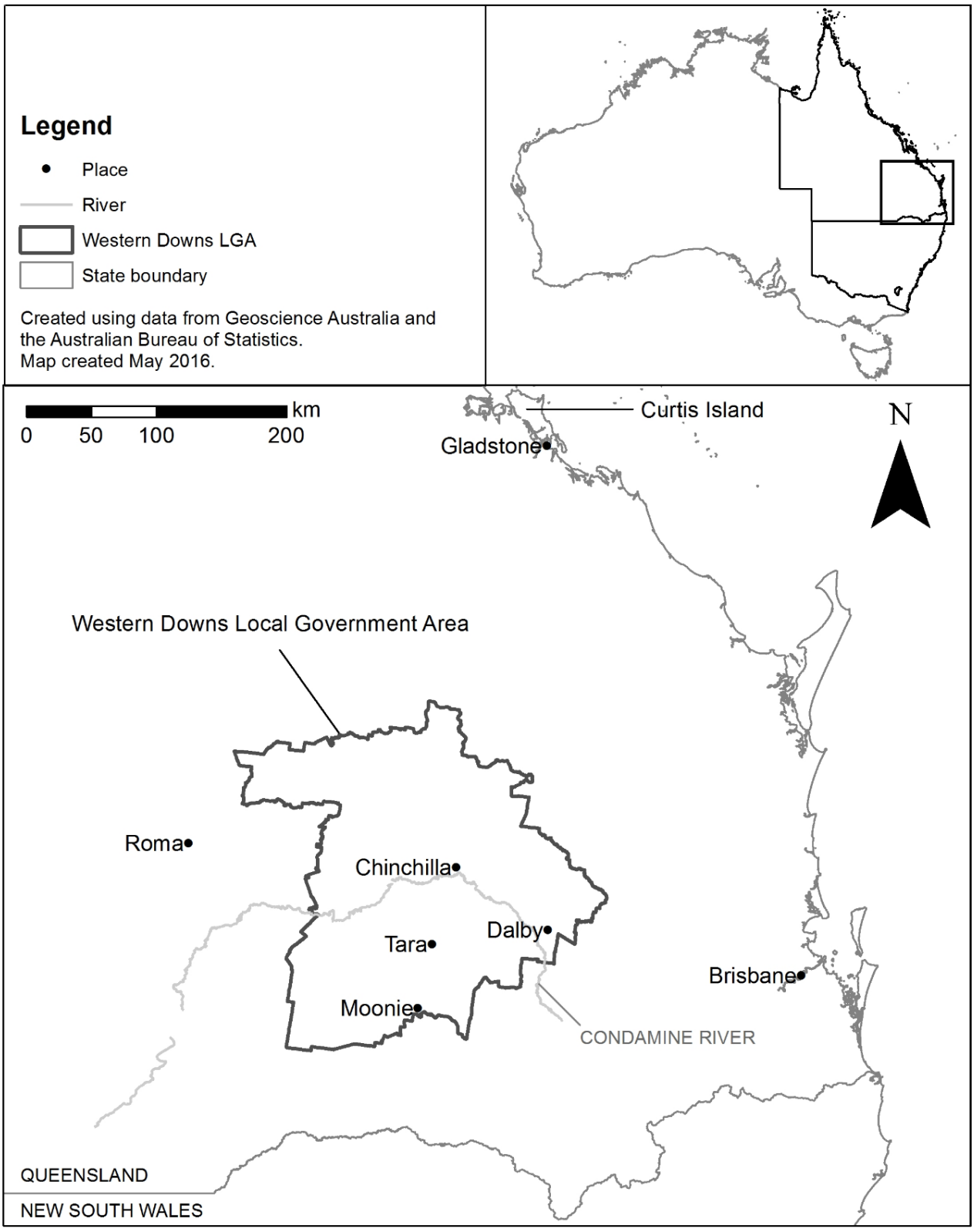
Brisbane, February 2018

1. Introduction

1.1. An Overview of the Western Downs

This study draws primarily on research conducted in the Western Downs that are located in the south-eastern part of the Australian state of Queensland and 200–300km inland from Brisbane, the state's capital (see Map 1). The region is first and foremost a political municipality that was created in 2008 through the amalgamation of six independent shires and local government areas. The council's eastern areas do, however, incorporate the north-western parts of the historically important Darling Downs region (see Chapter 3.1.). In its current form, the municipality covers almost 38,000km^2 (comparable to Switzerland). The Western Downs are home to over 33,000 people, with the majority living in the local town centres of Dalby, Chinchilla, Miles and Tara (AWD 2016). The Western Downs are a predominantly regional to rural area and possess a long pastoral and agricultural history that has been made possible by partly high quality soils and a semi-arid to humid subtropical climate with annual average rainfalls of around 600mm (BOM 2017; RGSQ 2017). Over the last century, natural mineral and hydrocarbon developments have also shaped the environment. The interested reader may refer to Appendix 1 for a photo essay of the region.

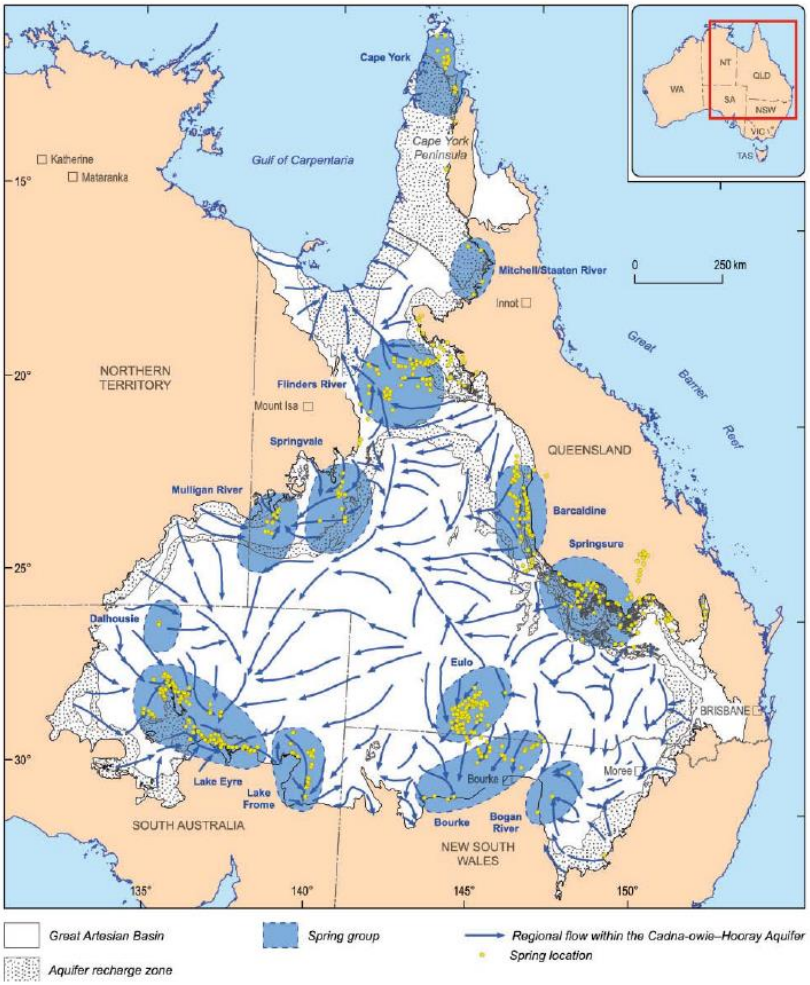
The geographies and land uses of the Western Downs are therefore diverse with the dense, often intensely irrigated, crop farming of the flat eastern floodplains giving way to mixed farming and grazing towards the drier, more profiled western landscape (see Chapter 3). Agriculture is the primary industry in the region, accounting for approximately 47 per cent of all businesses. While the types of dominant crops and livestock changed considerably throughout its history, the region is now largely characterised by grain and other broadacre cropping (especially cotton) and beef cattle and pig rearing. In addition to agricultural commodities, the Western Downs have experienced significant capital investment and rising employment by the mining and resources sector. This has largely been due to a booming coal seam gas industry that in 2014/15 alone contributed approximately $662.8 million in direct expenditure — over 93 per cent of the sector's total spending. The strong agricultural and extractive sectors have contributed to a lower than state average unemployment rate at currently four per cent and a significantly higher than average Gross Regional Product per capita. However, individual and household per capita income is 20 per cent below the State average (WDRC 2016; also UQ's Boomtown Indicators Report). Overall, the Western Downs appears to have benefited from these two sectors and maintains, unlike other rural areas, a strong and somewhat diversified economy.



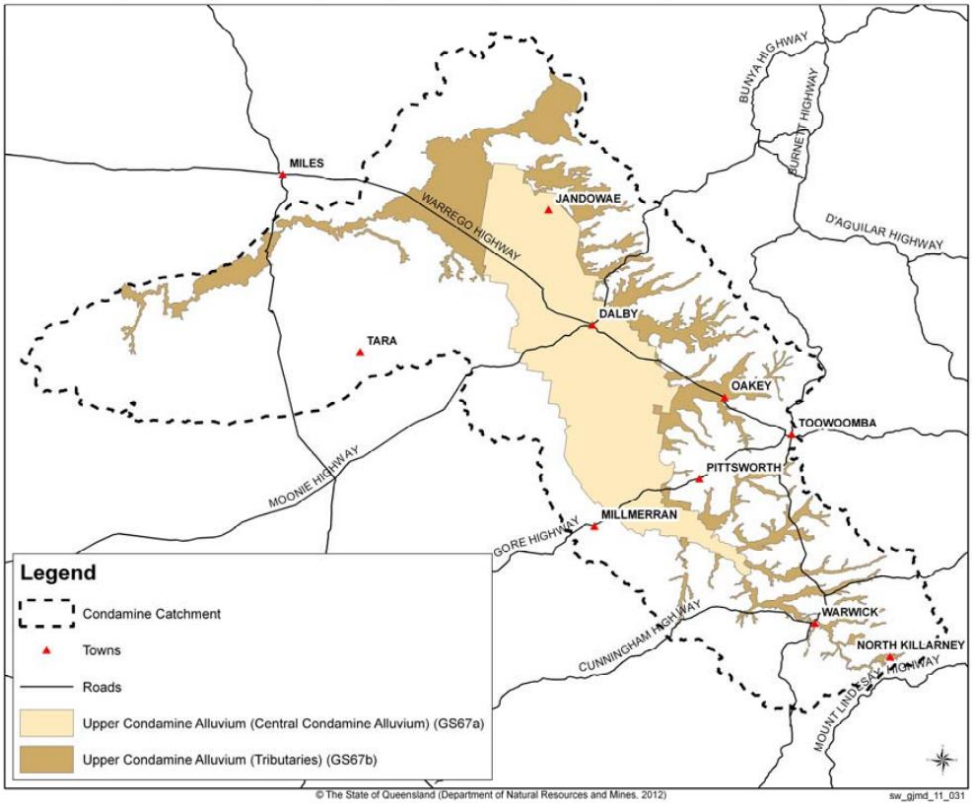
Map 1 The Western Downs Local Government Area (source: de Rijke forthcoming)

The Western Downs' main waterways, the Condamine River and its tributaries, provide domestic and agricultural water supplies. However, their insufficient quantities and regular drought conditions mean that the region's population and industries are also heavily reliant on limited groundwater resources. The history of the Western Downs is hence one of complex entanglements between surface and subterranean resources, as I demonstrate in Chapter 3. Particularly the Great Artesian Basin (GAB), which is one of the world's largest groundwater reservoirs, and the shallower Condamine Alluvium are crucial underground water sources for the region (see Maps 2 & 3). With the intensification of agricultural and industrial land uses and recurring severe droughts over the last century, the competition for groundwater has increased and led to overallocation and depletion. Similarly, soil degradation from land clearing and overuse has affected parts of the region since the 1980s. Complex natural resource and scientific land management regimes have therefore emerged over the last decades to address these issues. As such, large parts of the Western Downs can be seen as a cultivated, intensively farmed and actively managed landscape.

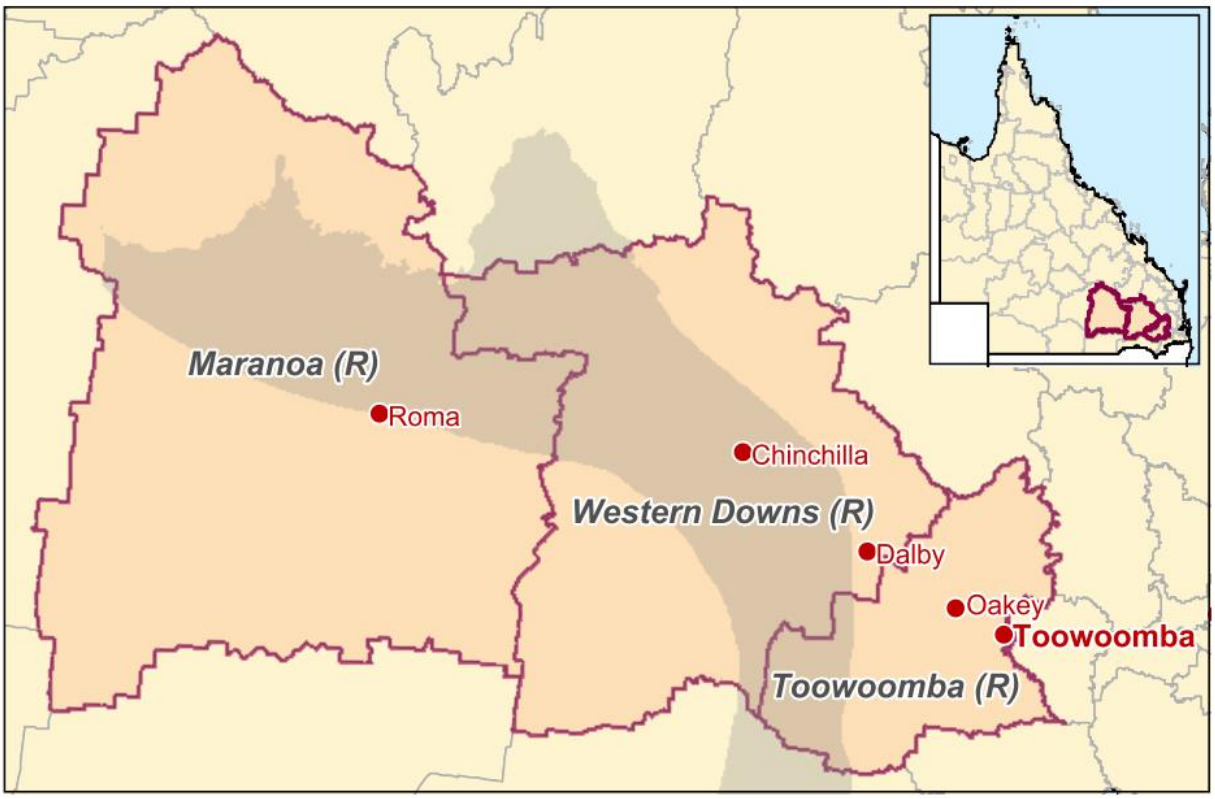
At the same time, the Western Downs are also situated above the coal-rich geological Surat Basin and, to a lesser extent, southernmost tip of the Bowen Basin (see Map 4, which omits the Bowen Basin for clarify). The Surat Basin forms part of the GAB and covers almost 300,000km^2. It underlies the Darling and Western Downs at varying depths, almost surfacing at its eastern outcrops and gradually diving below 1500 meters westwards (Scott 2008: 8). In combination with the diverse patterns of land and groundwater use throughout the Western Downs, these changing conditions create individual hydrological and geological settings for any given location within the region. Adding the Surat Basin as another aspect of the interconnected horizontal and 'vertical territory' (Braun 2000) of the Western Downs is crucial for understanding the particularities of its resource history and the more recent risk controversy that was sparked by the rapid development of unconventional gas reserves throughout the region.



Map 2 The lifeblood of Australia's interior: the Great Artesian Basin (source: Brodie *et al*. 2012: 342)



Map 3 The lifeblood of the Darling and Western Downs: the Condamine Alluvium (source: Qld Govt 2012)



Map 4 The Surat Basin underlying the Western Downs and neighbouring government areas (source: Qld Govt 2015)

1.2. Coal Seam Gas and its Controversy

The Surat Basin is layered with coal seams of various thickness and quality. The primary coal-containing formations are grouped into the Walloon Coal Measures (Scott 2008). Throughout the Western Downs' post-settlement history, these measures have been the target of mineral and hydrocarbon exploration and extraction (see Chapter 3). Whereas for most of the twentieth century the coal itself was the desired resource, the Walloons, like most coal-bearing strata, also hold varying quantities of other solid, liquid and gaseous hydrocarbons. Important for this study is the gas present within the coal.[1] This gas had been known primarily as a nuisance since the beginning of groundwater exploitation, and only recently coal seam gas (CSG) — also coalbed methane — came to be seriously considered as a potentially exploitable energy resource. Since the turn of the millennium, and especially over the last decade, these CSG reserves have been developed by a number of proponents on a large-scale and at a rapid pace across the Surat Basin.

The CSG of the Surat Basin is a natural gas that, although varying by depth, consists on average of approximately 97 per cent methane, minor volumes of carbon dioxide and traces of ethane, hydrogen and nitrogen (Scott 2008: 171 & 196). Unlike conventional gas in pressurised reservoirs that, once accessed through a single or small number of wells, flows relatively freely, CSG is

[1] The gas is technically not located 'within' the coal but held in place across its porous surface and cleats by hydrostatic pressure. I will, however, simplify my language throughout this thesis.

located more homogenously across the Walloons and other coal measures. Since it does not move freely and without stimulation, it is regarded an unconventional gas that requires more intensive extraction techniques. These technologies were previously not available or economically unviable. Over the last two decades, however, they made it possible to extract unconventional gas at a large industrial scale. In the United States, this has led to a domestic 'shale gas revolution' that significantly altered the global energy landscape.

The two major stimulation techniques used in the Surat Basin, and which are the principal focus of risk debates, are the depressurisation and also hydraulic fracturing of coal seams. Depressurisation is the lowering of the hydrostatic pressure that holds the gas in place and is required for every newly drilled well. This is achieved by, as one hydrogeologist noted, 'taking off the head'; that is, by pumping out substantial quantities of groundwater. This procedure reduces the water pressure around the immediate well site, which allows the CSG to follow the groundwater to the surface. Once at the surface, the produced water and gas are separated and individually processed (see Figure 1 & Image 1).

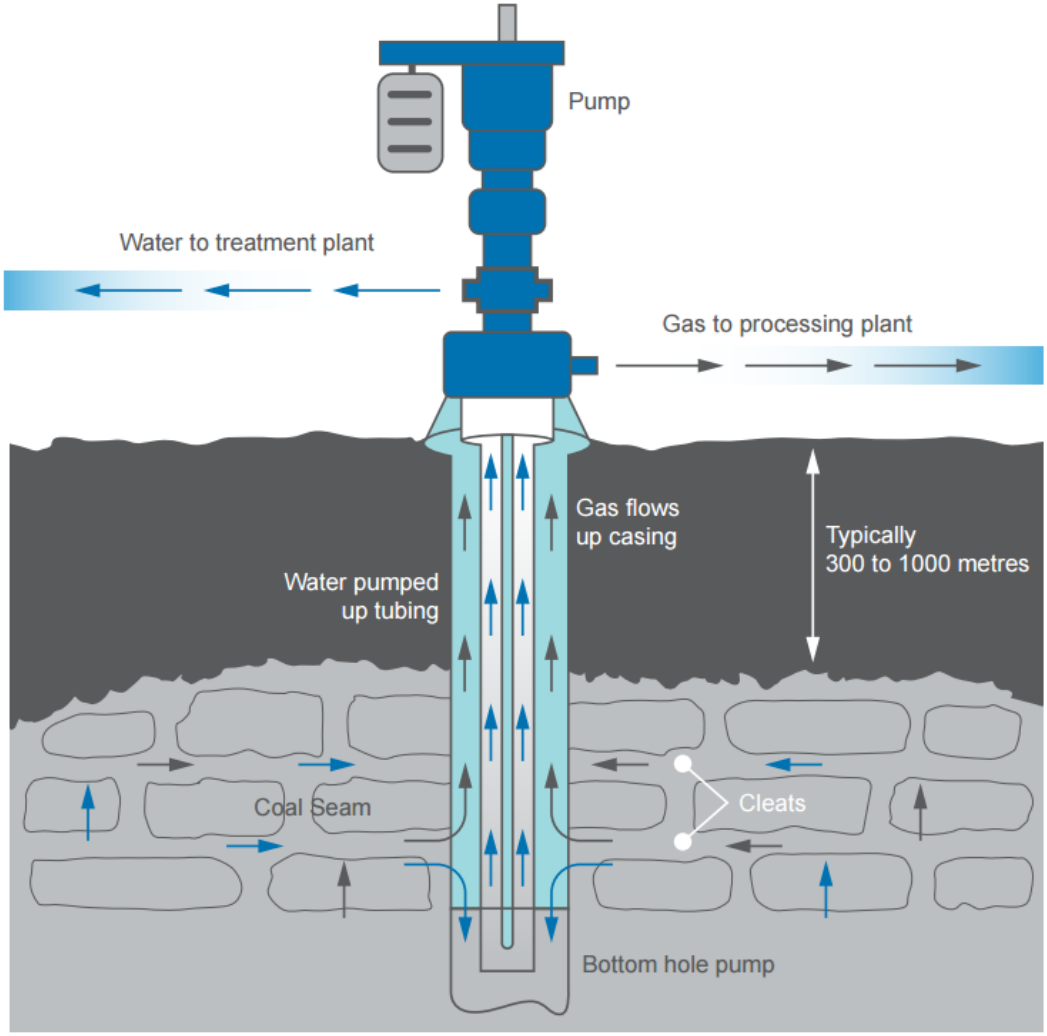


Figure 1 Schematic of a CSG well (source: OCE 2015: 10)

Image 1 A CSG well in a state forest west of Dalby (source: author 2015)

Classified as a waste product, this produced water has become the focus of debate for two primary reasons. First, many aquifers in the Western Downs are already overused. A principle concern has thus been further drawdown and reduced availability of groundwater in the Walloons themselves and also in, possibly interconnected, over- and underlying formations. All of these formations are already intensively exploited aquifers. Second, the groundwater of the Walloons is of brackish quality and may contain varying levels of heavy metals and other potentially harmful substances. Produced water is therefore desalinated in reverse osmosis plants and either supplied to irrigation farmers or released into local waterways. However, a highly saline residue remains, which is, at the time of writing, collected in large storage dams and options for its eventual disposal are still being discussed. Concerns have been raised about the residue's contamination risks and also the question of whether reverse osmosis can actually remove all heavy metals and harmful substances.

The second crucial stimulation technique and focus of risk debates is the use of hydraulic fracturing.[2] While the subject of varying definitions and interpretations, hydraulic fracturing "is a

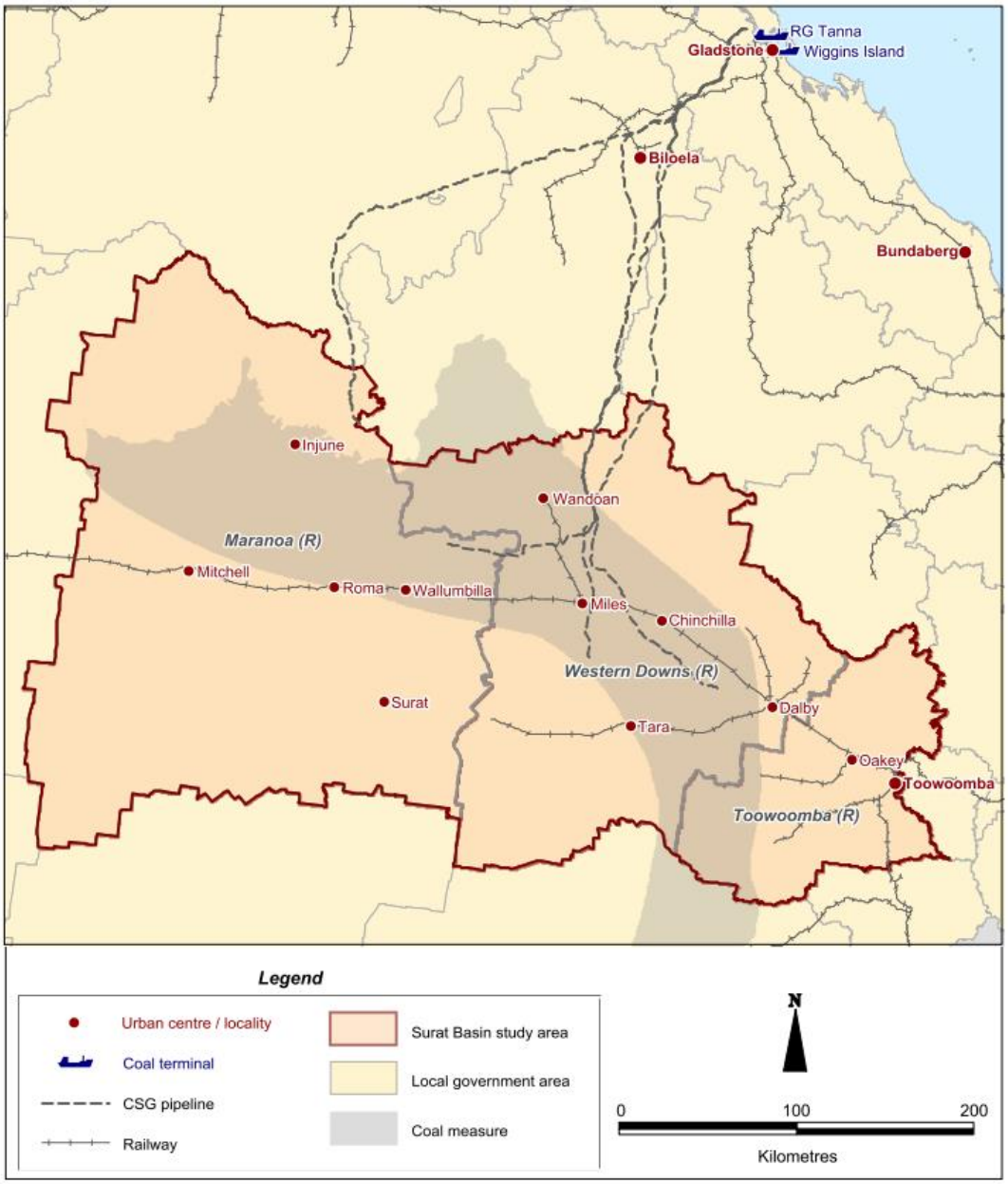
[2] Under the well-known alias of 'fracking', these technologies have become somewhat synonymous with unconventional hydrocarbon extraction in North America, Europe and Australia. However, extraction techniques between different forms of unconventional gas do vary and hydraulic fracturing is not always required (Cook *et al.* 2013: 43). Generally, about 70 per cent of the Australian public are opposed to 'fracking' (Lamberts 2017a). Nonetheless, 'fracking' is attributed with a wide range of meanings

generic term that is used to describe the process where fractures are created or enlarged in underground rock strata through the application of fluid under pressure … to 'stimulate' the production of a petroleum well by increasing the porosity and the permeability of the target formation" (Hunter: 2014: 66). For this purpose, various compositions of water, sand and a high number of different chemicals are used. The applications and (potential) environmental impacts of hydraulic fracturing thus vary significant throughout history and across given contexts. However, "one aspect remains universal: the risk of pollution from the fluids that are placed down the well and return to the surface" (*ibid.*: 67).[3] As of July 2014, approximately eight per cent of Queensland's CSG wells had been hydraulically fractured. This proportion may increase to 10–40 per cent though, as the industry extends into areas with less favourable geologies and as production rates in existing wells decline (Towler *et al.* 2016: 257; OCE 2015: 43).

These stimulation techniques have enabled resource companies to exploit the CSG reserves of the Western Downs since 2006. However, unlike North American shale gas developments, Queensland's projects are primarily oriented towards international export. CSG from the Western Downs is therefore pumped over some 500km to the coastal town of Gladstone where it is converted into liquefied natural gas (LNG) (see Map 5). This CSG-to-LNG technology has been described as "a bold undertaking, with Australian projects largely pioneering the process" (Reid & Cann 2016: 6). Following capital investments exceeding AUD 80 billion, the establishment of these large LNG export capabilities required the rapid and large scale development of CSG reserves across the Surat Basin. This led to "an 'arms race' of sorts in assuring access to scarce resources, with wage rates soaring to astronomical levels" (*ibid.*: 10; see Chapter 6.1.). Consequently, the Western Downs experienced an unprecedented resource boom with the construction of new infrastructure and well drilling peaking between 2013 and 2014 (WDRC 2016; UQ's Boomtown Indicators Report). Currently around 9,000 production and exploration wells have been drilled, but their ultimate number is likely to reach 18,000 or more over the next decades (GasFields Commission Queensland 2017; OGIA 2016).

and connotations that require careful analysis (Evensen *et al.* 2014; cf. Stoutenborough *et al.* 2016a, 2016b; Evensen 2016). To avoid confusion and to not obfuscate my own analysis, I will, where possible, refer to CSG extraction.

[3] Where necessary, I will elaborate on the specifics of hydraulic fracturing. It may suffice here to point out more detailed sources (Hunter 2014; King 2012).



Map 5 Complex resource networks: CSG-to-LNG pipeline system (source: Qld Govt 2016a)

The CSG industry's rapid growth has led to profound changes of the hitherto predominantly agricultural Western Downs. Within but a few years appeared an entirely new land use that, unlike most current mining projects, exists not besides but within and atop existing farming and grazing operations. The emergence of these 'agri-gas fields' (de Rijke 2013a) has multiplied and intensified land uses (see Figures 2 & 3). CSG developments also rearranged the social spaces and altered the regional identity of the Western Downs. Everingham *et al.* (2015: 43 & 60) note:

> After more than a century of agricultural hegemony, the advent of the mining and resource sector opens new forms of competition over resources such as land, ecological services, infrastructure and labour, and also over the use of public spaces where much of this competition is played out. … After more than a century of experiencing drought, flood and natural disasters as key livelihood threats, local citizens and organizations on the Darling Downs that once shared an identity based on agriculture were forced to adjust to changes to

international trade regimes … . Now they face greater disruption evident in a differently configured physical and social spaces.

CSG developments have thus play a part in transforming the narrative of the Western Downs' iconic pastoral and agricultural roots. As a result, the region is now also promoted under the trademarked label of 'Energy Capital of Queensland' (see Chapter 3.2.2.). The interested reader may refer to Appendix 2 for a photo essay of CSG and its controversy in the Western Downs.

Figure 2 Multiple land uses near Dalby (west to east): CSG infrastructure in State Forest near a cattle feedlot, an open-cut coalmine, and partly irrigated farmland (source: author via Google Earth June 2015)

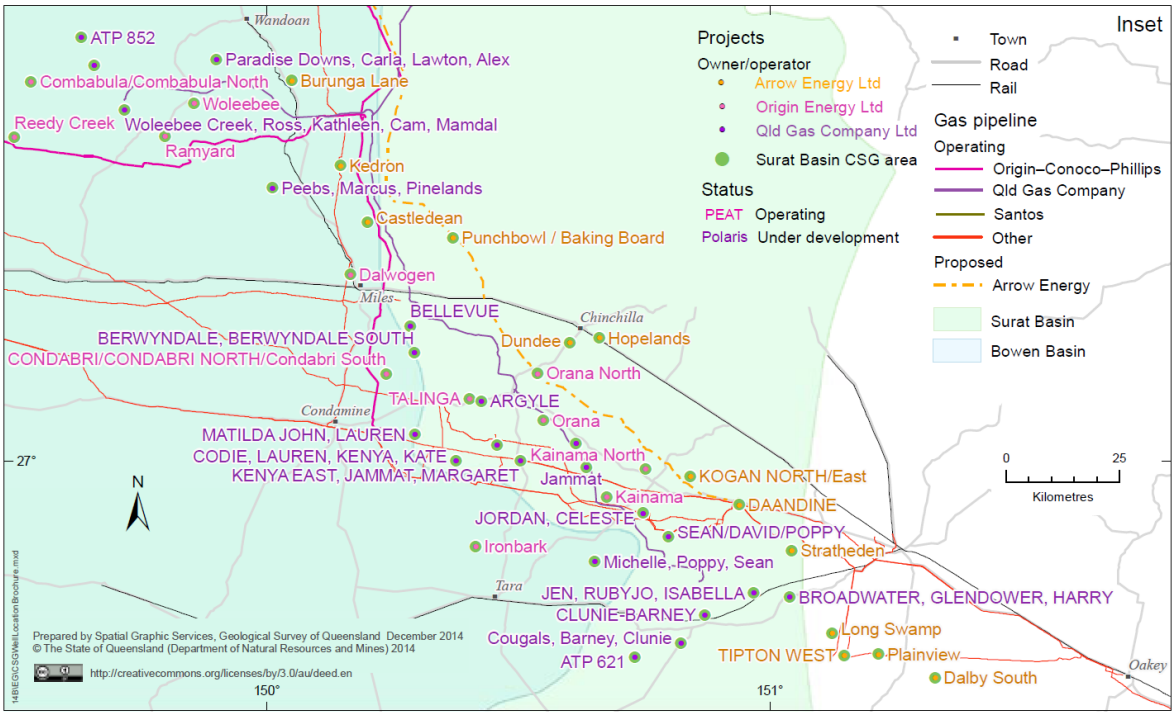


Figure 3 Complex resource environments: CSG proponents and projects throughout the Western Downs in late 2014 (source: Qld Govt 2016b)

The region's CSG developments and transformation are not occurring without complex social disputes over the industry's impacts and risks. These cover a vast array of social, legal, economic, environmental and health-related issues (AgForce 2017; de Rijke 2013a: 46–48; GasFields Commission Queensland 2017; Price 2017a). I will not attempt to comprehensively address this complex 'multidimensionality of public concerns' (Stilgoe 2007) for two reasons. First, substantial social science research on CSG's (cumulative) impacts and concerns in the Western Downs already exists.[4] I would largely restate these findings without adding to them. Second, with such a wide range of interconnected impacts, each individual research project can cover but certain aspects of CSG developments. Following these considerations, my proposed contribution in this thesis is therefore focused on one particular aspect of these wider debates: the evolving controversy over potentially unknown environmental risks and the role of scientific knowledge and uncertainty.

This attention follows debates among a variety of actors regarding insufficient knowledge of CSG projects' impacts. Concerns have been expressed especially about potentially unknown and unforeseeable impacts to groundwater resulting from the industry's rapid growth. University of Sydney-based agricultural economist Randall (2012: 156 & 157), for instance, contends that the "unknowns … are overwhelming" and that the risks to groundwater are "far beyond anything yet experienced" (also Mudd 2012; Pells 2014). As a result, "[u]ncertainties and unknown unknowns are of such magnitude that they tend to dominate the policy discourse" (Randall 2015: 132). Likewise, a principal policy officer in the Queensland Department of Mines and Energy noted in a 2006 issue paper that "the evidence has grown that this industry is being developed faster than capabilities of the authorities to moderate the potential downsides" (Edwards 2006: 53). Similar concerns have also been raised about broader environmental and human health impacts. Werner *et al.* (2015; 2016), for example, emphasise the inconclusiveness of current evidence for a link between unconventional gas extraction and health impacts, but also of conclusive proof to rule out those links. They therefore see "a clear gap in the scientific literature that requires urgent attention" (Werner *et al.* 2015*:* 1127; also Claudio *et al.* 2017; Krupnick & Echarte 2017; McCarron & King 2014). Among landholders and residents in areas of CSG developments, this has led to various levels of uncertainty. As a female grazier notes on a rural community website, "[t]he problem is not the known impacts, but rather the unforeseen impacts that will occur. It will be hard to address the issue of compensation for such unknown effects" (Price 2017b). Concerns over insufficient knowledge are thus expressed by a number of actors.

[4] See Claudio *et al.* 2017; de Rijke 2013a, 2013b, 2013c; Everingham *et al.* 2013, 2014, 2015; Leonard *et al.* 2016; Lloyd *et al.* 2013; Mactaggart *et al.* 2017; Makki 2015; Mercer *et al.* 2014; Phelan *et al.* 2017; Rifkin *et al.* 2014; Walton *et al.* 2013, 2014, 2015, 2016; Werner *et al.* 2015, 2016; Williams & Walton 2014. For CSG in other Australian contexts and more generally, see Askland *et al.* 2016; Colvin *et al.* 2015; Lloyd *et al.* 2013; Luke *et al.* 2013; Morgan 2016; Morgan *et al.* 2016; Norman 2016; OCE 2015; Sherval & Hardiman 2014.

On the other hand, however, claims and research are presented by some proponents, government agencies and academics that suggests that impacts are sufficiently understood and that the industry is manageable and safe. The Australian Academy of Technology and Engineering, for example, urged the governments of the Australian states of Victoria and the Northern Territory to reconsider existing CSG bans and moratoria and "take a science-based approach to regulation of this industry" (Gas Today 2016). This argument was also advanced by the then chief executive of the Queensland Resource Council at an opening speech in November 2015 when he dismissed the "scaremongering tactics from politically and fundraiser motivated activists … [who] need to listen to the country's leading scientists and not the increasingly hysterical chatter on social media that tries to pass itself off as informed debate" (Queensland Gas Conference, 24th November 2015). Less controversially, the Australian Government's Department of Industry, Innovation and Science released a review paper of the socioeconomic impacts of CSG and concluded that the "evidence to date shows that there have only been negligible impacts on water and air quality" (OCE 2015: 1). Despite some actors' concerns, these accounts suggest that impacts from CSG developments are sufficiently understood.

In this context of conflicting knowledge claims, discussions frequently require involved actors to make sense of a plethora of novel information and to negotiate (scientific) uncertainties about potential risks (Everingham *et al.* 2014: 125–126). These uncertainties and perceived unknowns have sparked a variety of reactions. While some local actors have come to some form of arrangement with the new industry, others deciding to leave the Western Downs due to risk concerns (see Chapter 6.2.–3.). For local landholders and involved 'outsiders', negotiating conflicting claims and (scientific) uncertainties is thus an important aspect of debates over CSG developments. This can prompt different responses. With increasing amounts of data, information and research generated over the last decade, some actors' attitudes have also changed significantly over time, but uncertainties remain in many instances.

These uncertainties are also central to the 'adaptive management' regulatory regime applied to Queensland's CSG developments. As a 'learning by doing' method, this framework consists of the "imposition of layered duties for the operator (reporting and monitoring), alongside obligations to compensate landholders, and 'make good' any harm caused" (Hunter 2015: 9). Such an approach has been adopted in response to the uncertainty surrounding CSG activities. It thus constitutes "very much reactive type regulation, which responds to regulatory issues rather than anticipating and legislating for problems prior to the activity taking place" (*ibid.*). Swayne (2012: 184) therefore notes that "only time will tell whether the current adaptive approach will be able to protect the Queensland environment from what the Queensland Government acknowledges are the 'unknown

and unintended impacts' of CSG production". Uncertainties therefore do remain not just on a local level but also with the regulation and management of CSG projects.

The threat of unintended consequences and unknown impacts has sparked a controversy over CSG developments which features debates about current levels of knowledge, acceptable uncertainties and tolerable environmental risks. At the same time, some social scientists have argued that the Australian public's trust in CSG-specific (scientific) knowledge claims and governing structures has been diminishing (Lloyd *et al.* 2013; also Taylor 2010: 384–385; cf. Lamberts 2017a). Many citizens demanded that the industry's impacts must be better understood before further developments commence (*ibid.*), while others embrace associated financial and economic prospects. This poses challenges to governments, regulating state agencies and CSG companies that have to justify their policies and actions. In such instances, Yearley (2005: 138) notes, "official agencies are commonly left with no alternative but to demand 'more and better' science; yet there are few grounds for thinking that further steps down the same path will resolve the problems". However, what may constitute 'more and better' science in the CSG context has so far only been peripherally addressed from anthropological perspectives. In this thesis, I therefore critically analysis these epistemic facets of the CSG controversy, which are intrinsically related, but are not limited, to scientific knowledge.

1.3. Research Question: Problems of Knowing

The rationale of this thesis is that CSG developments have created a 'need to know' CSG and its impacts for a large number of actors. This starting point becomes apparent if one considers how onshore CSG projects partially dissolve the clearly confined boundary between the 'inside and outside' of sites of conventional resources extraction. As such, these projects illustrate the growing scopes and altering qualities of many contemporary resource developments, which progressively extend resource extraction into the centres of public life (Measham *et al.* 2013). Put differently, certain aspects of such resource and energy developments cannot easily be "offshored" and excluded from public sight (Urry 2014: 96–117). In the context of CSG developments, this means that a large number of local landholders and residents have to make sense of changing environments and negotiate the industry's potential impacts. The resulting need to know can frequently not be resolved directly through sensory experience or existing knowledge alone. Rather, knowing CSG requires scientific knowledge claims (see Chapter 4).

Following this indispensability of scientific knowledge, I demonstrate in the fifth and sixth chapter that scientific research is not always able to provide the answers some local and non-local actors seek. Instead, scientific knowledge claims can be conflicting, which means that unknowns

can become the focus and locus of debates. Hence, science itself becomes an unforeseen site of contestation (Barry 2001: 197–215; see Chapter 7). Since science is an integral part of knowing CSG, this can create uncertainties to varying degrees among a variety of actors, especially those immediately affected by CSG developments. It is here that 'problems of knowing' emerge. As Stilgoe (2007: 48) points out, "[a]ny novel technology will open up new doubts and ask new questions of the adequacy of scientific understanding. In any technological risk issue, discussions of uncertainty (or ignorance) are just as important in the representation of scientific reality as discussions of knowledge". My guiding research question is consequently an enquiry into the problems of knowing resulting from CSG developments.

To be sure, "the problem of 'knowledge' has always been at the center of anthropological attention" (Boyer 2005: 142). The anthropology of knowledge is thus "not a subfield but merely a reminder of what anthropology is centrally concerned with" (Crick 1982: 287; also Boyer 2005: 147). However, I employ the concept of problems of knowing in a more specific sense and intend to emphasise the abovementioned problematic nature of knowing CSG and its risks. In this sense, historian Burke argues that members of highly industrialised, contemporary societies might be "information giants drowning in information" while becoming "knowledge dwarfs" (Burke 2012: 5). My particular interest is therefore an ethnographic examination of *exactly how* "[l]iving in world risk society means living with ineradicable non-knowing *(Nichtwissen)* or, to be more precise, with the simultaneity of threats and non-knowing and the resulting political, social and moral paradoxes and dilemmas … [that] cannot be overcome by more and better knowledge, more and better science" (Beck 2009: 115; cf. Auyero & Swistun 2008; Dwyer & Minnegal 2006). I proposed that addressing this questions eclectically can expand the disciplinary repertoire of anthropology and contribute to a better understanding of the CSG controversy.

For this purpose, I investigated the CSG developments within the Western Downs region by sampling a cross-section of the population together with case-relevant interlocutors in the urban centres of Toowoomba and Brisbane. My aim was to gain insights into the different ways participants within the controversy came to know the new CSG technology, its accompanying environmental risks and negotiated potential unknowns. This task was guided by the following research questions:

- i) what and how do participants know about CSG and how are associated risks related to other resources known (especially the interplay of gas and water);
- ii) what are the social dynamics of this knowledge, e.g. do clashes of competing knowledge claims exists;
- iii) how are knowledge and unknowns communicated and acted upon, especially under conditions of uncertainty;
- iv) and what could be potential implications for decision-making processes?

In following these guiding research questions throughout fieldwork and interviews, I particularly attended to the role and status of scientific knowledge claims. This is due to the indispensability of scientific representations for knowing CSG, the general intimacy between the language of risk and science (Yearley 2005: 129), and the commonly special role of science within contemporary debates associated with complex environmental problems (Bocking 2004; Checker 2007). However, I certainly did not exclude other ways of knowing in my analysis (see Chapter 4).

1.4. Anthropology and Coal Seam Gas

Large CSG-to-LNG projects have so far only progressed in the Australian state of Queensland and distinctly anthropological engagements with these developments remain limited (e.g., de Rijke 2013a, 2013b, 2013c; Espig & de Rijke 2016a, 2016b; Mercer *et al.* 2014; Trigger *et al.* 2014). However, I have mentioned examples of the growing number of social scientific literature addressing CSG developments above. Despite the considerable amounts of CSG-related research and literature that emerged over the last decade, I agree with Willow and Wylie (2014: 223) who in the North American shale gas context observe that "[w]hile actual and potential environmental degradation resulting from fracking has received a significant amount of scholarly attention, … sociocultural consequences have been comparatively overlooked". This holds especially true for anthropological accounts. Consequently, much of the anthropological literature that informed my research is drawn from related anthropological research on, for example, shale gas developments in the North American context (Cartwright 2013; Hudgins 2013; Hudgins & Poole 2014; Paladino & Simonelli 2013; Simonelli 2014; Willow 2014, 2015; Willow & Wylie 2014) and energy and resource developments generally (Boyer 2011, 2014; Clarke 2015; Richardson & Weszkalnys 2014; Rogers 2011, 2015; Smith & High 2017; Strauss *et al.* 2013; Szeman 2017; Szeman & Boyer 2017; Weszkalnys 2014, 2016).

While informative and guiding, this literature remains specific to their given contexts, including anthropological engagements with North American shale gas developments. I have already noted that, although also an unconventional gas, Queensland's CSG projects constitute socio-political, technical and geologically distinct resource developments. Research on shale gas developments is thus useful but there remains a lack of anthropological engagements with CSG's specific social and cultural dimensions. Throughout this thesis, I will therefore relate the existing anthropological literature on unconventional resource developments and other relevant social scientific research to the idiosyncrasies of CSG developments. Combining insights from a variety of disciplines and conceptual approaches will, I hope, enrich the anthropological repertoire for the critical examination

of CSG and unconventional resource developments more generally. I propose that this approach can also reveal dimensions of the CSG controversy that have so far only been addressed peripherally. These findings can be useful for a variety of actors who are involved in these debates. I will therefore draw out implications arising from my research in the conclusion.

1.5. Methodological Framework

The outlined research questions and thematic focus may suggest certain theoretical and methodological inclinations or — to follow Sardan's (2015: 7) spin on Weberian terminology — selective affinities. My research is therefore surely situated within a qualitative framework (cf. Abbott 2001: 28). However, this does not automatically imply tacit positioning within any baseline ontological or epistemological binary typologies and their associated methodologies (*ibid.*; Bernard 2006: 1–27). In fact, some social researchers have mentioned the problematic nature of such dichotomous distinctions and conceptual bifurcations (Abbott 2011; Blok 2010: 24–28). While delving into these debates is beyond the present scope, it is nonetheless important to acknowledge my point of departure and foreshadow the conceptual clarifications in Chapter Two. As Rabinow (Rabinow & Stavrianakis 2016: 404) notes, "the question and posture of the anthropologist is not a basic presumption … [but] rather a problem that requires conceptualization" (also Harris 2007b: 8–12). Clarifying my views and assumptions thus allows the reader to assess the practices through which I generated the empirical materials and analysis developed throughout this thesis.

My thinking around the outlined research questions was informed by postconstructivist and also critical realist approaches (Asdal 2003; Wehling 2006a, 2006b; Willig 1999). By focusing on situated material and discursive practices, postconstructivist scholars move beyond the unproductive dichotomy between the 'philosophical undead' concepts of realism and social constructionism (Rouse 2002; Wehling 2006b). Following these perspectives, I am interested in culturally, historically and materially 'situated experiences' — as opposed to 'experienced situations' (Burke 1994: 37) — wherein "meanings are afforded by discourses, accommodated by social structures and changed by human actors" (Wittig 1999: 44). In this sense, practices and (inter)action are the crucial mediators between material constraints and subjectivity (*ibid.*: 40, also Bourdieu 1990). I outline my understandings further in Chapter Two, but the reader may refer to these considerations throughout the thesis as the justification for my empirical and analytical approach.

1.5.1. An Ethnography at Home

I opted for an ethnographic approach that is best suited to engage with the situated experience of the CSG controversy. However, providing a coherent interpretation of what may constitute an ethnographic study is challenging. While single definitions are limited at best (O'Reilly 2012: 1–27), Willis and Trondman (2000: 5) provide a helpful starting point by understanding ethnography as "a family of methods involving direct and sustained social contact with agents, and of richly writing up the encounter, respecting, recording, representing at least partly in its own terms, the irreducibility of human experience" (cf. Ingold 2014c). I concur with this conceptualisation as it highlights why and how ethnographic approaches are well-suited to capture the complexities of human interaction. That is, ethnographers not just observe, but reflexively and empathetically engage with people's life-worlds (Ingold 2008: 82). Ethnographic methods thereby allow to address the multiple layers of the outlined research questions and aims. Having hinted at the potential range of possible methods employed under this umbrella term, it is important to clarify my chosen methods.

Taking the geographic and cultural proximity to the studied region and controversy, I understanding this project as an ethnography done 'at home' (Alvesson 2009; Trigger 1997).[5] My research thus constitutes, to some degree, a modernist ethnographic approach that goes beyond traditional realist conceptions. Some anthropologists have argued that traditional ethnographers often literally map notions of community and culture onto specific spatial localities, historical metanarratives and structural patterns as a point of reference (Marcus 1992: 315–319). Instead, my research follows ethnographic approaches that do "not build upon the idea of little worlds in and of themselves - of community or an autonomous and spatially discrete locus of social activity - … [but] cross-cut time frames and spatial zones" (*ibid.*: 321 & 325–326). For this purpose, I conducted multi-sited, focused, and short-term ethnographic research.

Firstly, multi-sited ethnography is Marcus's response to the challenges of the transboundary nature of the multilocalities he observes in modern cultures (cf. Chapters 1.3. & 4.1.). Such a "mobile ethnography takes unexpected trajectories in tracing a cultural formation across and within multiple sites of activity … to examine the circulation of cultural meanings, objects, and identities in diffuse time-space" (Marcus 1995: 96). Conducting multi-sited research is, however, not merely based on changing intellectual preferences among ethnographers, but an empirically-dictated response to ongoing global transformations and increasing interconnectedness of what may be (misleadingly) dichotomised as the local and global (*ibid.*: 97; Nader 2011: 217). I therefore

[5] I am using this notion somewhat loosely considering my own German background and the Western Downs' distance to Brisbane. However, I have lived in Australia and the UK for over a decade and have been researching the CSG controversy since 2011.

'followed' the CSG controversy by resorting to a multi-sited ethnographic framework, which (Marcus 1995: 105):

> is designed around chains, paths, threads, conjunctions, or juxtapositions of locations in which the ethnographer establishes some form of literal, physical presence, with an explicit, posited logic of association or connection among sites that in fact defines the argument of the ethnography.

Such an approach is, however, largely unsuited for the intent and single-sited, time-extensive characteristics of 'conventional' (Pink & Morgan 2013) or 'realist' (Marcus 1992) ethnographies.

I therefore, secondly, draw on the notion of 'sociological ethnographies' — those conducted within one's own society. Knoblauch (2001, 2005a) proposes a complementary methodology that he terms focused ethnography. Knoblauch argues for a form of ethnography that, instead of extended, open-ended immersion into any one setting, utilises short-term, data-intensive enquiries that are purposely focused on particular elements or specific thematic issues. To do so, it is crucial that the ethnographer is not 'naïve' but possesses background knowledge of the field before she commences research (*ibid.*). In light of the increasingly interconnected, pluralistic life worlds of those involved in contemporary risk debates within highly industrialised societies, I regard Knoblauch's approach not as a superficial "quick and dirty" alternative (Hughes *et al.* 1994: 10; Knoblauch 2005a: 16) but as well-suited for addressing the CSG risk controversy.

Focusing on particular elements that emerge across such multi-local settings does require not just existing knowledge of the studied field, but also a prior and ongoing dialogue between empirical practice and theoretical considerations.[6] I therefore, thirdly, draw on what Pink and Morgan (2013) coined short-term theoretically informed ethnographic methodologies that can create these dialogues. They outline an unbounded ethnographic place that can transcend immediate localities and is characterised by periods of intensive data collection with a focus on detail. Within these enquiries "the focus is sharper, the research questions need to be responded to more firmly and data collection and analysis intertwined" (*ibid.*: 357). With this ethnographic approach in mind, I employed a range of methods during fieldwork.

1.5.2. Methods and Data Collection

To generate relevant data, I adopted widely used ethnographic methods (Bernard 2006; O'Reilly 2012; cf. Ingold 2014c). Between late 2014 and mid-2016, I conducted fieldwork that consisted of open to semi-structured reflective interviews (Hammersley & Atkinson 1995: 152), participant observation, informal conversations and document analysis. Formal interviewing occurred primarily

[6] Cf. Ingold's (2008, 2011: 229–243, 2014c, 2016) discussion of the different objectives of anthropology and ethnography, which are, in my view, complimentary rather than distinct endeavours. Relevant is also Nader's (2011) 'ethnography *as* theory' or, conversely, Biehl (2014) on 'ethnography in the way of theory'.

in February to July 2015 and I limited their number to approximately 40 one to five hour interviews to keep data analysis manageable. Additionally, I participated in over 20 relevant community events, landholder meetings, industry facility tours, senate hearings and protest gatherings. I further attended a variety of academic and government-organised informal and formal workshops and meetings. This participant observation was conducted between October 2013 and October 2016. The CSG controversy also prompted the generation of a vast amount of scientific reports, government papers, industry documents, academic briefs and senate bill submissions, transcripts and reports. In addition to archival research, I therefore also analysed and, where possible and helpful, include excerpts from these documents.

Considering the multilocal and transboundary nature of the CSG controversy, much social interaction and communication also occurs online through social media. Makki (2015: 151–156) argues that this virtual communication has created "digital coalitions" and forms of "cyberactivism" across the Western Downs and Australia. The transformative role of the internet in contemporary societies can hardly be exaggerated (Weinberger 2011), and I particularly noted the importance of CSG-specific social media groups, email lists, and online video sharing platforms. I therefore also gathered and perused some of these important secondary data sources. However, attending to the "electronic fabric of the struggle" (Makki 2015: 150) requires a detailed analysis in its own right. To keep data analysis feasible and due to the ambiguous ethical status of presenting this data, I largely omit these secondary data sources. Finally, I have systematically collected media, government and industry news articles since 2013 via online notification tools. These secondary data sources were only supplementary and primarily collected to keep me informed and able to contextualise the ongoing debate.

1.5.3. Field Sites, Research Participants and Data Analysis

I already noted that the Western Downs is a local government area that is comprised of geographically and socially diverse regions. Furthermore, CSG developments have connected the localities of extraction to nearby urban centres and global energy markets. As a result, the CSG controversy includes a large number and variety of actors in a multitude of sites. In addition to my multi-sited ethnographic approach, I therefore opted to study 'up, down, and sideways' (Nader 1972, 2013; Stryker & Gonzalez 2014).[7] My intent was to capture the complexity of CSG developments by gathering data from a cross-section of the diverse range of actors and from

[7] Barry (2006: 244) argues for a similar approach: "anthropology of technological zones [the social spaces within which science and technologies emerge] is likely to be multi-sited, tracing the relations and flows of knowledge between government bureaucracies and activists, and between multi-national companies, consultants and local populations. Such an analysis should certainly be critical, but criticism is unlikely to be served by reiterating the positions taken by those involved in the controversies … . Rather, a critical analysis of technological zones starts from the recognition that the formation of such spaces may lead to the formulation of new alignments and divisions and new relations between scientific and technical expertise and political action and, as a result, may demand new ways of thinking about politics".

purposefully chosen sites and events (cf. Delamont 2004: 223). Geographically, my focus has been on the Western Downs and the urban centres of Toowoomba and Brisbane. I consciously approached potential interlocutors and attended events throughout the Downs (see Map 1). The agricultural Western Downs is the host region for the majority of CSG gas fields in Queensland. Most of the government departments in charge of assessing and regulating the industry are located in Toowoomba and Brisbane, which similarly applies to the university-based natural scientists researching the industry.

This strategy was similarly applied for reflecting the social diversity throughout the region. However, capturing these social dimensions is difficult and, as outlined above, prior background knowledge and ongoing reflexive adjustments were crucial during fieldwork. I developed actor categories that helped to 'map the field' socially by drawing on existing personal experience and feedback from other researchers in the CSG arena. While these categories are of course artificial, not mutually exclusive and often overlapping, they allowed me to systematically approach potential interlocutors and to cover a balanced range of different actors, perspectives and opinions.[8] Interlocutors therefore included *inter alia* local landholders with and without CSG infrastructure, town residents, government officials, anti-CSG activists, CSG-specific or related interest group representatives, natural scientists, and gas industry professionals. I focused primarily on 'settler-descendant' interlocutors (Trigger 2003). This was a conscious decision out of respect for the complexities of indigenous perspectives and responses to CSG, which warrant an examination in their own right (see, e.g. de Rijke *et al*. 2016; Norman 2016; Trigger *et al*. 2014). The sampling process was largely reliant on purposive and snowball sampling (Gobo 2004).

The Western Downs have been the focus of much ongoing social and natural scientific academic research, industry testing and consultation, as well as government and interest group engagements in relation to CSG developments. As a result, I encountered residents who were unwilling to participate in my study, were unable to clear time for an interview, or were emotionally too stressed for further engagement. Some researchers and government bodies even argued that "a very real risk of research fatigue" exists in the Downs (OCE 2015: 7). In addition to data from direct interactions with interlocutors, I therefore also analysed publicly available content of, for example, recorded interviews, existing publications or Australian Senate hearing testimonies in order to reduce further disturbance from research. Where personally interviewed, interlocutors' background information was recorded to aid my analysis. I provide interlocutors' basic details but keep them general due to concerns related to internal confidentiality (Tolich 2004; see Chapter 1.7.).

[8] For a critical discussion of essentialist and homogenising notions such as 'local' or 'insider' as opposed to 'outsiders', and the 'myth of community' see de Rijke (2012: 12–19).

The data I gathered as hand-written notes and observations was subsequently copied as electronic versions and interviews were transcribed. Some secondary data was readily available in electronic textual form, whereas other sources had to be transcribed. I analysed relevant data in an iterative coding process, for which I use the NVivo software at early stages (Delamont 2004: 225; O'Reilly 2012: 179–207). My approach partly followed the six-step thematic analysis proposed by Braun and Clarke (2006). [9] However, I believe that especially data familiarisation and initial coding (step one and two) already take place during ethnographic fieldwork. It is important to note that my intent was to gain nuanced insights into a particular issue: the knowledge-related facets of the risk controversy around CSG. The analysis may thus be characterised as a latent, theoretical thematic analysis that looked at particular aspects of the data set rather than attempted to capture its entirety (cf. Braun & Clarke: 82–86). To relate these coded ethnographic findings to the broader research and theoretical questions, I developed and interpreted key themes and concepts (*ibid.*; Hammersley & Atkinson 1995: 205–262). Similarly to the sampling process, the strategy for my analysis was aimed at including a balanced range of views and opinions.

1.5.4. Research Challenges and Limitations

I explicitly attempted to maintain neutrality throughout the research. The role and positionality of the anthropologists are, of course, an area of ongoing debate within the discipline (see, e.g., Trigger 2011; Responses to David Trigger 2012). It may here suffice to position myself similarly to Trigger (2011: 242) who argues that "[i]n contrast to an approach as advocate based on political commitment, anthropologists are worth more to local communities as skilled professionals able to engage meaningfully with institutions of power in the wider society". With this in mind, I aimed to approach CSG developments through a process of 'rigorous approximation' (de Sardan 2015) that equally attends to the various voices within the risk controversy.

However, engaging with a variety of sometimes fiercely opposed interlocutors in diverse roles and localities posed numerous professional and personal challenges. Most important may be the multitude of interpersonal relationships that spring from empathetic ethnographic research and the moral, ethical and professional dilemmas these can create. For example, I was staying with a local landholder's family overnight and the next morning she asked me if I could help distributing flyers for a community meeting that was aimed at stopping proposed CSG developments in the area. The next day, I was to meet a worker for the proposing company who also lived nearby with his family. This situation created some internal conflict. As Marcus (1995: 113) describes:

[9] Braun and Clarke (2006: 87) describe the process of such a six-step analysis as: 1. Familiarising yourself with your data; 2. Generating initial codes; 3. Searching for themes; 4. Reviewing themes; 5. Defining and naming themes; 6. Producing the report.

> In conducting multi-sited research, one finds oneself with all sorts of cross-cutting and contradictory personal commitments … renegotiating identities in different sites as one learns more … . In certain sites, one seems to be working with, and in others one seems to be working against, changing sets of subjects.

I also described access-related research challenges elsewhere (Espig & de Rijke 2016b) and referred to concerns about research fatigue above. In summarising these challenges, it is worth noting that studying 'up, down, and sideways' is often not equally possible due to various personal, social, legal, or professional barriers, as well as more practical organisational or financial obstacles. These challenges created limitations that must be acknowledged and reflected upon in order to allow the reader to critically evaluate the interpretations and knowledge presented in this thesis (Teo 2010).

Firstly, it is important to emphasise the timeframe during which my fieldwork was conducted due to the constantly evolving and changing contexts of Queensland's CSG developments. Most of the empirical fieldwork data cited in this thesis was generated between late 2014 and early 2016. During this time, many CSG projects in the Western Downs have progressed from construction to operation and global oil and gas prices significantly decreased, which has put increasing economic pressure on all proponents. Both developments led to a substantial and sharp reduction in CSG-related activity and an economic downturn in the region (WDRC 2016). Also, by 2015 a number of individuals and groups that initially actively resisted CSG developments in some areas had either retreated from the ongoing debates or left the Western Downs altogether. Others continued their engagement and new community members and groups also emerged (for a detailed overview see Makki 2015). The scope of my analysis is therefore limited to the timeframe of fieldwork.

Secondly, while I am interested in CSG and unconventional gas developments generally, my specific focus was on the controversy emerging from knowledge-related debates over potential environmental risks. This attention impacted the purposive sampling process insofar as I frequently approached individuals and groups already engaged in these debates and who regard them as pressing issues. These individuals and groups are not necessarily representative of the diverse local population of some 32,000 (see Chapter 6.4.).[10] It is thus important to bear in mind the nature of the data at hand. As one senior natural resource manager noted (Interview May 2015):

> It's an interesting consideration for you, where do you find people to talk to? Because you might be just as well off finding people in the pub, because they are random. Or the coffee shop, or the hair dresser, or the bakery in [local town]. How do you find people so that your methodology in itself gets a good cross-section of different opinions? Because you can go to landholders who have infrastructure, landholders who like it, the ones who don't. And they are the sort of stereotypical groupings that are being targeted at the moment by lots of research projects, but there's a lot of people out there in the community that don't get asked.

[10] Neither am I suggesting that they are not representative, but merely that one unavoidable limitation of my fieldwork on a particular thematic issue is that the data is insufficient to make such inferences.

The purposive sampling was therefore influenced by my thematic interests and research questions. At the same time, I also tried to go beyond the "usual suspects" in environmental management stakeholder consultation (Colvin *et al.* 2016) by engaging with a broader variety of actors.

Thirdly, towards the end of this research project, I began deliberating and informally discussing the potential role of gender identities and their implications for some of the aspects addressed in this thesis. While I engaged with approximately equal numbers of male and female interlocutors during my fieldwork and formal interviewing, my study did not explicitly enquire into the role of gender. Despite indicative insights, the ethnographic data that I generated does thus not allow me to draw substantial conclusions on this matter. The role of gender identities within CSG developments and environmental risk controversies more generally therefore remains a topic for further research.

Lastly, it has proven difficult to sufficiently engage with industry representative outside of informal meetings and conversations (although not for a lack of trying). The contact with industry workers and personnel was therefore often limited to off-site talks and anonymous, unrecorded interviews. Access to work sites is usually restricted and largely unattainable without influential internal gatekeepers who in turn may demand control over research outcomes (Espig & de Rijke 2016b). Such challenges are, of course, nothing unusual in ethnographic research but I note them here to enable the reader to contextualise and critically assess the subsequent analysis.

1.6. Thesis Argument and Chapter Outline

My principal argument is to appreciate the limits and merits of science. As such, I caution against the utilisation of scientific knowledge claims to mask what are essentially complex social and political questions arising from environmental risk debates. My argumentation begins by demonstrating that the sciences are crucial for knowing environmental risks associated with CSG developments. However, knowing within dwelled-in environments ultimately involves more than scientific knowledge — for instance, direct sensory experience. The role of the science is thus limited in this fundamental sense. In another sense, scientific knowledge claims are limited due to the nature of scientific research as situated practices. That is, scientific research and the resulting knowledge claims are, just like other epistemic claims, a practical performative act by socially positioned persons. This means that these practices and their outcomes are limited by the predispositions of their practitioners; as various anthropologists have noted, science is full of culture and there is, in many respects, "nothing special about scientists qua scientists" (Nader 1996: xiii & 13). Beyond individuals' cognitive limitations, this situatedness also implies social restrictions and material boundaries imposed by the physical properties of particular environments. It is therefore

intuitively apparent that not ‘everything’ can be researched. Scientific researchers are instead limited by research agendas that determine what is possible within given social, political and economic contexts. In short, the sciences are situated practices that are subject to particular enabling but also restricting individual limitations, social arrangements and material constraints.

In itself, this is not necessarily problematic. Issues can arise when actors have to make sense of the side-effects of the applications of growing techno-scientific capabilities, such as those of nuclear power or pesticide use. These consequences are often unintended and *a priori* unknown or uncertain. Detecting and fully understanding associated environmental impacts therefore frequently requires substantial scientific research. However, scientific research practices are socially co-constructed and thereby malleable practices; that is, they emerge in certain arrangements that could be otherwise. The arrangements and outcomes of scientific research are open for questioning and, to some degree, contestation. In these contexts, scientific research may not deliver the certainties demanded by some actors at given points in time. This is particularly so if the adequacy of the underlying conditions of its production become an area of concern. So while the sciences are important for knowing impacts from CSG developments, scientific findings and research practices themselves can become a site of contestation. This often means that uncertainties persist for some actors who remain unsure about the impacts of CSG extraction and the sciences’ capacity to assess these impacts.

Such contestations do not inevitably result in dysfunctional social conflict. Instead, critical engagements with science, by public or scientific actors, are an important aspect of ongoing research and can be beneficial. Problems can emerge when the political dimensions of these contestations are neglected, which often leads to pro- versus anti-scientific discourses. Such discourses mask what are essentially questions of morality, ethics and politics. Debates over science can thus become an area for covert political struggles. I will demonstrate that such ‘scientisation’ of risk debates is not just an obstacle for the democratic processes through which conflict might be addressed. It can also be detrimental for the status of necessary scientific research. In this sense, my aim in this thesis is similar to Rouse’s (2014: 290–291, original emphasis):

> My aspiration is to show how science matters, and makes authoritative claims upon us, *because* of rather than *despite* its historical and cultural specificity. Science, as a powerful but historically specific extension of the conceptually articulated way of life that is our biological heritage, is not an essential possibility perennially available to any entities with sufficient intellect and social support. It is likewise not an aspiration to transcend our historical contingency through taking up a “god’s-eye view” of ourselves and the world. Sciences are instead precarious and risky possibilities that only emerged in specific circumstances, and could disappear. The contingency of conceptual understanding generally and scientific understanding specifically does not thereby undercut the authority or significance of the

sciences, but instead calls attention to what is at stake in whether and how those practices continue and develop.

The overall rationale throughout this thesis is consequently to move from a deconstruction of the sciences' role within the CSG risk controversy towards an analysis of the wider politics of knowledge and ignorance. In doing so, I intend to go beyond mere deficit and linear models of science by demonstrating how debates over scientific knowledge claims are part of the wider CSG controversy. Outlining the ambiguities and limits of scientific research allows an appreciation of the roles science can and cannot take within complex environmental risk debates. This may, in turn, preserve the merits of science without denying the open discussion of crucial moral and political questions.

I begin this task in the following chapter by clarifying my understanding of the three key conceptual areas that underlie this research. I propose a postconstructivist perspective of (not) knowing that does not regard knowledge and ignorance as externalisable possessions but rather as performative acts by situated actors. Risks are described as special forms of this knowledge and as active human attempts to systematically assess and act upon potential hazards through the lens of future (im)probabilities. I conceptualise science and scientific knowledges as situated practices whose social authority and 'special status' is the result of active boundary work that demarcates them from non-scientific practices. These three conceptual outlines are the cornerstones of my anthropological approach to knowing risks.

The third chapter provides the historical context of the study area, especially the importance of scarce surface and groundwater and the region's emergence as 'the Energy Capital of Queensland'. I consider the making and transformation of the Western Downs as a pastoral frontier region that was subsequently developed into what is, in large parts, an intensely farmed and managed manufactured landscape. I emphasise the existing role of scientific knowledges in agricultural and natural resource management practices. The chapter then addresses the century-long history of hydrocarbon exploration and extraction in the Western Downs and Surat Basin of which large-scale CSG projects are but the most recent episode. This chapter contextualises crucial aspects of the CSG risk controversy, especially over CSG projects' potential impact on groundwater aquifers. I also briefly address some economic and financial impacts of CSG developments.

In Chapter Four, I begin analysing the findings from my ethnographic fieldwork by enquiring into the role of scientific ways of knowing in the context of my interlocutors' sense-making of CSG's environmental impacts. This chapter is largely structured around Ingold's typology of environmental awareness between experience and projection. I examine the elusive material properties of the odourless and invisible gas through the notion of CSG as a transcendent quasi-

matter and then consider how CSG becomes known through direct phenomenological experiences and also by proxy, particularly among my local interlocutors. This experience is limited due to CSG's minimal materiality and it is also crucial to address projected ways of knowing. Local actors therefore usually know CSG through an entanglement of projected and experienced ways of knowing and I consequently propose the notion of 'hybrid CSG'. It is, however, important to consider the possibility for a problematic dominance of projected ways of knowing and so-called deficit models of a science-public relationship.

Chapter Five explains such deficit models perspectives and demonstrates that these can be found in the context of CSG risk debates. I problematise deficit models' key premises, namely that adequate scientific knowledge is available and that the wider public is merely unable or unwilling to grasp it. For this purpose, the second section addresses the manufacturing of (un)certainty through groundwater modelling practices, employed by industry, government and academic researchers, on which much of the understanding and regulation of CSG's impacts relies. I argue that the science may not be conclusive to a degree that satisfies all actors, including hydrogeological experts, and that uncertainties about groundwater impacts emerge from scientific criticisms themselves. These uncertainties leave the problems of knowing created by CSG extraction partly unanswered. Yet, local actors in particular still need to make sense of (potential) impacts and environmental changes. I explore the resulting ambivalence through the empirical case of gas seepages in the region's main watercourse, the Condamine River. My conclusion is that while more research is certainly necessary, it cannot be assumed that 'just more' will solve the issues at stake.

Chapter Six focuses on the diverse responses to these unsolved problems of knowing and the social and political aspects that influence these responses. I begin by demonstrating how the rapid pace and scale of CSG projects has created problems for local actors as well as staff in government departments, industry and the regional council. This has affected some actors' trust in state government's 'adaptive management' regulatory regime. The second section considers what I themed instances of (felt) organised irresponsibility and the veil of secrecy surrounding CSG developments. Interlocutors noted a lack of clear responsibilities in government and industry and also the industry's secrecy as an obstacle to receiving a 'straight answer' and gaining certainty. Consequently, some actors object to the industry or move away from the region altogether out of concerns over persisting uncertainties. Others appear to not, or no longer, hold such concerns. I therefore also attend to their accounts and then conclude by contextualising these diverse responses through qualitative and quantitative findings regarding attitudes towards the CSG industry.

Chapter Seven specifically addresses the ambivalent status of scientific knowledge claims. I employ the notion of technological zones to demonstrate how scientific research efforts are situated practices that emerge within access-restricted epistemic spaces. As constructed practices, the

sciences can be critiqued, but debates over the adequacy of CSG-specific scientific research should not be understood as pro-scientific versus anti-scientific perspectives. Instead, some of my interlocutors who were critical of existing levels of scientific understandings critiqued not science *per se* but what they regard as wrong scientific practices. I subsequently examine what they viewed as potential causes for inadequate scientific research, including access to technological zones. Shifting from wrong to right science, the third section considers what might be regarded as prerequisites for acceptable scientific research, namely issues emerging from research politics and the perceived independence of scientific researchers. I conclude by conceptualising the sciences as situated practices whose social authority is partly dependent on maintaining the myth of 'pure' science. My closing argument is that conflicts over the appropriateness of scientific research can be understood as politics of (im)purity wherein actors attempt to impose definitions of wrong and right science.

Chapter Eight follows this argumentation and attends to the politics of knowledge and the limits of science. I demonstrate how appeals to scientific knowledge and ascriptions of ignorance are crucial components of cryptonormative claims and social positioning. By using the term cryptonormative, I refer to how debates over different morals and values can be masked by claiming to merely respond to scientific findings. This links to who interlocutors regarded to have the onus of proof and what counts as evidence when conflicting claims are made. My analysis highlights that cryptonormative claims and the making of evidence as decidedly political aspects of CSG developments and demonstrates that debates over science are also negotiations over legitimate concerns and participation in research and decision-making processes. This leads me to consider the importance of social engagement and trust. My conclusion is that CSG risk debates do not just concern environmental hazards, they also constitute social commentaries that can go beyond questions of scientific adequacy. I therefore caution that the moral and political dimensions of CSG developments can be debated covertly through science. Such debates ultimately do not sufficiently address these social dimensions, and they can have negative implications for the status of scientific knowledge claims.

In Chapter Nine, I summarise main thesis findings and my overarching argumentation. I reflect on the anthropological and interdisciplinary literature that constitutes the starting point of my enquiry and draw out some key insights that may contribute towards this literature. I also outline some modest implications of my research for those involved in Queensland's CSG controversy and similarly cases of environmental risk debates. My principal suggestion is to avoid 'scientising' debates that also concern moral, ethical and political questions. Such scientisation can adversely affect the status of science. Instead, it is more productive to openly discuss the limits of scientific research and knowledge claims, which involves finding ways to combine scientific and other ways

of knowing. This might improve the increasingly ambiguous relationship between science, politics and society.

1.7. A Note on Conventions and Data Presentation

Throughout this thesis, I primarily refer to actors and interlocutors. I use actor in a general sense to describe individuals who take part in contemporary environmental risk debates that occur in various forms all over the world. In the context of Queensland's CSG developments, this includes any members of the Australian public, local to my study area in the Western Downs or not, who are involved in current debates. Reference to actors is made regardless of whether or not I had personal contact with these individuals. Interlocutors are those actors whom I encountered personally. These encounters may have occurred formally through a recorded interview where an individual explicitly consented to participate. They also include less formal settings of, for instance, informal conversations community events or unrecorded interviews. To avoid a third layer of differentiation, no distinction is made between formal participants and informal interlocutors. Instead, I specify the setting within which encounters occurred in parentheses after interlocutors' accounts. These encounters were mainly interviews, informal conversations, and meetings.

I also provide basic background information on interlocutors, either within the sentence that includes their accounts or following indented quotations. This information includes interlocutors' gender, actor category or occupational role, and the month and year that I recorded their accounts either via voice recorder or as field notes. I do not provide further details for two reasons. First, this information should suffice for the reader to contextualise quoted excerpts. Second, I aim to maintain internal confidentiality (see Chapter 1.5.3.). Some interlocutors may have also discussed content that could violate contractually enforceable confidentiality agreements they signed with CSG companies, or employment contracts they held with government departments or private companies. While restricting details reduces the ethnographic depth and richness of their accounts, I believe that the trade-off with those concerns is justified. Adding more individual information could thus be a gain that is disproportionate to the possible negative ramifications should the individual become identifiable. These considerations also apply to visual materials. I similarly de-identified excerpts taken from publicly available data sources — for instance, Senate hearing transcripts. However, where possible, I provide in-text hyperlinks to the original sources, which provide more details.

Further, the presentation and discussion of empirical data is not divided into separate sections or chapters. I instead analyse empirical data in constant dialogue with relevant social scientific literature. The reader will therefore encounter a variety of shorter in-text and longer indented quotations throughout the thesis. For in-text quotations, I decided to visually separate those from

the literature and empirical data. In-text empirical data quotations are thus italicised. However, longer indented empirical data quotation are not italicised for reasons of readability; they are never in the same indented section as literature sources and are also easily distinguishable since they are followed by background information on the account in parentheses. I do not italicise the published accounts of academics and/or researchers that have not been peer-reviewed, particularly those published in *The Conversation*.[11] Some readers might question the quality assurance behind these sources (cf. Weinberger 2011) and my visual grouping together of these sources with peer-reviewed literature. I therefore reference them accordingly following in-text citations.

Lastly, I refer to homogenising notions such as community members, landholders or the CSG industry. These notions can be problematic since they obfuscate the diversity of these actor categories. However, it is not always feasible to delve into the complexities behind these categories. It may suffice to note here that there are marked differences between, for instance, individual residents or landholders. Further, Queensland's CSG industry consists of four major proponents and a large number of subcontractors and associated industries. The performances and community perceptions of certain companies differed and have also changed, for better or worse, over time. Hence, there is a need to differentiate and avoid oversimplification between the specific cases and contexts of CSG developments. Where possible, I will clarify those idiosyncrasies within the overarching analysis and narrative. However, these differences do not subvert the thrust of the overall thesis argument. My analysis and review of the relevant literature instead suggest that I am not merely drawing conclusions from outlier accounts but that my findings address a number of general themes and topics related the Western Downs' CSG developments.

[11] *The Conversation* is an Australian online platform and, self-described, "one of Australia's largest independent news and commentary sites, … an independent source of news and views, sourced from the academic and research community and delivered direct to the public".

2. Conceptual Framework: Towards an Anthropology of Knowing Risks

This chapter outlines the three major concepts and bodies of literature that guide my enquiry and to which I propose to make a contribution. In the first section knowledge and ignorance are approached as social practices instead of merely regarding them as externalisable possessions or the lack thereof. Drawing on postconstructivist approaches, I emphasise their processual and relational characteristics. The second section expands upon this perspective and I argue that risks, as one particular form of knowledge, are not calculable 'given facts' but constitute normative cultural negotiations. The third section deals with science and scientific knowledge, especially its role in late modern societies' risk debates. Combining these bodies of literature allows for a novel perspective on the CSG controversy and may expand the anthropological repertoire.

2.1. Knowledge and Ignorance as Social Phenomena

I am attending to knowledge in this thesis for three primary reasons. First, the abovementioned research questions unswervingly direct one's attention to specific problems of knowing. More fundamentally though, studying knowledge provides a clearer-defined, less equivocal enquiry over broader notions such as culture. I therefore agree with Barth (2002: 1; also Kirsch & Dilley 2015: 11) that:

> in calling it knowledge rather than culture I think that we ethnographers will analyse it differently … . Knowledge provides people with materials for reflection and premises for action, whereas 'culture' too readily comes to embrace also those reflections and those actions. … Thus the concept of 'knowledge' situates its items in a particular and unequivocal way relative to events, actions, and social relationships. … Differences in knowledge provide much of the momentum for our social interaction.

Lastly, a language centred on knowledge also seems more readily communicable across disciplinary boundaries, which has — preferable or not — become an important aspect of contemporary academic research (High 2012: 123).

Following these considerations, it is necessary to emphasise my axiomatic focus on knowledge as a socio-cultural phenomenon, thus taking its sociality for granted (Knoblauch 2005b: 344–348). In drawing this conceptual boundary I do not suggest that knowledge only emerges in the intersubjective and social, which would dismiss insights from, for example, cognitive or neuroscientific perspectives (*ibid.*; Cohen 2010; Marchand 2010).[12] Rather, I argue below that knowledge is dependent upon knowing individuals and, in doing so, intend to stress that these

[12] I also avoid discussing philosophical understandings of knowledge as justified true beliefs (Gabriel 2013), which may be compatible with my approach if one asks what makes a belief justified or true. In any case, I follow Berger and Luckmann (1966) in that questions of truth and reality are socially relative: "the sociology of knowledge is concerned with the analysis of the social construction of reality", and thus "must concern itself with everything that passes for 'knowledge' in society" (*ibid.*: 15 & 26).

knowers need to be regarded — in a Weberian sense — as socio-cultural beings always already suspended within culturally shared and shaped webs of meaning and significance (Geertz 1973: 5). I thus understand knowledge intersubjectively as the specific form of meaning humans can share with others and that guides their experiences and actions (Knoblauch 2005b: 348, 2013: 11). Conceptualising and analytically operationalising knowing and not knowing in this way allows me to specifically focus on the important socio-cultural aspects of epistemological debates.

2.1.1. Knowledge

Anthropological approaches that explicitly focus on knowledge as their primary object of study remain sparse. Surely, the so-called reflexive turn within anthropology has sparked ongoing debates since the 1980s over notions of truth, representation and knowledge in relation to ethnographic encounters and anthropologists' subsequent epistemic claims (e.g., Clifford & Marcus 1986; Geertz 1988; Marcus & Fischer 1986; Vargas-Cetina 2013). Beyond this, the topic of knowing and not knowing appears to have not featured as prominently as other areas of enquiry. So while anthropologies of knowledge, and also ignorance, have received more attention since Crick (1982: 287) critiqued their 'comparative rarity', such approaches have so far not developed the same comprehensiveness of, for example, the century-old sociology of knowledge (Berger & Luckmann 1966; cf. Knoblauch 2005b: 313–319 on the contribution of cognitive anthropology). I therefore not only draw on anthropological literature but also from scholars in the sociology of (scientific) knowledge, the anthropology and sociology of risk, and science and technology studies. Following a review of this literature, it is possible to broadly describe my understanding of knowledge as postconstructivist (Asdal 2003; Wehling 2006a, 2006b), but certain approaches with critical realism suggest a similar perspective (Willig 1999).

Most postconstructivist scholars fundamentally argue for a deflational concept of knowledge, marking a "shift away from thinking about a putative object that a concept could describe to thinking about the practices in which the concept is used" (Rouse 1996: 199). They subsequently stress the situated materiality and discursivity of these practices; that is, "how meaningful language and other practices are sustained as part of the ongoing reconfiguration of a reliable and meaningful environment" (Rouse 2002: 69; also Barad 2007). This perspective makes knowing a continuous practical performative act by agents situated in social and material places and times (Harris 2007a; Wehling 2006b).[13] Knowledge is therefore not an externalisable static possession but forms, as a 'capacity to act' (Stehr 2001, 2012; cf. Wehling 2006a: 23), part of the being of socially positioned

[13]On the 'practice turn' generally see Schatzki *et al.* (2001). I also find common ground with accounts that regard practices of representation as originary of 'reality' rather than *vice versa*; that is, knowing *as* reality instead of knowing *of* reality (Rheinberger 2010: 81). This is how I understand 'making sense' or 'coming to know', which further clarifies the constitutive status of knowledge in the social construction of reality.

thinking and acting persons who experience and co-construct their environments (Barth 2002: 10; Ingold 2007; Marchand 2010; Martin 2013; cf. Fabian 2012). By thus recognising knowledge as a situated 'interested activity', one can appreciate that "knowers are always *somewhere* - and at once limited and enabled by the specificities of their locations" (Code 1993: 39, quoted in Alcoff 2007: 41). Turnbull (2003: 10) similarly refers to 'knowledge spaces' and contends that all knowledge "is both situated and situating. It has place and creates space" (also Edwards *et al.* 2007: 13; McCarthy 1996: 4).[14] From this perspective, knowing inevitably involves limitations and processes of epistemic exclusion; that is, knowledge entails ignorance (Rayner 2012: 111; see Chapter 2.1.3.).

Crucially then, postconstructivists leave behind the unhelpful dualisms between nature–culture, structure–agency or the "by now rather dull debate between 'realists' and 'constructivists'" (Macnaghtan & Urry 1998: 2; also Asdal 2003; Barad 2007; Gingrich 2014; Latour 1993; Rouse 2002; Wehling 2005).[15] In doing so, these scholars do (Wehling 2006b: 96, original emphasis):

> not seek to "overcome" the relativism-constructivism divide by successively weakening and playing down the difference between them until they meet somewhere "in the middle" (in the shape of "moderate" versions). On the contrary, the critical strategy of postconstructivism aims at transforming (or at least irritating) the dichotomy itself by questioning the hidden background assumptions on which it is founded. … [Hence], it becomes meaningless to ask whether those practices *either* are determined by the reality of natural objects *or* constructed by social actors and influences.

This perspective appears to respond with many contemporary anthropological accounts, such as Ingold's understanding of the environment as "a world that continually *unfolds* in relation to the beings that make a living there" (2007: 14, original emphasis; also 2000). Likewise, Herzfeld's 'militant middle ground' approach to ethnographic writing "breaks down the dualism of material-versus-symbolic" (2014: 3). Central to my perspective is therefore a rejection of the ontological separation between nature and culture or society (Descola & Palsson 1996; Hastrup 2014; Ingold 2004; Martin 2013) and of knowing from being (Ingold 2006, 2011: 114).[16]

Viewing knowing as discursively and materially situated (inter)actions is useful for the case at hand. On a general conceptual level, practice and interaction are certainly crucial for the realisation

[14] On the 'nonfungible nature of knowers' see Alcoff (2007: 42). She clarifies that "an adequate concept of epistemic situatedness must involve much more than the knower's position in time and space and must include individual factors about her or his history and experience" (*ibid.*).

[15] I hence agree with Asdal (2003: 66) that natures — not Nature — and societies are constantly in the making. Using Alcoff's critical theory-inspired argument, one can connect this continuous production of nature and society to that of knowledge by bringing "to consciousness the link between the social production of knowledge and the social production of society, and thus to show that the production of knowledge is the product of conscious activity (even when it is not self-conscious about this fact) rather than activity that operates merely in the sphere of nature or that is wholly determined. In other words, knowledge, no less than 'subway trains and tenement houses,' reflects the current condition of human praxis" (2007: 54; also Hastrup 2014).

[16] Others may disagree. For example, anthropologists who follow the recent 'ontological turn' appear to "eschew 'epistemic intermediaries' between subject and object" (Paleček & Risjord 2012: 4) and argue that "concepts and things are one and the same" (Henare *et al.*2007: 13).

of the cultural and social (Knoblauch 2001: 136; also Barth 2002: 2; Crick 1982: 299). However, such a framework also holds analytical value. As Barth argues (1995: 66–67, original emphasis):

> The image of culture as knowledge abstracts it less and points to people's engagement with the world, through action. … Thus a focus on knowledge articulates culture in a form that makes it *transitive* in the interaction between people, because of its potential use to both parties. Thereby, other modes of representation and other and more dynamic questions come to the fore when we model culture in such modalities: variation, positioning, practice, exchange, reproduction, change, creativity. … Our analysis and comparison should turn to an inspection of the differing *criteria of validity* in different traditions of knowledge and the different kinds of knowledge that are *produced* by embracing these different criteria.

In this sense, "[i]f knowledge is made, its making can be looked into" (Geertz 1990: 19). My argument is that investigating the making of knowledge must not just include its symbolic aspects but also its entanglements with structural and material factors, which can be enabling for some actors and restricting for others (see Chapter 7 & 8). This point corresponds with Barth (2002: 10) who notes this entanglement by stressing that "all knowledge … engages 'nature' in that it is used to interpret and act on the world". Scholars therefore "need to be precise and discriminating in our description of how different representations of knowledge and different sociologies are linked to different practices of application to nature" (*ibid.*; also Hastrup 2014; Rayner & Heyward 2014). As noted above, though, these practices are just as determined by the physical properties of natural objects as they are socially constructed and influenced. I will demonstrate these entanglements in the context of CSG developments in Chapter Four.

2.1.2. Ignorance

A similar perspective is also insightful for considering the "the other side of knowing" (Luhmann 1998: 81). Crick (1982: 301) already refers to the "anthropology of not-knowing", but not until recently have such approaches gained explicit attention (Dilley 2010; Dilley & Kirsch 2015; High *et al.* 2012; cf. Gershon & Raj 2000; Hobart 1993; Paine 1995). This invigorated anthropological focus must be positioned within a currently increasing social scientific interest into ignorance. To name but a fraction, unknowns have been addressed from fields as diverse as sociology, philosophy, political sciences, science and technology studies, economics, psychology and history (Beck 2009; Gross & McGoey 2015a; McGoey 2014; Proctor & Schiebinger 2008; Sullivan & Tuana 2007; Smithson 1989; Wehling 2006a; Zimmerman 2008; Zwierlein 2016). These diverse approaches have, unsurprisingly, led to a large variety of often ambiguous terminologies describing the unknown. As Kirsch and Dilley (2015: 1) recall, "ignorance came to stand as a portmanteau term that embraced various forms of not-knowing (intentional and

unintentional), unknowing and secrecy". I therefore clarify some of these notions, but will commonly refer to ignorance in its most general sense to avoid confusion.

The argument that knowledge is not an externalisable possession suggest that this characteristic similarly applies to ignorance. If knowledge is not mere possession, ignorance cannot just be a lack thereof. Instead, as a "substantive historical phenomenon" itself (Mair *et al.* 2012: 3), ignorance is an active component in the ongoing reconfiguration of reliable and meaningful environments, which applies on an individual as well as social level. This positivity of ignorance, which "provides the grounds for action, thought and the production of social relations" (Kirsch & Dilley 2015: 21; also Frickel & Edwards 2016; Townley 2006), thus illustrates that ignorance is not simple absence but the "presence of an absence" (Raj 2000: 31; also Michael 1996). Such a perspective is helpful when considering, for example, critiques of ignorance that has allegedly resulted from so far not conducted (scientific) research (see Chapter 7 & 8). Viewing this present absence as a potentially productive force itself requires to demarcate ignorance from other social phenomena and to unpack some of its dimensions.

Insightful research of the unknown in relation to contemporary risk debates has, among others, emerged from German sociologist Wehling's work on non-knowledge (2006a, 2006b). Non-knowledge, as the somewhat counterintuitive translation of the German *Nichtwissen*, has to date not seen much use apart from German scholars' translated works.[17] However, Dilley and Kirsch's (2015) referring to non-knowledge in the subheading of their anthropological volume on *Regimes of Ignorance* may signal a growing acceptability of the term. In reviewing both non-knowledge and ignorance, however, one might question Dilley and Kirsch's apparent synonymisation of these notions. Conceptually speaking, I regard non-knowledge as more specific and encompassing fewer dimensions of unknowns. As such, ignorance may include 'unknown unknowns' while non-knowledge usually implies some knowledge or at least suspicion of what is not known. Furthermore, non-knowledge is analytically interesting as it seems *prima facie* less value-laden than ignorance when employed discursively. Nonetheless, both notions can and are often used somewhat interchangeably, and it is necessary to distinguish them from closely-related concepts.

To begin with, non-knowledge can be separated from risk and uncertainty (Wehling 2006a: 109–115). As Wynne (1992) argues via a four-fold conceptual model, both risk and uncertainty still imply some knowledge about the odds or at least parameters of proposed actions and thus do not constitute non-knowledge (also Dwyer & Minnegal 2006; Faber & Proops 1993: 114; Knight 1921).[18] Ignorance is a third state where we 'don't know what we don't know' (Wynne 1992).

[17] The notion of non-knowledge is not uncontested among German scholars. Some regard knowledge as the defining characteristic of contemporary 'knowledge societies', while others speak of 'non-knowledge societies' (Beck 2009: 115–128; Japp 2000; Stehr 2012).
[18] As Stilgoe (2007: 48) notes, "[u]ncertainty only exists as that which emerges from negotiations about the adequacy and relevance of current knowledge".

While Wehling generally agrees with these three distinctions, he is skeptical about Wynne's fourth stage of indeterminacy or "real open-endedness in the sense that outcomes depend on how intermediate actors will behave" (*ibid.*: 117; Wehling 2006a: 109–115). Important, though, is the difference between risk, uncertainty and non-knowledge. Less relevant but noteworthy is that Wehling also proposes to separate non-knowledge from error or untrue knowledge, which already constitutes a form of knowledge (2006a: 113–115). These distinctions may justify a specific focus on ignorance. A precise analysis does, however, require drawing out the underlying and differentiating dimensions of ignorance.

In doing so, it is important to acknowledge that ignorance "is not a flat object; it is a stratified object with multiple levels and layers" (Caduff 2015: 32). To reveal those layers, I refer again to Wehling (2006a: 116–149) who suggests three possible dimensions of differentiation for non-knowledge: the (claimed) degree of knowledge about unknowns; the intentionality of not knowing; and its temporal stability. I propose that these dimensions are a substantial contribution to the anthropological study of ignorance as they allow moving beyond the clear-cut and polarising 'extremes' of widely-accepted, settled knowledge and fundamental or even unknowable unknowns. These extremes do not explain the large spectrum in between them. While Wehling develops these dimensions in compelling detail, I can here consider but a few key implications relevant to the CSG controversy.

First, on the level of knowledge about unknowns, a significant range between — using Donald Rumsfeld's famous terminology — known unknowns and unknown unknowns can be observed (Wehling 2006a: 117–126). Faber and Proops (1993: 110–113) similarly refer to open and closed ignorance. They note that "closed ignorance concerning environmental issues means that we either neglect the problems themselves, or do not take notice of intuitive insights, experience, information, models and methods of solutions which are available within society" (*ibid*.: 115). Through the element of surprise, however, individuals or groups can become aware of their ignorance and enter a state of open ignorance, which in turn may be reducible or irreducible (*ibid.*).[19] Over time, unknown unknowns can then become known unknowns and, possibly, knowns. Following these considerations, Wehling's differentiation is helpful as he shows that in between these two ideal type poles non-knowledge can emerge that is less specific and less readily articulable; particularly important is the 'middle regions' of suspected, guessed or feared unknowns. In addressing this liminal middle region, Gingrich (2014: 121) refers to the "human capacity of imagining the unknown". Within contexts such as CSG risk debates, this imagining is often intrinsically related to

[19] Cf. Paine's (1995) reference to canonical and referential knowledge in the history of European thought. In his terms, canonicity forecloses doubt while referential knowledge is open to doubt and 'the new' of discoveries and innovations (also Hastrup 2014: 9).

the awareness of potentially unanticipated consequences of large-scale technological developments, which are increasingly difficult to predict due to their growing temporal and spatial complexities.[20]

Second, by focusing on the intentionality of non-knowledge, Wehling (2006a: 127–131) challenges the often unquestioned Enlightenment assumption that knowledge is desirable and that, with its accumulation, ignorance will gradually diminish, especially through scientific research (Faber & Proops 1993: 124; Gross & McGoey 2015: 3). Despite this often proclaimed "will to knowledge" (Foucault 2006), non-knowledge is not always unintended and can, in fact, be explicitly pursued either for oneself or towards others. The latter is the case for strategically employed unknowns, the maintaining of taboos, or intentionally kept secrets (High 2012, 2015; Kirsch 2015; McGoey 2012; Nelkin 1995: 455–456; Schudson 2015; Simmel 1906). The former is apparent in contradictions to the assumption that individuals desire to know about, for example, their genetic predispositions for particular disease (Andorno 2004; Kerwin 1993; Last 1981; Wehling 2015). Further, by expanding the notion of intentionality beyond the individual, Wehling demonstrates how intended non-knowledge can become institutionalised as 'rational ignorance' when certain information or knowledge claims are systematically excluded from institutional considerations due to their deemed valuelessness (2006a: 127–131; Somin 2015; see Chapter 7 & 8 on 'undone science' (Hess 2015)).

While this 'rational choice' can be problematic as *a priori* considerations of value are themselves taken under conditions of non-knowledge (Wehling 2006a: 130), such omissions are often intentional in that they allow institutions to keep "uncomfortable knowledge" at bay through strategies of exclusion (Rayner 2012; also Beck 2009: 126–128).[21] More critically, Luhmann (2000: 187) remarks that non-knowledge is frequently employed by politicians since 'not having been informed' and thus ignorant can later indemnify from guilt and responsibility.[22] Intentionality is therefore crucial for reflections on non-knowledge, particularly in the context of debates over the consequences from large-scale technological developments such as CSG projects.

[20] In developing his philosophical anthropology for the age of technology, German philosopher Anders (1980) argues that the fundamental problem of highly industrialised societies is a discrepancy between its technological capacities to create and destroy and its members' capacity to imagine such destruction (cf. Cartwright 2013: 206). This discrepancy becomes problematic when utilising these technological capabilities shifts from the possibility of 'could' to the imperative of 'should': "because today … the possible is accepted downright as the mandatory, the accomplishable downright as the supposed" (Anders 1980: 17, my translation).

[21] See Douglas (1986) on 'structural amnesia' in *How Institutions Think*: "Institutions create shadowed places in which nothing can be seen and no questions asked" (*ibid.*: 69). Frickel and Edwards (2016: 215) even understand "ignorance not as a cognitive condition held by individuals, but as an institutional outcome". They analyse how ignorance was organised and hiding in the aftermath of Hurricane Katrina to create scientific certainty and technical manageability. Likewise, Jasanoff (2002) problematises institutions' love of quantification and predictive ambitions that can "promote a kind of peripheral blindness towards uncertainty and ambiguity. Analytical attention focuses on the known at the expense of the unknown, leading to possible overconfidence in the in the power of prediction … helped along by a cultural lean towards technological optimism. … These predictive methods … are designed on the whole to facilitate management and control rather than justify precaution … , they tend to overstate what is known about risks and to downplay areas of ignorance, uncertainty and conflict" (*ibid.*: 374–375 & 377).

[22] Cf. Dilley (2010: 178–179) on not-knowing as a state of excusable innocence but with the moral obligation to overcome it and Luhmann (1998: 91) on the communication of ignorance as excuse and relief of authority. This relates to Povinelli's (1993) observation regarding the relationship between knowledge-claims, responsibility-culpability and authority-status: "Once knowledge is claimed ... it immediately becomes fragile in the gale-winds of unforeseen events. A person's knowledge-claims enter a circuit of responsibility and status" (*ibid.*: 685; also Gluckman 1972; cf. Chapter 6.2.).

The third dimension of differentiation is the temporal stability of non-knowledge, which concerns the (im)possibility of transferring non-knowledge into knowledge. This dimension ranges from 'not-yet-knowledge' to permanent non-knowledge (Wehling 2006a: 132–146). These extremes are, again, ideal type poles of a large spectrum. After all, how could one determine *ex ante* whether any presumed unknown will be known in the future or remain unknowable? One of Popper's intuitively plausible theorems thus suggests that the future is fundamentally unknowable (Luhmann 1976; Stehr 2001: 70). Yet, as Faber and Poops (1993: 124 & 127) argue, in "Western civilization our response to ignorance is generally the assumption that it is reducible by science. We assume that the scientific method and the abilities of humankind will eventually fill these gaps in our 'knowledge'. … Hence, there is no concept of irreducible ignorance in modern science" (also Caduff 2015: 33; see Chapter 2.3.). I propose that these arguments are not necessarily contradictory. Instead, many epistemic disputes occur within the grey areas of this spectrum as social processes of definition and negotiation over whether ignorance claims are in fact (ir)reducible. Crucial is the notion of anticipating the future, which can provide grounds for actions — especially under conditions of uncertainty (Hastrup 2013).

I will elaborate on the notion of anticipating futures via the concept of risk and the role of the sciences below, but here follow Wehling's (2006a: 140–141) argument that highly industrialised societies increasingly (have to) attempt to systematically anticipate impacts and thereby 'colonialise' the future by bringing it into the present (see, e.g., CSG-specific groundwater impact forecasting in Chapter 5.2.). In doing so, the temporal dimension of non-knowledge itself becomes a socially contested and negotiated space or complex 'timescape' (Adam 1998). For example, one might ask how much uncertainty about possible future impacts is acceptable, when has the precautionary principle been satisfied, or a reasonable balance between certainty and uncertainty been achieved (see Chapter 8.2.)? Especially in environmental disputes like the CSG controversy, claims that natural systems are too complex to know — to irreducible ignorance — then frequently clash with counterclaims that certain knowledge is only a matter of time and more research — claims of reducible ignorance. Hence, it becomes apparent that the temporal dimension of non-knowledge is hardly ever fully settled and often remains subject to social disputes and negotiations. I thus agree with Wehling (2006a: 145–146) that only because the future has not yet occurred does not mean that it cannot be known, or at least speculated, and debated. The temporal dimensions of (non) knowledge therefore remain an "open, context-dependent and contested question" (*ibid*.: 146, my translation).

In conclusion, I have outlined a spectrum of three possible analytical dimensions along which types of ignorance might be specified and differentiated. Empirically, these dimensions can usually not be neatly separated but form complex interconnections. Wehling (2006a: 146–148) therefore

stresses the multi-dimensionality of non-knowledge phenomena. The interplay of these dimensions is apparent in contexts where partial, unsettled or contested knowledge becomes the ground for actions and counter-actions, as in the context of CSG developments. Here, non-knowledge as well as knowledge prompts actions or serves as the impulse for the transformation of one form of non-knowledge into another.[23] Ignorance is thus not always eradicable, negative or undesired but can also provide meanings and grounds for social (inter)action (High 2012).[24] Gross and McGoey (2015a: 4) therefore suggest "to view ignorance as 'regular' rather than deviant".

2.1.3. The Relationality of Knowledge and Ignorance

Addressing knowledge and ignorance separately can be misleading insofar as both always relate in complex interplays within lived social realities. To be sure, I am not suggesting an inevitable equilibrium in the sense that "more knowing necessarily leads to even more ignorance" (Luhrmann 1998: 97), but rather that knowledge and ignorance form multifaceted entanglements within any given empirical context.[25] My focus lies on this relationality of knowing and ignorance as a pair rather than binaries, which implies giving "non-knowledge its full due as a social fact, not as a precursor or an impediment to more knowledge, but as a productive force itself, as the twin and not the opposite of knowledge" (McGeoy 2012: 3). Mair *et al*. (2013: 20) therefore regard ignorance as an indicator or expression of knowledge itself; or, as Alcoff (2007: 54) holds, any "claim that charges ignorance must have access to the alternative … and thus make a claim of improved reference and reliability". It is this interconnectedness I have in mind when speaking of the relationality of knowledge and ignorance.[26]

Understanding knowing and not knowing as entangled features of the ongoing reconfiguration of a reliable and meaningful environment of situated actors allows one to appreciate this relationality as constituting a context-specific social phenomenon. To recall Luckmann and Berger's premise for a sociology of knowledge, "knowledge refers to any and every set of ideas accepted by a social group or society of people, ideas pertaining to what they accept as real for them*"* (McCarthy 1996: 16, italics omitted). However, conflicting knowledge and ignorance claims and their acceptability are often the very focus of environmental risk debates, as within the CSG controversy. This raises the empirical question of what passes for knowledge in society and becomes the ground for

[23] For instance, scientific scoping studies or 'blue sky' research where initial suspicion of an unknown can lead to the identification of a specific known unknown — a now clearly defined 'knowledge gap' that can become the ground for further enquiries (cf. Faber & Proops 1993: 107–134).
[24] Cf. linguists' work on the notion of silence as a diverse communicative phenomenon (Boldt *et al.* 2013; Jaworski 1993; 1997; 2005), which requires going "beyond the simple view of silence as 'absence of sounds'" (Jaworski 1997: 3). Likewise, Bille *et al.* (2010) developed an anthropology of absence to "probe into the specific ways absences have or take power, and thereby have important bearing on people's social, emotional and material lives" (*ibid.*: 4).
[25] More useful may be the notion of a "knowledge-ignorance paradox", which "captures how the growth of specialized knowledges implies a simultaneous increase in (general) ignorance" (Ungar 2008: 311).
[26] Cf. Ingold's (2016: 8) argument that anthropologists have a predisposition to relational ways of thinking; to "see a world of intricately enmeshed relations rather than one of already divided into discrete and autonomous entities".

legitimate action (see Chapter 8). McCarthy (1996) therefore critically evaluates this definition of knowledge by including discursive and material practices in relation to others. In doing so, she expands on the above definition by adding: "… ideas and acts pertaining to what they accept as real for them and for others" (*ibid.*: 23, italics omitted, my emphasis). Put differently, (not) knowing is a social, political and cultural process.

Knowledge and ignorance claims therefore constitutes an appeal to social meaningfulness and justified action.[27] In this sense, "constructions of knowledge may be agentive, in that they indicate who is qualified to know and act, and who is not" (Hobart 1993: 11). Correspondingly, ignorance in this context is "a state which people attribute to others … laden with moral judgement" (*ibid.*: 1). Viewing knowledge and ignorance in their social relationality thus prompts to go beyond investigating knowledge of something but "knowledge for someone and some end" (Satterfield 2002: 97). This perspective extends epistemic debates into political and moral domains, which makes it important to empirically ask who claims and is considered to (not) know in relation to others; how clashing knowledge and ignorance claims are negotiated and within what structural and institutional contexts; and how are decisions eventually made under conditions of uncertainty and ongoing risk debates (Auyero & Swistun 2008; Beck 2008: 8; Dilley 2010: 182–183; Dwyer & Minnegal 2006)? A nuanced ethnographic enquiry is well-suited to address these questions and can thus make a valuable contribution to the CSG controversy and wider anthropological literature.

2.2. Uncertain Times: Risk and Late Modernity

The second central theoretical component of this thesis is the notion of risk, especially the gradual shift in the sources and kinds of dangers that emerged over the last decades *inter alia* due to techno-scientific innovations.[28] To conceptually grasp this shift, I consider the transition to so-called manufactured risks. But why link risk to debates over knowledge and ignorance? In general, I agree with Giddens that "this apparently simple notion unlocks some of the most basic characteristics of the world in which we now live" (2002: 21). Risk explicitly connects (not) knowing and human action by highlighting disputes over unanticipated consequences. Furthermore, risk is currently a dominant form of knowledge employed to anticipate, debate and negotiate the future. I therefore focus on how modern "understandings of uncertainty … are expressed in the notion of 'risk'" and that "its utility is now to be found in its roles as a guide for action in late

[27] Cf. my axiomatic assumption concerning the sociality of knowledge; i.e., the form of meaning humans can share with others.
[28] See, e.g., Carson's (1962) seminal *Silent Spring* for man-made environmental risks and impacts from pesticide use.

modern societies" (Reith 2004: 383).[29] This relationship between knowledge, uncertainty and risk is a key aspect of the CSG controversy.

2.2.1. The Collective Construction of Risk

Historically and conceptually, risks have been characterised in various ways (for a succinct overview see Aven 2011; also Arnoldi 2009; Lupton 1999a). It may suffice to highlight that I fundamentally do not regard risks as 'objective uncertainty' and that "[i]ndependent of the approach taken, it is essential that the risk description captures both subjective judgement and hard data" (Aven 2011: 39 & 42). I therefore view risks as "not *actual* but rather *potential* dangers" (Arnoldi 2009: 8, original emphasis; also Beck 1992). As an essentially modern phenomenon, risk constitutes a shift towards active human attempts to systematically assess and act upon potential hazards through the lens of future probabilities (Arnoldi 2008: 35–37; Giddens 2002: 20–35; also Faber & Proops 1993: 110; Luhmann 1998: 63–74). Reith (2004: 385 & 386, original emphasis) thus argues:

> that 'risk' is *not* real, but rather that it is a measure of calculation: A means of quantifying that reality. … The notion of 'risk' expresses not something that *has* happened or *is* happening, but something that *might* happen. … risk can still be defined largely through its attempts to calculate and so manage the uncertainties of the future. … Risk vanishes as soon as the anticipated event occurs. … risk is fundamentally an epistemic category - it exists as a feature of *knowing*; not an aspect of *being.*

Such an "enforced separation of knowing from being" (Ingold 2011: 114) is problematic and Beck's perspective that "risks are a kind of virtual, yet real, reality" (2005: 588) may be more suitable. However, the crucial point is that risks are knowledge claims specifically aimed towards acting upon and managing the future.

Following this notion, Beck (2009: 67) remarks that risk "is synonymous not with catastrophe but with the anticipation of the catastrophe". This logic of anticipation is "a systematic way of dealing with hazards and insecurities induced and introduced by modernization itself" (Beck 1997: 21; also Hastrup & Skrydstrup 2013). Risks and the emergence of modern industrial societies are then inseparably linked (Giddens 2002: 20–35; Lupton 1999a). As Douglas (1992: 15) insightfully notes:

> The idea of risk could have been custom-made. Its universalizing terminology, its abstractness, its power of condensation, its scientificity, its connection with objective analysis, make it perfect. Above all, its forensic uses fit the tool to the task of building a culture that supports a modern industrial society.

[29] While I borrow this section's heading from Reith (2004) and also employ the notion of 'late modernity', this term is not unproblematic. Other descriptions exist from 'high', to 'post', 'advanced' or 'reflexive' modernity (*ibid.*: 391).

Risk can therefore be regarded as a complex modern socio-cultural phenomenon that is more than the mere product of calculative rationalisations of potential impacts' likelihood and severity (cf. Aven 2011). Instead, as a collective construct, risks constitute an integral part of culturally-biased normative systems and should thus be understood as "a joint product of *knowledge* about the future and *consent* about the most desired prospects" (Douglas & Wildavsky 1982: 5, original emphasis; also Lupton 1999a, 1999b). This process of anticipating and negotiating futures is "as much about what makes for a good society as about danger in a narrow sense" (Arnoldi 2009: 105; see Chapter 8.4.). This is how I employ the notion of risk throughout this thesis.

2.2.2. Late Modernity and Manufactured Risks

Following these insights, a number of scholars — particularly sociologists Giddens and Beck — have highlighted a shift in the characteristics of the risks of 'first modernity' to those facing late modern societies.[30] As Giddens (2002: 25–26) notes:

> in the current period risk assumes a new and peculiar importance. Risks was supposed to be a way of regulating the future, normalising it and bringing it under our dominion. Things haven't turned out that way. Our very attempts to control the future tend to rebound upon us, forcing us to look for different ways of relating to uncertainty.

To conceptualise this change, he introduces the distinction between external ('natural') risks, which more or less affect all cultures, and manufactured risks that are predominantly created by the increasing scale of humans' application of techno-scientific capabilities. In Giddens' view, contemporary late industrial societies undergo the transition from the predominance of external risks to that of manufactured risks and the totality of humanly created environments. As he proclaims: "Our society lives at the end of nature" (*ibid.*: 27). Sörlin & Warde (2009) similarly emphasise 'nature's end' as the beginning of the age of human environments (see also McKibben 2006 [1989]; Minnegal & Dwyer 2008: 80; Purdy 2015; Strathern 1992a). In applying such a perspective to contemporary risks, Beck (1992: 80–84, 2009: 27) argues that the historical antithetical dichotomy between society and nature is dissolving in the late industrial era, which is characterised by the socialisation of nature, but also the socialisation of the destruction of nature. For Beck (1992: 81, original emphasis), at "the end of the twentieth century nature *is* society and society also *'nature'*", with this shift being typified by the emergence of novel societal relations within "risk societies".[31]

[30] I cannot develop the distinction between first and second or late modernity in detail. For a succinct overview, see Beck *et al.* (2003) and Dwyer & Minnegal (2006) for an anthropological critique.

[31] Cf. Wehling (2005) who contends that processes of denaturalisation are concurrent to a simultaneous renaturalisation. It is therefore important to focus on the "intertwined dynamics of denaturalization and renaturalization of the social" (*ibid.*: 3). In referring to Beck and Giddens, I am thus cautious to not suggest a quasi- or crypto-realism.

From an anthropological perspective, these perspectives are likely too simplistic in their essentialising and universalising undertone (Dwyer & Minnegal 2006; also Lupton 1999b: 6), but are nonetheless conceptually intriguing. The distinction highlights that risks increasingly emerge as the result of growing technological capacities to act upon and alter the physical world — potentially beyond the capacity to foresee the full range of subsequent consequences, but yet with humans entirely responsible (Renn 2014: 5). Furthermore, these risks frequently concern larger geographical and temporal scopes (see Chapter 4.1.) and they transcend existing social and ecological boundaries, which creates new epistemic and political challenges. Beck (in Yates 2001: 97) therefore notes:

> At the speed of its technological development, the modern world increases the global difference between the language of quantifiable risks in which we think and act and the world of non-quantifiable insecurity that we likewise create. Through our past decisions about atomic energy and our present decisions about the use of genetic technology, human genetics, nanotechnology, and computer science, we unleash unforeseeable, uncontrollable, indeed, even incommunicable consequences that threaten life on earth.

A number of anthropologists and social scientists from related disciplines have similarly begun to examine these challenges of manufactured risks under the now (in)famous notion of the Anthropocene (e.g., Hamilton *et al.* 2015; Hann 2017; Haraway *et al.* 2015; Latour 2014; Moore 2015; Purdy 2015).

What relates the concept of manufactured risks to the preceding section is the question of (not) knowing. Regarding some of the consequences of humans' individual and collective actions, like climate change, 'we now know what we do' (Malm 2016: 2–3). However, Beck (in Yates 2001: 97 & 99) contends that many manufactured risk are first and foremost accompanied by not knowing, which brings with it 'manufactured uncertainties' (also Minnegal & Dwyer 2008; see Chapter 5.2.):

> In all these new uncertain risk technologies, we are separated from the possible results by an ocean of not knowing. … We don't know if we live in a world any more risky than those of earlier generations. It is not the quantity of risk, but the quality of control or - to be more precise - the known uncontrollability of the consequences of civilizational decisions, that makes the historical difference.[32]

Crucial in this regard is the often invisible and possibly undetectable character of, for example, toxic or nuclear hazards (Adam 1998; Beck 1992; Cartwright 2013; see Chapter 4). What has then emerged is a somewhat paradoxical situation of not necessarily more unknown dangers but of many actors' knowledge — or suspicion and awareness — about potentially unforeseen and unforeseeable impacts. Around the world, many people are thus frequently confronted with the knowledge of

[32] Cf. a relevant lecture giving by Giddens on 22nd October 2014 at Durham University (here) where he argues for 'on the edge of history-type risks' and 'don't know' futures within which we cannot be certain "whether we can control the forces that we ourselves have unleashed upon the world".

previous instances of ignorance about the unanticipated consequences of human actions (e.g., the 'ozone crisis' Roan 1989; cf. Fukuyama 1992: 306) and the uncertainty of what else may remain undetected. As such, "the source of the most troubling new risks we face is something most of us would regard as unequivocally beneficial — our expanding knowledge" (Beck 2005: 589; also Stehr 2001). Techno-scientific capabilities and their application can, in this sense, themselves increasingly become sources of risk (Douglas & Wildavsky 1982: 10).

Contemporary risk controversies are therefore usually inseparable from debates over knowledge and ignorance, especially within environmental conflicts. However, these debates not merely concern the 'natural boundaries' of knowledge, but emphasise how acceptable applications of (new) knowledge are frequently contested and how the limitations around what is, can and ought to be known are negotiated (Wehling 2006a: 328).[33] For Beck (2005: 589 & 590), among others, this leads to crucial political and moral questions (also Douglas & Wildavsky 1982: 8–9):

> Risk becomes another word for 'nobody knows.' We no longer choose to take risks, we have them thrust upon us. … The basic question here is: how can we make decisions about a risk we know nothing about? Should we ignore it and possibly get hurt or killed? Or should we be alarmed and stop or exclude all likely causes? … So the lesson of the risk society is this: politics and morality are gaining - have to gain! - priority over shifting scientific reasoning.

Anticipating and subsequently answering these questions makes risk disputes decidedly political, with not merely the determination of hazards but also the negotiation of acceptable levels of uncertainty at stake (see Chapter 8). This is especially so since it is, arguably, impossible to anticipate all potential consequences of any action *ex ante*, to the very least in the sense of unavoidable indeterminacies (Douglas & Wildavsky 1982: 8–9; Wynne 1992). So while modern society may indeed "experiences its future in the risk of deciding … and thereby within the present" (Luhmann 1998: 70–71), this inevitably involves acting under socially negotiated conditions of partial knowledge and potential unknowns.[34] This raises crucial questions that need to be addressed empirically: what risks and uncertainties are debated and deemed acceptable; which ones are investigated by the sciences; or what risks are acknowledged — that is, anticipated — in official impact assessments and mitigated? The shift towards techno-scientifically manufactured risks is then also characterised by a growing need to socially and politically justify risk decisions and acceptable levels of uncertainty.

In turn, this creates a number of social, cultural and political ramifications of which I can address but two relevant to the CSG controversy. It is, firstly, important to consider who decides what is (not) at risk. To some degree, Beck here usefully dissolves the distinction between 'objective'

[33] As Strathern (1992b: 59) argues, "we cannot rely on nature to impose its own limits".
[34] As Douglas & Wildavsky (1982: 4) note, "[y]et, act we must, not knowing what will happen to us along the path we choose to take" (also *ibid.*: 22; Kirsch & Dilley 2015: 21; Luhmann 1998: 98).

notions of risks and risk perception (cf. Aven 2011). As he argues, risks "characterize … a peculiar, intermediate state between security and destruction, where the *perception* of threatening risks determines thought and action" (Beck 1999: 135, original emphasis). Risks are thus not objective categories, but culturally perceived and defined (*ibid*.). As a socio-cultural phenomenon, the relations of this definition are subject to power dimensions or 'relations of domination' (Beck 2009: 30, original emphasis; see Chapter 8):

> *Risks are social constructions and definitions based upon corresponding relations of definition*. … As a result, their 'reality' can be dramatized or minimized, transformed or simply denied according to the norms which decide what is known and what is not.

Douglas and Wildavsky (1982: 29–48), likewise, stress that risks are selected. The resulting relations of definitional power and selection provide the ground for social negotiations and potential conflict. In such contexts, as in the case of CSG developments, it is sometimes not merely the acceptability of established risks but indeed their 'reality' that is debated in the first place. In these instances, it is crucial to empirically investigate whose knowledge claims predominantly determine risks and political actions (Satterfield 2002: 97). This is especially important since risk definitions have not just symbolic but also material implications. Ignored dangers or unilaterally accepted risks can lead to social risk positions wherein social and material inequalities are (re-) created (Beck 1992: 19–50).[35]

The second aspect concerns the diminishing of ontological securities associated with manufactured risks. Giddens (2002: 28) argues that "there is a new riskiness to risk. The rise of the idea of risk … was closely tied to the possibility of calculation. … Situations of manufactured risks aren't like this. We simply don't know what the level of risk is, and in many case we won't know until it is too late". In some cases, the actual danger may turn out to be minimal. In others, unanticipated consequences can lead to significant environmental and health impacts, which are often irreversible (Beck 1992: 22–23; Douglas & Wildavsky 1982: 21–28).[36] Through an awareness of previous instances of unanticipated impacts, doubts and fears may arise despite — or precisely because of — no clear indication of the presence but likewise absence of any danger (see Chapters 6.2. & 8.2.). As such, living with manufactured risks frequently entails ontological insecurities. Within worlds "saturated by risk discourse", Beck (2009: 45–46 & 195, original emphasis) thus observes that (also Reith 2004: 384):

[35] Beck (1992: 53 & 55, original emphasis) turns Marx's famous phrase back to a more idealist reading and — albeit too simplistically — contends that "in class positions being determines consciousness, while in risk positions, conversely, *consciousness (knowledge) determines being*", which suggests that increasingly the "quality of life and the production of knowledge are locked together".

[36] At the time of writing, two cases of underground contamination near and within the Western Downs are becoming known *ex post*. At Oakey, carcinogenic firefighting foam that had been used at an Australian military air force base has allegedly contaminated groundwater and nearby soil. In another unconventional gas development, Linc Energy trialed underground coal gasification technologies near Chinchilla and caused permanent acidification and underground contamination to an area larger than 300km^2.

> a dramatic decline of ontological security now confronts lifeworlds, even in the peaceful corners of the earth. The three pillars of security are crumbling — the state, science and the economy … — and are naming the 'self-conscious citizen' as their legal heir. But how are individuals supposed to accomplish what state, sciences and economic enterprises are unable to achieve? … The brutal fact of ontological insecurity always has an ultimate addressee: … the *individual*. Whatever propels risk and makes it incalculable … shifts the ultimate decision-making responsibility onto the individuals, who are ultimately left to their own devices with their partial and biased knowledge, with undecidability and multiple layers of uncertainty.

I will address the resulting 'organised irresponsibility' (Beck 2005), which may also lead to a personalisation and privatisation of risk (Jasanoff 2002: 375; Rose 2006: 158), in Chapter 6, but focus here on the potential psychological effects on knowing individuals.

Regarding ontological insecurities, Giddens (1991: 131, original emphasis) notes "the *inevitability* of living with dangers which are *remote* from the control not only of individuals, but also of large organisations, including states". This uncontrollability can lead to a "sense of dread which is the antithesis of basic trust" (*ibid.*: 133; also 2002).[37] I certainly not suggest that these are the only possible reactions to manufactured risks or that they cannot change over time. However, Beck and Giddens highlight an often underappreciated aspect of what it might mean to live with the insecurities of complex, manufactured risks. That is, knowledge reassures one's place in the world, while not knowing, conversely, "can suggest uncertainty and a discomfort about the world" (Dilley 2010: 188; also Edwards *et al.* 2007: 7; King 2005; Minnegal & Dwyer 2008). Contemporary risk debates are therefore closely linked to questions of knowledge and the ramifications of ignorance.

In conclusion, I propose that risks are essentially modern socio-cultural phenomena that are best understood as cultural negotiations over desired futures. The link between this section and the discussion of knowledge and ignorance is most apparent in late modern shifts towards a growing importance of manufactured risks for which partial knowledge and unsettled epistemic debates are characteristic. Investigating such risk debates is often "really the anthropology of the unknown, the invisible, the just beyond the senses" (Cartwright 2013: 201; see Chapter 4). Such an anthropological approach must *inter alia* address the question of ontological insecurities and relations of risk definition, as I shall do over the following chapters.

2.3. The Power(lessness) of Science

I so far only considered the role of science in passing. In this section, I specifically contemplate two related questions: first, how can science and scientific knowledge be conceptually defined; and,

[37] Cf. Beck's (1992: 49, original emphasis) argument that the "*commonality of anxiety* takes the place of the *commonality of need*".

second, what might be the role of such knowledge within contemporary risk debates? I start by demarcating scientific knowledge claims and contend that the sciences can be understood as cultural practices. Instead of providing 'placeless expertise', these practices are just as situated within the epistemic dynamics of knowledge and ignorance. This argumentation leads, thirdly, to a discussion on the increasing contestation but also simultaneous opening up and utilisation of the sciences in contemporary environmental debates.

To begin with, it is worth highlighting my own disciplinary position. Segal (2001) intriguingly enquires about the relationship of anthropology and the sciences by reflecting on "anthropology and/in/of science". Clarifying the place of anthropology is important if its practitioners are to move beyond taken for granted assumptions that may contribute to science being "reduced to polarization and polemics asserting a glorified science or a despicable science" (Nader 1996: xi & 3–7). In this regard, I claimed to have shifted towards an anthropological enquiry of knowledge *and* science (Edwards *et al.* 2007; see Preface). This is not to suggest that I consider myself outside of science (cf. Ingold 2016; Marks 2009). However, within environmental risk disputes such as the CSG controversy, many of the disciplines addressing these debates can be grouped into — for lack of a better term — the natural sciences (e.g., hydrogeology). Without polarising the sciences between natural and social, it is fair to say that I am no expert in those natural sciences and am *with* rather than part of them.

2.3.1. Demarcating Science

Over the last centuries, scientific practices and knowledge have gained significant importance for modern societies. As well-known sociologist of scientific knowledge Yearley (2005: vii) points out, "[s]ociety today is suffused with technologies and with insights and beliefs derived from science. Increasingly in modern cultures, citizens think about themselves and their own lives through the lenses of science". In many cases, scientific practices also revolutionised the very understanding of knowledge itself (Nader 1996: xiii & 3; Yearley 2005: 1; Stehr & Grundmann 2012: 39).[38] Taking this apparent 'specialness' of science, one may ask what exactly makes science special? Yearley (2005: 1–2) notes that unlike knowledge derived from logic or religion, which offers consistency and certainty, scientific knowledge is frequently changeable and fallible. Hence, it cannot be the correctness of scientific knowledge that makes it special. He therefore insightfully discusses four possible aspects that might set it apart: the empirical foundation of science; the scientific method; scientific conduct; and scientific values (*ibid.*: 3–20). While I cannot elaborate on this outline, it

[38] As Sellars (1997: 83) argues, "in the dimension of describing and explaining the world, science is the measure of all things, of what is that is, and of what is not that it is not". Rouse (2014: 280) similarly contends: "The sciences change the terms and inferential relations through which we understand the world, which aspects of the world are salient and significant within that understanding, and how those aspects of the world matter to that overall understanding".

may suffice to highlight that Yearley's discussion does not deliver any sole philosophical reason as to why scientific knowledge is exceptional. He contends (*ibid*.: 19, original emphasis):

> The only philosophical approach (realism) which comes close to making science stand out and be truly exceptional pulls off this trick by claiming that the practice of science *necessarily* implies that the world is real and that science gives us access to that real world. Realism insists that science is exceptional but the only evidence is the existence of science itself.

So if not inherently exceptional, what demarcates science and how is this status maintained?

Both Nader (1996) and Yearley (2005) emphasise the importance of boundary-work and power relations in this regard. Boundary-work refers to a now frequently cited concept developed by the sociologist of science Gieryn for whom it "describes an ideological style found in scientists' attempt to create a public image for science by contrasting it favorably to non-scientific intellectual or technical activities" (1983: 781). This demarcation of science is not derived from independent criteria of universal truth but constitutes a continuous act of (re) creating boundaries and particular relations of political power and social authority (Jasanoff 2012; Wynne 1995).[39] Establishing such boundaries rests on the ideal of scientific knowledge claims derived directly from a 'state of nature'. As Yearley (2005: xii) notes, the proclaimed (cf. Chapter 7):

> purity of this knowledge offered to put science into an unusual social role since no other knowledge could match its objectivity or detachment. … [I]t is a remarkable achievement for one group in society to have created a situation in which that group is believed to speak transparently about how the world is.

It is, however, not only the demarcation of the known that assures the sciences' authority, but also its capacity to label, limit and regulate the unknown (Caduff 2015).

This status of detached objectivity, which has grounded the sciences' authority throughout modernity, rests on what Latour (1999: 14) termed the socio-cultural arrangements of 'the modern settlement' (also Ingold 2011: 114). This settlement describes the enforced separation of the natural and the social world and is achieved through practices of "translation" and "purification", which allow for the objectification of nature and the neglect of its hybrid entanglements with the social (Latour 1993: 10–12; also Boyer 2007; Gingrich 2014). For Ingold, these practices thus correspond to ontologies of detachment and uninhabitable, projected environment (2014a; see Chapter 4). Scientific practices and knowledge claims, in turn, reproduce this separation (Wehling 2005). Edwards *et al.* (2007: 4) succinctly summarise this argument by noting how this "abstraction of knowledge from the social conditions of its production … has always rested on its [the sciences'] ability to stand outside 'society' and apart from the lived experiences of a more complex

[39] Claiming that science is not inherently special due to exclusive access to universal truths is not to suggest that it is not special otherwise. That is, science is special in the same sense as other specialised practices with specific knowledges that are derived from a high division of labour (e.g., particular trades; see Dilley 2010).

materiality".[40] This drawing of boundaries is, however, not necessarily always intentional but becomes itself part of embodied cultural practices. In her seminal study of physicists, Traweek (1988: 162, my emphasis) describes "an extreme culture of objectivity: a *culture of no culture*, which longs passionately for a world without loose ends, without temperament, gender, nationalism, or other sources of disorder — for a world outside human space and time". These cultural perceptions are emblematic of a scientific image that is rooted in a desire for disembodied, 'placeless expertise' and ahistorical, asocial, value-free knowledge (Franklin 1995; McCarthy 1996; Reno 2011; Rouse 2014; Yearley 2005).

Following such perspectives, modern scientific enquiries and knowledge claims have historically often been raised above non-Western belief, myth or traditional knowledges, and lay or public perceptions. Early anthropologists had their share in recreating the Western sciences' root metaphor of "impersonal causal forces that oppose 'nature' to 'mind', 'spirit' and 'culture'" and in subsequently portraying "non-Western knowledge processes as 'pseudoscientific,' 'protoscientific,' or merely 'unscientific'" (Scott 1996: 69; also Ingold 2014a: 236). For instance, we may recall early anthropological debates concerning what Malinowski and Lévy-Bruhl regarded as 'primitive' thinking, which is primarily driven by concerns for basic sustenance or emotion and thus distinct from modern thought. Lévi-Strauss later criticised these categorical distinctions; while unfortunately still claiming that 'primitive' thinking "remains different in any way, and inferior in another" (2005 [1978]: 5; cf. Crick 1982; Douglas 2002 [1966]: 91–116; Kirsch & Dilley 2015: 11–15; Nader 1996: 3–7). However, such framing of (legitimate) knowledge through the metaphor of the modern settlement is no value-free endeavour but itself reflects dominant paradigms and moralities that justify existing social arrangements. Western science discourse thus "tends to hierarchy and centralized control … and this is the morality that is metaphorically projected onto our own relations with 'nature'" (Scott 1996: 85). By creating a non-scientific Other, the sciences played therefore an integral part in naturalising and ordering social life and its inequalities. In this sense, "knowledge is power, science is both" (Marks 2009: 279).

This demarcation not merely occurs between the 'West and the rest' (Scott 1996), but also within societies from which 'Western' sciences emerged. Most notably, modern science is set opposite the experiences of everyday life and common sense (Geertz 1983: 86–87; Nader 1996: 1). An inferior Other can thus also be found in the imagery of the "savagery of the domestic mind" (Lave 1996). As Lave contends (*ibid.*: 95 & 97; also Haraway 1989):

> The opposed low categories against which the scientist and scientific thinking play include any and all marginal, powerless, or stigmatized categories in Western society: the lower classes, women, children, criminals, the insane, and, of course, the primitive. But the central

[40] For a detailed history on the rise of modern science as practices of knowledge production see Burke (2000, 2012).

> focus is not the same today as it was in 1910. .. The more salient contrast today is between the everyday thinking of "ordinary" folks and scientists. … Each represents the "inferior other" satisfactorily in opposition to the white, European, bourgeois, male scientist. … The domestic savage is alive and well.

Historically, and maybe more so today, the relationship between the sciences and wider public has thus frequently been uneasy. Whereas scientific knowledge and representations are increasingly inseparable from the creation of manufactured risks that affect a growing number of citizens, the sciences' authority conversely rests on the boundary-work that demarcates them from those citizens. Hence, Edwards *et al.* (2007: 8) argue that "[t]raditionally 'publics' have been problematic for 'science' when science is defined in relation to the search for autonomy from the prejudices of the uneducated, the emotions of the undisciplined and the inherent conservatism of the uncurious". Herein lie the roots of so-called deficit models of the public understanding of science, which generally considers 'lay' publics to lack sufficient scientific knowledge and thus in need of information and education in scientific literacy (see Chapter 5.1.).

With such lay–expert distinction often too simplistic, especially in complex environmental debates (Satterfield 2002), determining who is scientifically (il)literate itself becomes a societal negotiation (Claeson *et al*. 1996). It is therefore important to ask whose knowledge claims are accepted as scientific while others are disregarded as anecdotal and unscientific (see Chapter 8.2.). Ascriptions of laity are consequently related to boundary-work and power relations. Edwards *et al*. (2007: 9) therefore caution that:

> Whenever 'lay beliefs' are set in opposition to 'scientific understanding', we have to ask to what effect. At the turn of the nineteenth century, 'primitive thought' was compared to 'scientific thought' and generally found lacking, and science and sorcery were placed on different sides of the civilizing fence. … The new 'primitive' is the scientifically illiterate.

As I demonstrate throughout the thesis, this observation is relevant in the context of CSG developments. With these considerations in mind, it nonetheless remains to clarify my understanding of science.

2.3.2. Science as Situated Practices

Against this background, social scientists from various disciplines have critically examined science over the last decades. Many argued that the demarcation of science — its 'purity' — is not derived from privileged access to universal truths but the result of continuous socio-cultural boundary-work. Largely by ethnographically tracing the origins of scientific knowledge and 'facts', these scholars instead highlighted the situtatedness and 'impure' hybridity of scientific practices and knowledge (Haraway 1989, 1991; Knorr Cetina 1999; Latour 1987, 1993, 1999, 2004; Latour &

Woolgar 1986; Pickering 1992, 1995; Shapin & Schaffer 2011 [1985]; Traweek 1988). In deconstructing the sciences, these scholars contest the sciences' claims to cultural immunity and, instead, regarded science to be 'full of culture'; notions of 'science as culture' subsequently gained traction (Nader 1996: xiii; McCarthy 1996). However, these researchers have shown that it is too simplistic to regard the sciences as a unified, universal set of practices. Instead, viewed as practices conducted by situated scientists, it becomes important to understand the various cultures of science and the different epistemic cultures these practices recreate (Franklin 1996; Knorr Cetina 1999).[41] Those account demonstrate the cultural situatedness of the sciences.

While this multitude and indeed 'disunity of science' (Galison & Stump 1996) prevents any singular definition (cf. Nader 1996: 1), it is nonetheless possible to provide a general conceptual understanding that will be helpful for the analysis of what I observed in the CSG context. In the simplest sense, science might be defined as the systematic production of convincing knowledge in modern societies (Marks 2009: 2; Pielke Jr. 2007: 31). From a postconstructivist perspective, this production must be regarded "primarily in term of [the sciences'] situated material and discursive *practice*"; that is, their active "performativity" (Wehling 2006b: 81, original emphasis). These practices do, however, not merely represent a body of 'facts' and a specific method, but also reflect specific institutional arrangements and areas of specialisation (Wynne 1996b: 8). This triple identity of science thus also includes science as a locus of social power and cultural authority (Marks 2009: x–xi). Through these practices and institutional arrangements, scientific research (Rouse 2014: 280, 286 & 288; cf. Berger & Luckmann 1966: 130; Nader 1996: xii):

> brings aspects of the world into the space of reasons by articulating them conceptually, so as to allow them to be discussed, understood, recognized, and responded to in ways that are open to reasoned assessment. … The sciences thereby conceptually articulate the world itself (and not just our thought or talk about it) … [and] transform the world we live in and our place and possibilities within it. In doing so, they articulate the world to allow its conceptual intelligibility.

As cultural practices, the sciences thus form an integral part of the ordering of (social) life and the ongoing reconfiguration of reliable and meaningful environments — on an individual and societal level. This is how I discuss science.

2.3.3. Contested Science

By unveiling science as situated practices, I did not intend to necessarily problematise those practices. Historically, the sciences have undoubtedly been immensely beneficial. In tandem with growing technological capabilities, the sciences have, for example, significantly increased humans'

[41] One can also observe 'scientific cultures of non-knowledge' (Böschen *et al.* 2006, 2010).

ability to alter the physical world and indeed themselves (e.g., Wehling 2005). Yet, these application of technology and scientific knowledge are an "act of will" (Renn 2014: 5–6). With science and technology increasingly employed to modify physical surrounds thus also grows humans' responsibility and the need to socially justify those applications (*ibid.*). This is particularly apparent in debates concerning science and technology's 'surplus of effects' (Stehr 2003) — the potential for unanticipated consequences. Within the described shift towards the growing importance of manufactured risks, the sciences and the side effects of their utilisation can then become subject to public scrutiny. Given instances of past large-scale environmental degradation caused by humans (e.g., the ozone crisis (Roan 1989) or Chernobyl meltdown (Beck 1992)), citizenries now "attempt to grapple with and to hold someone accountable for the increasing danger and risks of medical and technological developments" (McCarthy 1996: 90; also Jasanoff 2002: 368). As I shall show in the context of CSG developments, these demands pose challenges for opponents, proponents and regulators alike.

Yearley (2005: 138) therefore notes that "official agencies [and publics, I might add] are commonly left with no alternative but to demand 'more and better' science; yet there are few grounds for thinking that further steps down the same path will resolve the problems outlined above". This is especially so if no thresholds are established for when sufficient research has been conducted (Douglas & Wildavsky 1982: 21–28; Evensen 2015; see Chapter 8.2.). Additionally, one may frequently find that information "is no longer a scarce resource" and that "the idea of solving social problems through '*beefed-up* public education campaigns' is strikingly simple" (Ungar 2008: 321, original emphasis). Merely conducting more research may therefore do little in addressing citizens' scrutiny (see Chapter 5).

In fact, accumulating research itself can generate uncertainty and increase scrutiny in the first place. The technology assessment specialist Grunwald, for instance, describes how non-expert citizens and policy-makers often experience an "experts' dilemma" or the "confrontation of expertise and counter-expertise" when dealing with controversial issues (2003; also Douglas & Wildavsky 1982: 49–66). Appeals to scientific or expert advice are therefore frequently to no avail if counter-expertise is readily available or the conclusiveness of research subject to ongoing debates. Yearley (2005: xiv) thus fittingly remarks that "far from solving the questions once and for all, the recent experience of scientific testing ... is that it results in acrimonious and inconclusive conflicts among alleged experts". In light of this plurality and fragmentation, Jasanoff (2002: 364) consequently contends that nowadays "[c]itizens, experts and policymakers … cannot agree on the nature and severity of technology's risks, let alone on the measures that should be taken to control them". The resulting experiences of uncertainty, including its negative psychological effects, can further be increased by scientists and professionals themselves who, paradoxically, highlight those

uncertainties in order to remedy them; a phenomenon Minnegal and Dwyer (2008) coined 'uncertainty paradox'. Is the scientific endeavour then failing?

Quite the opposite may be the case. Following Beck (2005: 588, original emphasis), the contingencies and uncertainties of modern risk debates often emerge "precisely *because of* and not *in spite of* the knowledge that we have accumulated about ourselves and about the material environment" (also Stilgoe 2007: 48–49; see Chapter 6.2.). In highlighting the role of science in this context, Beck (*ibid*.: 589–590) contends that it "is not the failure but success which has demonopolized science. … The more successful sciences have been in this century, the more they have reflected upon their own limits of certainty, the more they have been transformed into a source of manufactured reflexive uncertainty". Contemporary criticisms of the sciences therefore not merely emerge from 'outside' but "rather is formulated as science" (Stehr & Grundmann 2012: 39); a situation frequently found within experts' dilemmas. Expecting to necessarily derive certainty from more research may thus be misleading and, as some scholars argue, "one could say that we 'know too much'" already (*ibid.*: 40; also Weinberger 2011). Contemporary risk debates that involve inconclusiveness and uncertainty are thus, to a degree, also the product of more scientific research and good expert conduct (Beck 2005: 590, 2009: 115). The sciences themselves can then create knowledge, or at least speculative awareness, of so far 'invisible' hazards and new potential risks through medical or chemical testing (Adam 1998; Arnoldi 2009: 8; Boudia & Jas 2016). Renn (2014: 10) thus cautions against the hubris to assume that uncertainty could be reduced to unequivocal answers about risks.[42]

As a result, the status of science as the "monopoly on the production of *socially relevant* knowledge" (Stehr & Grundmann 2012: 39, my emphasis) and its imagined position 'outside' society frequently become challenged in environmental risk debates. This has allowed for the expansion of the public sphere within which science and technology's legitimacy, authority and acceptable application are critically discussed (Stehr 2001; 2003; Wynne 2003). In these contexts, scientific expertise is now longer centralised and guaranteed but requires ongoing negotiation and justification (Böschen 2012: 117; Rifkin & Martin 1997; Weinberger 2011). The demonopolisation of scientific authority and the awareness of inconclusiveness in many risk controversies has granted alternative knowledge and ignorance claims to become a resource of resistance and contestation, including the enlisting of scientific counter-experts. Paradoxically then, those involved in risk debates may "believe less and less in experts, although we employ them more and more" (Stehr: 2003: 646, also 2001: 41). Within risk disputes, scientific expertise and the regulatory institutions

[42] Important is also the positivity and centrality of ignorance in scientific research itself (Gross & McGeoy 2015b: 2–4). Scientific research identifies new unknowns as much as it aims to settle conflicting knowledge claims, always with the belief that ignorance can be transformed into risks and that the unknown can be temporalised and reduced into a not-yet-known (Caduff 2015: 33; Faber & Proops 1993: 127–129).

reliant on it are thus frequently contested with conflicting (scientific) knowledge and ignorance claims that also demand validity and legitimacy (Böschen 2012). As I demonstrate below, this prompts the question whether environmental risk controversies require scientific solutions as much as social and political resolutions (cf. Beck 2005; see Chapter 8).

In conclusion, this chapter's three sections on (not) knowing, risk and science illustrate how within disputes over manufactured risks the sciences might not be able to entirely settle disputes. Negotiations over the validity and legitimacy of knowledge and ignorance claims therefore become normalcy rather than the exception. However, understanding how such contextually-situated epistemic disputes emerge and the ways that negotiations actually play out requires careful empirical analysis (Dwyer & Minnegal 2006). Further, stating that the sciences' authoritative status is diminishing does not sufficiently address the question what role scientific knowledge claims precisely take within any given debate. While this chapter clarifies my conceptual perspectives and theoretical framework, the next step is therefore to engage with these empirical questions within the context of CSG developments in the Western Downs. I will address the role of science in knowing environmental risks from CSG extraction after outlining the historical context within which CSG projects emerged.

3. Looking for Water and Finding Fire: From Pastoral to Extractive Frontier

The stories of Australia's inhabitation, especially when leaving behind the continent's narrow coastal strips, are inseparably linked to continuous struggles for securing access to fresh water — the 'lifeblood of the continent' (Brodie *et al.* 2012). In Queensland and the country's north-eastern semi-arid to arid interior, this quest requires careful resource management and would be largely inconceivable without the groundwater collected in the Great Artesian Basin (GAB) and other underground aquifers (see Chapter 1.1.).[43] The springs that emerge along the GAB's discharge zones were utilised by Aboriginal peoples for millennia and still hold cultural significance. However, it was the ability to collect scarce surface water and extract the underground's 'lifeblood' via modern bore drilling technology that enabled the post-European settlement expansions inland (de Rijke *et al.* 2016). My aim in this chapter is to specifically address this role of (ground) water as a 'geological agent of change' (Brodie *et al.* 2012: 354) by exploring the resource history of the Darling Downs and Surat Basin.[44] Particularly scientific knowledge and technological innovation are important within these historical transformations and the making of the GAB and other aquifers as knowable and exploitable resources — of the underground as 'vertical territory' (Braun 2000).

This similarly applies to CSG and other hydrocarbons. The becoming of water and CSG as resources can therefore not be understood in isolation but must be placed within broader resource environments. By this I refer to "the complex arrangements of physical stuff, extractive infrastructures, calculative devices, discourses of the market and development, the nation and the corporation, everyday practices, and so on, that allow those substances to exist as resources" (Richardson & Weszkalnys 2014: 7; also Bakker 2012). It is thus crucial to highlight the epistemic and technological practices that brought water and gas into being, as well as the historical connections and interplays between those resources. I do so by outlining the groundwater exploration of the Surat Basin that forms part of the GAB, but which also holds desirable mineral and especially hydrocarbon resources. It is further the basin that primarily underlies the Western and parts of the Darling Downs (see Chapter 1.1.). Focusing on the resource histories of the Darling Downs and the Surat Basin provides a case to elicit some important aspects of the entanglements between these surface and subterranean entities that are crucial in the context of CSG risk debates.

[43] For more detailed overviews of the GAB see Brodie *et al.* (2012: 341–345); de Rijke *et al.* (2016); Powell 2011.
[44] I utilise the notion of 'agent of change' to highlight the importance of certain resources in the transformation of the Darling Downs, but do not suggest that innate substances or objects have agency.

3.1. Looking for Water and Australia's Garden: the Transformation of the Darling Downs

In this section, I consider the contested post-settlement resource history of the Darling Downs and focus specifically on its northern and western areas that since 2008 form part of the Western Downs municipality, which in turn overlies the eastern outcrops of the geological Surat Basin where major CSG projects are being developed. The Western Downs nowadays constitutes a clearly demarcated political entity that extends past the less defined historical Darling Downs. However, these political separations are recent developments and the story of the Western Downs can be told through the lens of the Darling Downs region (see Map 6; cf. Map 1 & 4).

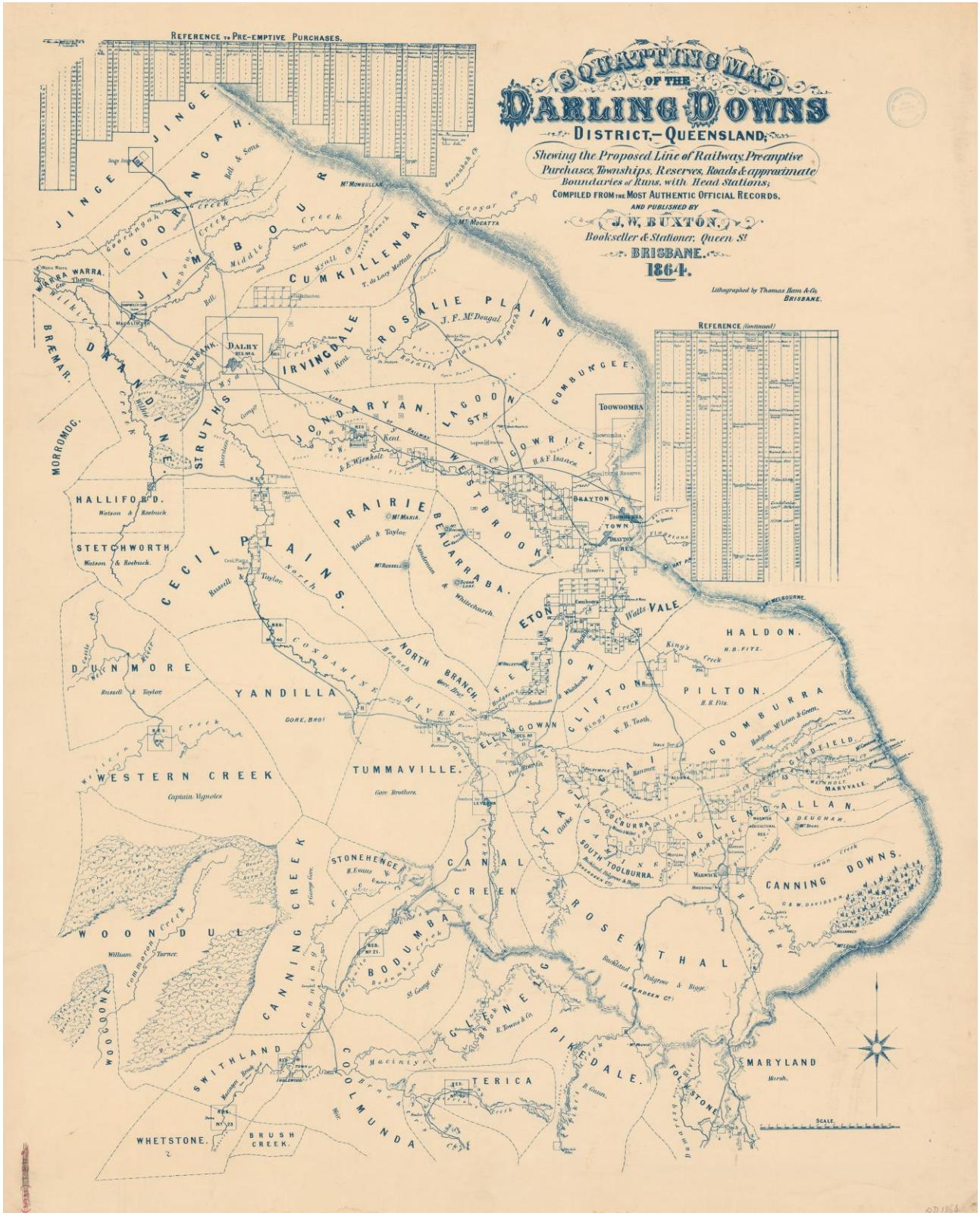
The post-settlement history of the Darling Downs begins on 5th June 1827 with its discovery by the distinguished explorer and botanist Allan Cunningham who "on this day … had the first view of the 'Garden of Australia', which it is now familiarly called" (Hall 1925: 5). Cunningham and his party had travelled north inland from the Upper Hunter Valley when, due to a detour east, they "entered upon the extensive Downs before us … [with] extensive tracts of open country, which I subsequently named (by permission) Darling Downs, in honour of His Excellency the Governor" (Cunningham 1827, quoted in Hall 1925: 7).[45] The region's main waterway — "a small river, about fifteen yards in breadth, having brisk current to the north-west" — he named Condamine River, "in compliment to the officer who is aide-de-camp to His Excellency the Governor" (*ibid.*: 6 & 7). A year later he also found a pathway across the mountain ridges of the Great Dividing Range that separate the Darling Downs from Australia's eastern seaboard; 'Cunningham's Gap' is still the route travellers take today to cross the range.

Cunningham had discovered an area of fertile plains with "extensive tracts of timberless lands [that] were not wanting in water" (*ibid.*: 6). Passing through this region two and a half decades later, the Prussian explorer and naturalist Ludwig Leichhardt noted (1844, quoted in French 1994: 16):

> Large plains extend along the River Condamine … a true savannah … . All this country, from the Condamine to the range, is called the *Darling Downs.* There is no equal to them over all the colony for sheep rearing, for the fatness and tenderness of the mutton, for the excellent qualities of the wool (which, however, is not generally admitted,) and for the cheap rate for which flocks can be managed. One shepherd can look after 2000 to 3000 sheep, which would require four shepherds in other parts.

By the time Leichhardt crossed the plains, the development of the pastoral frontier had only just started though, after the settlement of the Darling Downs had been prevented for over a decade due to several reasons (French 1997: 5–7).

[45] Sir Ralph Darling, Governor of New South Wales from 1825–1831 (French 2010).



Map 6 Squatting map of the Darling Downs district with Dalby in double squares (north-western corner), prepared by J.W. Buxton in 1864 (source: SLQ)

3.1.1. The Making and Transformation of the Pastoral Frontier

It was not until 1840 that so-called squatters began venturing into the Darling Downs seeking new pastures for their sheep and cattle beyond the overcrowding New England area further south (French 1997: 1 & 6). Squatters were either British free settlers or ex-convicts who claimed vast areas of land for grazing of sheep, cattle, and horses. These squatters "pursued an antipodean fortune on the pastoral frontier of New South Wales in order to retire in relative ease and comfort to an English estate, London club, or Sydney town house", which brought with it "high expectations of quick profits, cheap labour, political influence, and graceful living" (French 1990: 1). The newly discovered fertile Darling Downs were thus primarily perceived as promising for the profitable rearing of sheep and cattle (*ibid.*). These early pastoralists saw themselves as the 'Pure Merinos' elite — gentlemen pioneers that would bring civilisation to the barbaric frontier (French 1992: 1; 1997: 1; Waterson 1968: 15). They soon developed a distinctive culture and political milieu (*ibid.*). Their numbers and pastoral activities grew rapidly from a mere fifty-five Europeans in March 1841 (all males) with little stock, to 110,200 sheep, 9260 horned cattle, 445 horses, and 300 Europeans in September 1843. As these incoming settlers crossed the Great Divide, the Darling Downs became increasingly occupied and they were forced to extend the frontier further north and west past the Condamine (French 1989: 81–90). In doing so, they ventured into what is now known as the Western Downs.

While no distinct geographical features exist that could indicate where the Darling Downs transforms into the Western Downs, incoming mid-19th century pastoralists must have noted the changing landscape once they left behind the black soils of the Condamine flood plain (see Waterson 1968: 51–52). The contrast is still apparent a century and a half later. Hinting at the gradually declining availability of crucial natural resources such as high-quality soils, freshwater and lush pastures, Greenwood (1957: 3 & 9) fittingly remarks:

> The Western downs … present more undulating country with tracts of ridge and plateau landscapes, but on the whole there is no sharp topographic break at the western margin of the Condamine plain. The remarkable landscape change that does take place along this line reflects a change in soil character and therefore in vegetation and land use. … Immediately west of the black clay plains, there is an abrupt change to a coarse, dry, sandy soil which lacks the lime, phosphates and other useful elements of the black clays.[46]

The Western Downs were and are by no means unproductive or undesirable land though, and, like the entire Darling Downs, experienced a period of rapid settlement during the early frontier days.

The incoming pastoralists required and demanded vast territories that were already occupied by Aboriginal peoples. In expanding the pastoral frontier, they "slowly displaced the 1500 to 2000

[46] On the relationship between soil types, land use and population patterns see Allen & Skerman (1986: 49–53).

men, women, and children of the Jaroweir (Bunya), Giabal (Toowoomba), Keinjan (Warwick), Barunggam (Dalby–Chinchilla), and Kambuwal (Macintyre) tribes who had hunted, fished, and gathered in the region for at least 15000 years" (French 1997: 23–24; see Map 7).

Map 7 Aboriginal tribal boundaries in the Darling Downs (source: French 1989: 12)

The socio-cultural and environmental impacts of this displacement and subsequent development are noted by French (2002: 24):

> The Downs, where native grasses grew higher than a horse's belly … became the jewel in the diadem of squatterdom. Between 1840 and 1850, some 2000 white men (but few women) established fifty pastoral stations on the grassy plains; native fauna abandoned the polluted watercourses to 1,400 horses, 43,000 cattle, and 600,000 sheep; native grasses, destroyed by cloven hooves, failed to regrow as 'imported' seeds — such as Bathurst burr — gained hold. The environment - human and natural - was traumatized.

By 1859, a mere twenty years after the opening of the pastoral frontier, nearly all the land of the Darling Downs had been taken up by "7000 settlers, 1.5 million sheep and 140,000 cattle scattered over 1.2 million hectares; there were very few of the original inhabitants — the Aborigines — left" (French 1997: 1; also Waterson 1968: 11).

While the local Aboriginal histories demand careful examinations in their own rights, I can generally note that the systematic displacement and extermination of Australia's Aboriginal peoples was wide-spread practice and deeply rooted in the British doctrine of *terra nullius.* For example, in an effort to induce further settlement, the Unoccupied Crown Lands Occupation Act of 1860 promoted pastoral occupation of 'waste' lands, which suggests no prior or existing Aboriginal inhabitation (Allen & Skerman 1986: 11–12).[47] This lack of recognition and disregard of basic rights also led to mistreatment and outright violence during early settlement, such as the Darkey Flat Massacre around 1848 (French 1997: 25–31; Hall 1925: 149–152). However, it was not just acts of displacement and violence that decimated Aboriginal people (French 2002: 27):

> What bullet, sword, and dog did not accomplish, European diseases did. In 1847-1849, an influenza epidemic decimated the Darling Downs Aboriginals; smallpox struck them between 1849 and 1853. By the late 1840s, venereal diseases were taking their toll on fertility rates, so by 1852, Commissioner Rolleston reported 'a young child is rarely seen'. The world of the Downs Aborigines had been destroyed psychologically, culturally, and demographically.

Aboriginal peoples and their culture did not fit into the settlers' imagining of the Downs as an idyllic English landscape and their transformation from wilderness to civilisation according to Western ideals and with European technologies. Arriving settlers consequently made themselves 'at home' and created places of non-belonging for the Indigenous Others (Frawley 2007: 328; French 2010; Waterson 1968: 11–13).[48]

[47] However, the savannah-like grasslands that lend itself so well to pastoralism may not have existed without the landscape management by Aboriginal peoples (e.g., seasonal burning to prevent tree growth; Waterson & French 1987: 55).
[48] For detailed histories of Aboriginal struggles with European settlement in the Darling Downs see French (1989 – especially Chapter 7, 2002); Elder (2003: 147–158); Hall (1925: 7, 17–20); or Riethmuller (2008). Despite this adverse history, the Western Downs' Aboriginal heritage can be traced until today in numerous Gooneburra place names: Jimbour from *Gimba* (sheep or good pasture), Chinchilla from *jinchilla* (a cypress pine) or Jandowae (water-hole) (French 1989: 121).

It is therefore unsurprising that while some Aboriginal people found work on the pastoral stations, most labour was provided by white colonialists and required a constant influx of outside workers. Especially the collection and protection of valuable freshwater, including well-sinking, dam-building and fencing, proved labour-intensive and costly (French 1997: 1; Waterson 1968: 61). Labour shortages emerged during the 1850s when another resource attracted many free settlers: gold. Vast quantities were discovered in the fields around Bathurst in New South Wales and especially throughout Victory, so that gold became Australia's most valuable export commodity between 1851 and 1870 (Huston *et al.* 2012: 384–402). This "gold rush that changed a nation" (*ibid.*) caused wages to sore, while simultaneously drawing in significant numbers of overseas immigrants; by 1861, more than 24,000 Chinese had migrated to the Victorian fields alone.

The resulting labour exodus in the Darling Downs and also the promise of large profits prompted desperate and sometimes dubious searches for local fields, which ultimately remained unsuccessful (French 1990: 61–84; 1997: 57–68). It was not until September 1867 that Queensland's first major goldfield was opened some 300km north-east near Gympie. Together with another discovery near Charters Towers in the state's far-north in the early 1870s, these fields saved the young colony from bankruptcy (*ibid.*; Huston *et al.* 2012: 387). So while this early resource boom clearly brought brief disruptions to the development of the Darling Downs, its advantages, such as rising wool prices, ultimately benefitted the frontier settlers and led to the most profitable period of pastoral enterprise ever encountered in Australia between 1871 and 1877 (French 1997: 66–67; Waterson 1968: 60).

The late 1860s and 1870s experienced further intensification of land use through increasing subdivision of existing paddocks and improving carrying capacities. Stock numbers would ultimately peak in 1868 and remain so over the next decade with some 3.5 million sheep throughout the Downs. Pasture and stock growth in turn required stable water supplies against an inland climate that was and is prone to erratic precipitation extremes causing droughts and floods (see Images 2 & 3).[49] As Waterson (1968: 50–51) describes:

> The Downs was extremely well-favoured by nature, its unique combination of physical advantages making it one of the most attractive (and lucrative) areas of wool production in Australasia. All the Downs received an average annual rainfall of over twenty inches … . Nevertheless, severe droughts, felt more in the west than in the east, occasionally struck the Downs, causing considerable stock losses. … The short, sharp drought of 1871 was typical: 'For miles around Dalby the country … is as bare as the road, and almost entirely devoid of water … carcasses may be seen in hundreds. The lambs are perishing in immense numbers, the ewes through weakness being unable to rear them ... public prayers for rain have been offered at Dalby'.

[49] On the challenges of reoccurring floods and droughts see Heritage Consulting Australia (2011: 87–88) or Hall (1925: 84–87).

Image 2 Water — a crucial resource: washpool at the Jondaryan sheep station, ca. 1877 (source: SLQ)

Image 3 Water — a crucial resource: sheep dipping, Queensland, ca. 1897 (source: SLQ)

The omnipresent challenge of securing access to freshwater eventually prompted what would be revolutionary not just for settlement in the Downs but throughout inland Australia: the extension of the resource environment of the pastoral frontier underground. International advances in storage and especially bore drilling technologies opened up the subterranean groundwater of the GAB and other aquifers as the new vertical frontier (de Rijke *et al.* 2016; see Images 4 & 5). The utilisation of these new technologies and active water management became a crucial aspect of the Western Downs' resource environment (Waterson 1968: 61–62):

> Once subdivision had proceeded, each paddock had to have permanent water-supply. Pre-emption had safeguarded the natural water but expensive earth-dams and reservoirs were constructed where streams did not flow and waterholes dried up. … After the mid-'seventies all pastoralist were tapping the sub-artesian reservoir which lay from 40 to 100 feet under the soil. The American geared windmill, constantly pumping into an iron tank, was a familiar sight by 1880. Jimbour by 1884 had 22 dams, 26 reservoirs and 20 wells, while Yandilla alone had 24 windmills.

Image 4 Water management: sheep drinking water from an artesian bore on Cambridge Downs Station, ca. 1894 (source: SLQ)

Image 5 Water management: Horse teams and ploughs used to dig dams, Tara district 1932 (source: SLQ)

Apart from the first gold rushes and progressively more manageable natural challenges, a more severe threat to the pastoralists' idyll, established culture and profits arose during the later decades of the 19th century along with their intent to civilise the wild Downs. On the one hand, it was the growing agricultural sector that, supported by various favourable colonial selection acts, increased the existing land use competition. On the other, it was money-lending storekeepers and small entrepreneurs that brought urban lifestyles and — as the colonial by-product of the Industrial Revolution — bourgeoisie ideals and Enlightenment values to the emerging towns of the Downs (Waterson 1968: 66). One can thus observe a profound "transformation of the frontier from nomadism and pastoralism to settlement and agriculture … . Squatters may have been the heralds of civilization but townsmen and farmers confirmed its arrival" (French 1992: 1). Agricultural practices were about to fundamentally change the resource environment of the Western Downs.

In attempts to promote denser settlement with more intensive, family-operated agricultural land uses over extensive, less productive pastoralism, Queensland's colonial governments passed several Selection and Lands Acts during the 1860s and 1870s that encouraged the free selection of land (Allen & Skerman 1986: 11–17). The attracted 'selectors' — new settlers that were often German or Irish immigrants (French 2010) — regularly stood in direct competition with the established

squatters.[50] However, squatters were given the right to pre-emptive purchases of land and frequently choose crucial watercourses and the flattest, most productive land, which left selectors with the drier, hillier and timbered parts (French 1997: 2). The pastoral elite was also quick to proclaim the poor suitability and limited potential for agriculture in the region and that 'the Darling Downs will not grow a cabbage'.[51] Due to these and various other reasons (*ibid.*; Waterson 1968: 97) and although pro-active colonial legislation existed, only three per cent of the Downs had been developed into cropping land by 1892. Furthermore, inbound selectors were inexperienced, inherently conservative in taking up scientific agricultural knowledge and unfamiliar with the environmental and climatic particularities of the Downs. At least initially, agriculture was therefore not an idyllic success story but rather a struggling endeavour (French 1994: 2, 1997: 2–3; Waterson 1968: 97–125; see Images 6 & 7).

Image 6 The tough beginning of a new era: selectors' camp at Warra, ca. 1906 (source: SLQ)

[50] For a description of the selection process and early agricultural life on the Downs see Waterson (1968: 147–151).
[51] 'When wheat shall be grown on the Darling Downs' used to be an Australian expression for high improbability (French 1997: 1–2; Waterson 1968: 155).

Image 7 Selectors hut with the all-important rainwater tank at Warra, ca. 1906 (source: SLQ)

At the dusk of the century, however, the Downs' farmers began to understand their unique advantage: unlike almost any other region in Australia, much of the Downs is "overlain by immensely deep black soils, similar to the Russian chernozems, capable of being cropped for many decades without expensive fertilizers … . The fertility of the black earths giving extremely high yields of grain helped offset climatic disadvantages" (Waterson 1968: 143–144). After becoming more politically organised, the agriculturalists increasingly gained access to these fertile black and red volcanic soil plains and gradually adapted more resistant crops, improved farming practices and cost-cutting machinery. They also recognised that mixed farming — combining grain, dairy, cattle and pig rearing — on moderately sized selections was most successful. This diversification was itself only made possible by the introduction of refrigeration technology and an expansion of the existing railway network, which enabled the storage and transport of butter, cheese, milk and bacon (French 1997: 2–3, 2010; Hall 1925: 128–139; Waterson 1968: 152–163). The two and a half decades prior to the First World War were marked by unparalleled economic growth, with over a thousand new farms emerging out of pastoral estates and a doubling population with growing towns and villages along the region's improving transport network (*ibid.*). Throughout this time, the Downs became aptly known as the 'Garden of Australia'.[52]

[52] The garden imagery was invoked by the Toowoomba-based poet George Essex Evans whose 1899 essay refers to 'The Garden of Queensland', while in 1908 he uses 'The Garden of Australia' to describe the Darling Downs (French 1994: 3).

As for the pastoralists, however, this rapid agrarian transformation was and is crucially dependent on scare water supplies. During the turn and early decades of the 20th century, land clearing and advances in drilling and pumping technologies would therefore further alter the region's landscape, creating ever-changing resource environments marked by techno-scientific innovation and intimate entanglements between the surface and subterranean basins. By 1897, 541 bores had already been drilled across Queensland (Powell 2011), which highlights those dependencies and the growing importance of groundwater irrigation (see Images 8 & 9).

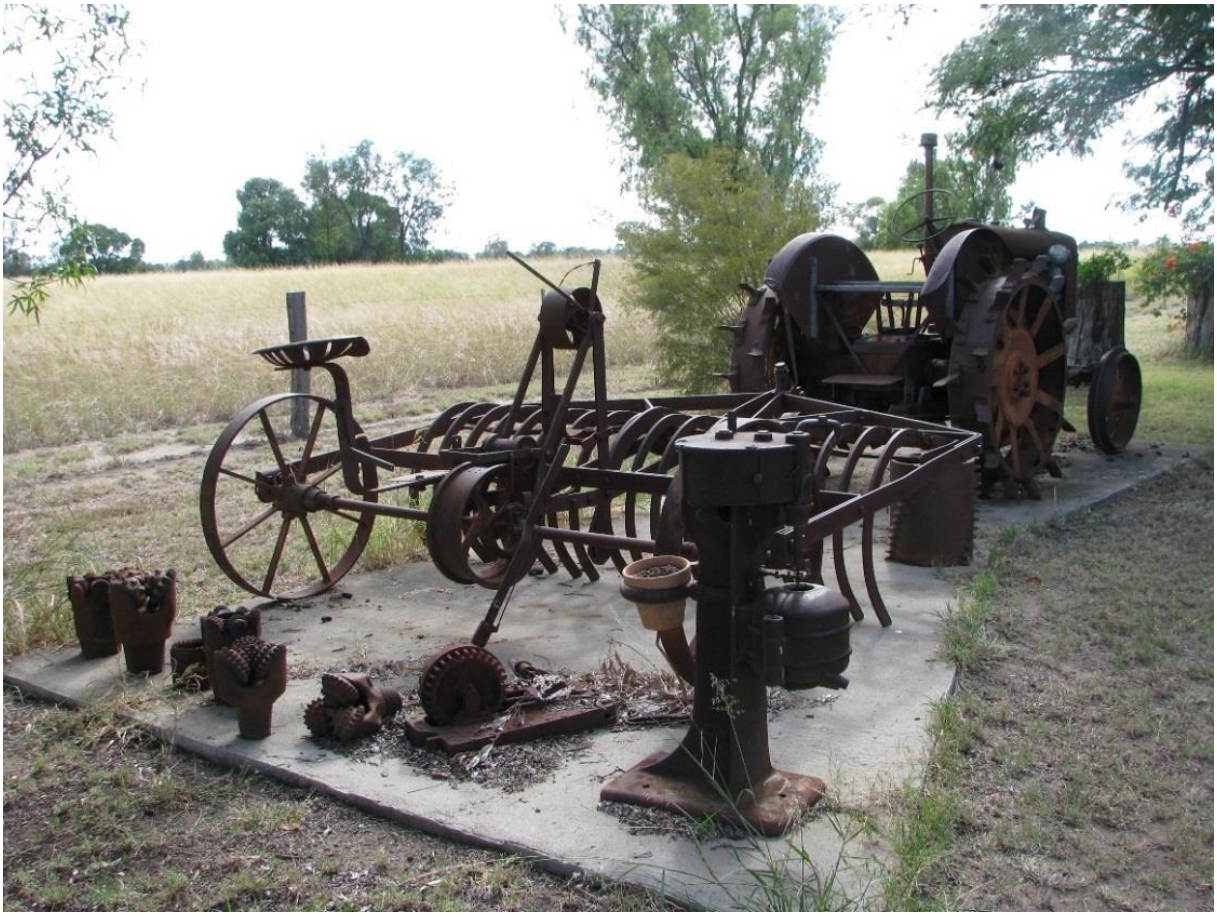


Image 8 Artefacts that illustrate the intimate entanglements between agriculture, industrialisation and subterranean resources: drill heads, plough and tractor on a grazier's property near Wandoan (source: author 2015)

Image 9 A common sight west of the Divide: a windmill near Toowoomba, ca. 1925 (source: SLQ)

With the arrival of the railway and the beginning exploration of the underground emerged also a demand and opportunity to benefit from another of the Surat Basin's resources: coal. As Hall (1925: 140 & 4) remarked:

> It is certain that coal underlies the Darling Downs in huge quantities at varying depths, and will become an asset of immense value to future generations. … Some coal beds have been worked successfully for years but there are many others lying as Nature made them, awaiting the power of Capital to vitalise the energy of man, so as to make the Darling Downs take its proper place as a coal mining area.

Unsurprisingly, coal was soon eagerly exploited.[53] Initially mined throughout the Downs in small underground pits such as Oakey, Gowrie, Sugarloaf and Tannymorel (Waterson & French 1987: 62), a larger deposit was later discovered near Warra, fittingly when a well was dug. This led to the opening of a privately-owned coalmine in 1914 (Heritage Consulting Australia 2011: 95–96; see Image 10). While profitable during the First World War when commodity prices soared, the mine was closed in 1919 due to safety problems caused by water seepages and unprofitability. To this day, however, coal — let alone associated CSG — in the Surat Basin remains a resource of interest with over thirty operating, planned or proposed individual projects throughout the Western Downs alone (AWD 2014).[54]

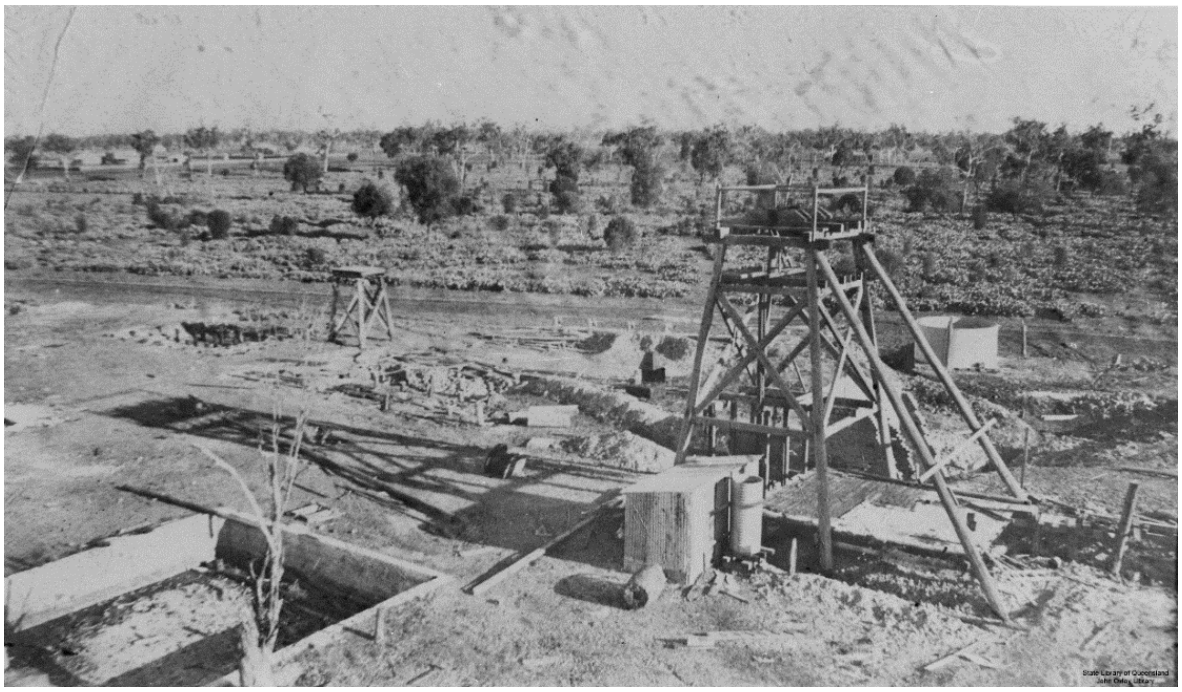


Image 10 Exploiting the underground: coal mining shaft at Warra, 1916 (source: SLQ)

Mixed farming on moderately sized properties remained the predominant land use though, with wheat growing and especially dairying the backbone of the Darling Downs' economy during the interbellum. Still a settler frontier, the Downs continued to be largely reliant on primary and extractive industries; "[w]hat people could produce from the land and what lay below it were still the major products in 1920, as in 1850" (Waterson & French 1987: 63). Until the late 1930s, the number of dairy farms grew to over 6,500 with an average of 30 cows each. Correspondingly, cheese factories would burgeon 1910–1921 and throughout the 1920s Queensland was the largest

[53] For an early example of pro-development discourses see the first issue of the *Queensland Government Mining Journal*: "'A New Birth.' It has long been the opinion of those most qualified to judge that the progress of the Colony of Queensland has been greatly retarded by an ignorance of her resources not very flattering to the eye of modern discernment" (15th June 1900: 1).
[54] Greenwood (1957: 32) notes: "Thin seams of coal that outcrop irregularly in various places in the eastern downs were counted of little value in the early days of 'gold fever', but it is the coal that has proven to be of more enduring value".

cheese producing state in the young Australian nation. The 'cream cheque' would save many families during tough droughts and the 1930s' Great Depression, which caused widespread unemployment and even homelessness (French 1994: 2, 2010; Heritage Consulting Australia 2011: 96–97 & 108–111).

3.1.2. Changing Landscapes, Shifting Economies and Manufactured Risks

In addition to the geo-political developments of the interbellum, the Downs' farmers also faced challenges within their immediate resource environments. Since the first artesian bore was sunk in 1878, thousands of bores, often free-flowing and only utilising fractions of the pumped water, had been drilled throughout Queensland and the Darling Downs. This over-exploitation of groundwater resources caused constant declines in groundwater levels throughout many areas during the 20th century (de Rijke *et al.* 2016). During the interbellum however, these arising difficulties were overshadowed by the rapid spread of an intrusive weed that would soon flourish especially in the brigalow (*Acacia harpoohylla*) landscape of the Western Downs.

Various species of the South American prickly pear (*Opuntia monacantha*) had been brought to Australia from as early as 1788 when the First Fleet arrived in Botany Bay after stocking supplies in Rio de Janeiro. Initially introduced as the host plant to an economically important cochineal insect that produces pigment-rich fluids used for dying fabric, prickly pear became domesticated as an ornamental, fence and fodder plant (Frawley 2007). It was grown only with limited success in the humid coastal climates of the first settlement areas, but soon found more favourable conditions in the drier bushlands and open forests further inland. While at first cultivated by settlers themselves, its indigestible seeds were uncontrollably scattered by cattle, sheep, native fauna and flood waters (*ibid.*). During its most active period after the First World War and the labour-shortages it had caused, prickly pear plants covered an estimated 10 to 25 million hectares of inland Queensland and New South Wales and spread at one million acres a year, displacing many resigned landholders (*ibid.*; de Rijke forthcoming; see Image 11). As Frawley notes (2007: 327–333), prickly pear:

> created a new distinctive landscape: not indigenous, not exotic, but a mixing of the two. … They [settlers] were now living in prickly pear land. … It became a serious biological barrier to the settlement of the Australian inland at a time when closer settlement was a cultural, political and economic desire of the colonies. … By its voracious reproduction the prickly pear had changed the reality of settlement. … [The plant] became more than a pest; it became an enemy.

The fight against prickly pear lasted decades and involved various strategies to bring the outbreak back under control from mechanical removal, to poisonous reclamation, and turning livestock into 'eating machines' (Frawley 2007). After years of intensive trial-and-error research

and numerous scientific studies, biological control became the focus of efforts to manage the pest. In 1919, eleven promising species of insects — natural enemies of the plant — were brought to Australia and by 1923 the response to this environmental crisis became institutionalised with the creation of the Commonwealth Prickly Pear Board. The establishment of a transnational network that "was not just a local place, but mobilised knowledges, plants, people and ideas from all over the world" (*ibid.*: 338) ultimately allowed for a successful treatment of prickly pear and another "triumph of modern pioneering" (Waterson 1991: 17). Field stations for scientific research and the reproduction of insect larvae, such as the one in Chinchilla, were founded and in 1926 the highly effective South American cactoblastis moth (*Cactoblastis cactorum*) was introduced to the Downs (see Image 12).

Image 11 Abandoned property overtaken by prickly pear near Chinchilla, May 1928 (left) & after biological treatment with cactoblastis moths, Oct. 1929 (right) (source: SLQ)

Image 12 Tending cactoblastis cages (left) & packing them for distribution (right) at the 1923 established Chinchilla field station — the 'bug farm', ca. 1930 (source: WDRC)

Just as water had become a geological agent of change that transformed the Downs, these moths arrived as 'biological agents of control' (Qld Govt 2014) and in the early 1930s the pest became manageable. However, the prickly pear invasion had altered the Downs' landscape by displacing much native fauna. Removing the dying plants provided an opportunity to convert large areas into cleared agricultural lands, so that these efforts where not restorative but an "even greater environmental transformation than any that had gone before" (Tyrell quoted in Frawley 2007: 337). New land was thus opened up for intensifying farming practices.

Further changes occured during and after the Second World War. Mixed dairy farming had been the region's economic backbone for decades, but many young men left once the war began to fight overseas or to migrate into urban centres as much-needed labourers. Dairying continued to strive, however, as long as the Australian and British military paid premium prices for butter and cheese. Local demand was also high with airfields, ammunition depots and defense infrastructure built across the Downs (French 2010; Heritage Consulting Australia 2011: 109–111). This started to change after the war when increasing economic pressures mandated a move away from small family farms towards larger commercial farming of not just wheat, but sorghum, sunflower and safflower. Extensive mechanisation also enabled agriculturalists to grow and harvest greater quantities of crop and large concrete wheat silos soon became a common sight throughout the Downs (Heritage Consulting Australia 201: 104). Mechanisation was further accompanied by transformative government land clearing policies and grand-scheme infrastructure projects such as sealed roads and rural electrification. Within this context of progressive rationalisation and globalisation, dairying gradually declined until the end of the 20th century and gave way to larger and more profitable industries (French 2010).

Crucial for this transformation was once again the increasing utilisation of surface and groundwater resources. Facing the ever-present threat of severe drought, water bore drilling had been a desired, yet costly, way to gain access to secure supplies. Around the middle of the century, however, drilling technologies improved and became more affordable. Large government irrigation schemes also encouraged groundwater use (Brodie *et al.* 2012: 347), so that thousands of bores were drilled across the Darling Downs and Queensland for domestic use, stock water and crop irrigation (de Rijke forthcoming). Especially the fertile black soils of the Condamine flood plains can, when irrigated, sustain high-yielding crops (Dafny & Silburn 2013: 5):

> Until the early 1960's, intensive agriculture expansion was also limited by water availability, as the major source for irrigation was surface water. Rapid growth of irrigated land occurred in the 1960's concurrent with the development of boreholes and pumps to extract groundwater: for example, in Jondaryan shire, total irrigated area increased from 372 hectares in 1960 to 4,259 hectares in 1969 … . Currently, the area is heavily utilized for agriculture and is one of the largest growing centres of cotton and grains in Australia.

The emergence of large scale irrigation also required further transformations of the Downs' landscape and resource environment. Land clearing continued and land use intensified, including laser-levelled broad acre farming and the construction of large irrigation infrastructure (see Images 13 & 14).[55]

Image 13 Intensified land use: irrigation infrastructure on a levelled cropping field with cotton pressed into bales near Dalby (source: author 2015)

Image 14 Intensified land use: irrigation infrastructure (source: Queensland Centre Pivots & Linears Pty Ltd.)

[55] Since the Europeans' arrival, over 90 per cent of Queensland's Brigalow Belt forest has been cleared (Seabrook *et al.* 2016; Waterson 1991: 18).

Water usage was initially not licensed and largely unmonitored, soon resulting in over-use and declining groundwater levels. The floodplains were declared a 'district of sub-artesian supply' in the 1960s and the Condamine Restricted License Area was established in 1970. These measures required new bores to be licensed and restricted the numbers of users. However, further steps were necessary to control the use of surface and groundwater, which led to the declaration of the Condamine Groundwater Management Area in 1978. Meters were installed in some parts of the floodplains, authorised allocations enforced, and excess water use charges introduced. While metered pumping subsequently became regulated and was reduced, unmetered and unregistered pumping for stock and domestic use as well as from extractive industries increased considerably between 1980 and 2009. It is thus difficult to estimate total extracted quantities since intensive irrigation began, but declining groundwater levels of up to 25 meters in some areas indicate over-allocation of available surface and groundwater supplies (Dafny & Silburn 2013: ii & 18). This gradual decline in levels and pressures can be observed throughout the entire Surat Basin. Exon (1976: 59) already notes in the 1970s that "[t]he rates of flow have diminished over the years and many artesian bores [in the Surat Basin] have ceased to flow. Flows of over 4000m^3 per day, which were once commonplace, are now rare" (cf. Figure 4).

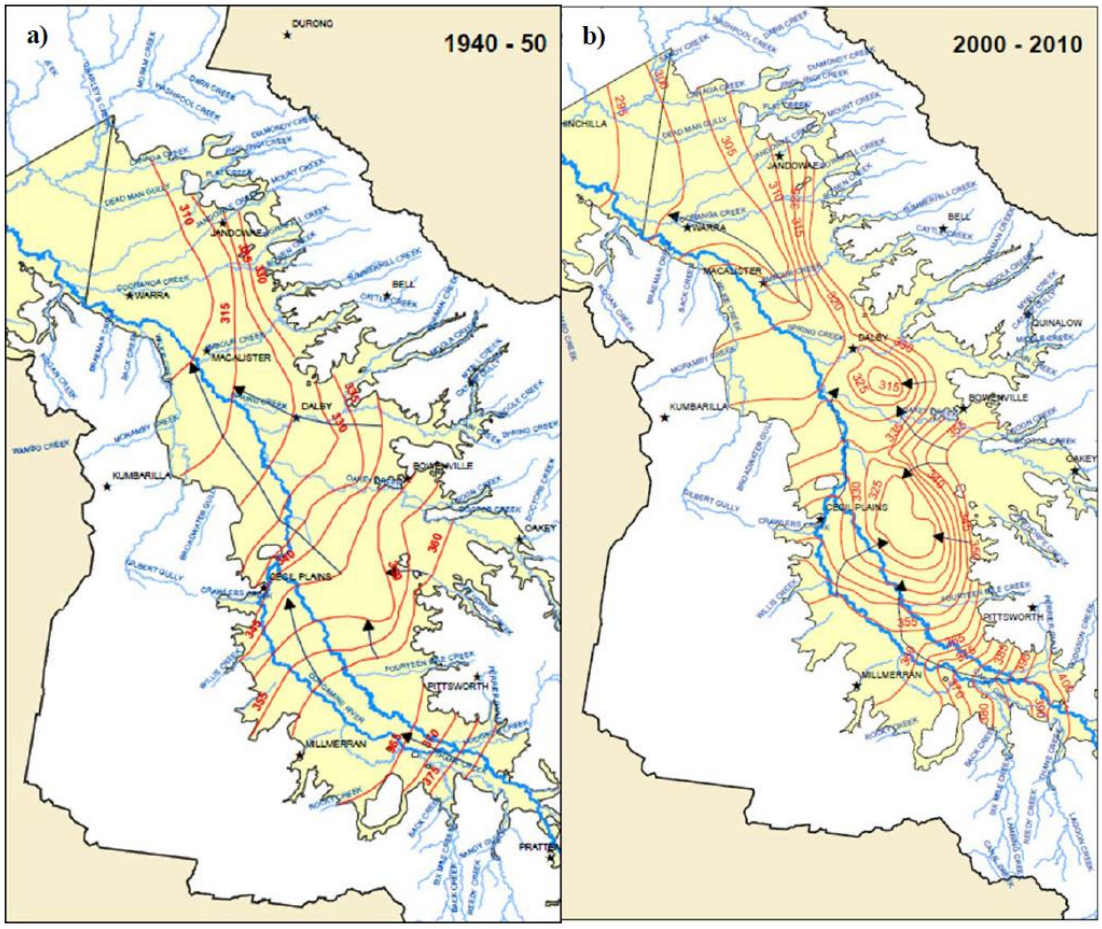


Figure 4 Changing the underground through overuse: groundwater levels and flow directions in the Condamine River Alluvial Aquifer (source: Dafny & Silburn 2013: 13; also Brodie *et al*. 2012: 357–359)

The mounting ecological cost of "the persistent 'progress through development' ethos on the Darling Downs" (Waterson 1991: 16) sparked environmental concerns and resource conflicts. For example, approximately 45 per cent of the Downs had experienced severe degrees of soil degradation from land clearing and overuse by the 1980s, creating not just regional but nationally significant challenges (*ibid.*). Also, the construction of large 'turkey nest' ring dams by some broad acre irrigators has created opposition since the 1990s. Downstream pastoralists who relied on overland flow suddenly faced further supply shortages and environmentalists became alarmed about the potential impacts on wetlands. A Water Allocation and Management Plans was therefore released in 2000, which received strong local resistance and was critiqued regarding the accuracy of scientific information and the hydrogeological modelling. Furthermore, extensive water monitoring throughout the management area was introduced in late 2009 to address problems caused by over-use of surface and groundwater (Tan *et al.* 2012: 39–40 & 45).

These measures illustrate the conflicts over water supplies in the intensively managed landscape of the Downs. These regional conflicts are generally situated within the broader context of Australia's complex post-settlement water politics (Bryant & George 2016; Neale & Turner 2016). More specifically, however, the developments over the last decades also demonstrate that humanly-induced, manufactured environmental changes and impacts of intensifying land and resource use increasingly become the focus of residents' concerns and official management efforts. A shift from notions of mere exploitation towards greater understanding and sustainable management can then be observed since the late 1980s (Brodie *et al.* 2012: 348–349; Powell 2011). As the responses to prickly pear outbreaks and groundwater overuse indicate, this shift is closely related to scientific research and knowledge claims. Therefore, many residents of the Western Downs, particularly those with long local family histories in agricultural occupations, engaged with environmental changes, manufactured risks and complex scientific research outputs well before large-scale CSG projects commenced in the mid-2000s.

3.2. Finding Fire and the Energy Capital of Queensland: Hydrocarbon and Coal Seam Gas Extraction in the Surat Basin

The quests of securing reliable water supplies and exploiting the regions' coal reserves extended the Downs' resource environment underground to the 'vertical frontier', but also brought it into relations to another agent of change: gas. Across the Surat Basin, which underlies most of the Western and parts of the Darling Downs, this has created a long resource history of complex entanglements between these subterranean substances. In this section, I consider the history of hydrocarbon extraction in the Surat Basin that cumulates in the emergence of the Western Downs as

a contemporary CSG hotspot and self-proclaimed 'Energy Capital of Queensland'. Together with the preceding sections, this allows the reader to further situate and contextualise the analysis that follows.

3.2.1. Early Oil and Gas Exploitation in the Surat Basin

The hydrocarbon history not just of Queensland but Australia can be traced back to the small rural town of Roma, which is located some 500km inland from Brisbane in the Maranoa district that is westerly adjacent to the Western Downs. While exploration drilling had occurred throughout Australia since at least 1866, it was not until 1901 that hydrocarbons were discovered accidentally — as typical for that period — when a 'blow-out' occurred during water bore drilling near Roma (Towler *et al.* 2016: 253; Wopfner 1988: 371, 376–378).[56] It took the town's residents five years to utilise the resulting free-flowing gas for street lighting, but in 1906 Roma became the first town with street lights lid by natural gas. As the visiting writer William Hatfield recalls (1932 quoted in French 1994: 293, my emphasis; see Image 15):

> Away back in the dawn of the present era … the citizenry decided the water-supply in the dam was inadequate. They sank an artesian bore to augment it, using the ordinary steam-operated deep drill, with an old-fashioned wood-fired boiler. One day a gust of wind blew across the borehead at the fire-hole door. There was a great flash and a roar. The derrick was blown sky-high. Where it had been rose a leaping flame variously estimated at hundreds to thousands of feet high.
>
> *Roma looking for water had found fire*. Engineers put their heads together and fashioned a great steel dome … and by means of a crane lowered it over the spouting flame, so extinguishing the eighth wonder of the world. It had drawn sightseers by special excursion trains from all parts to see the country-side lit up for miles around at night. They made a valve and fitted that on to the bore-casing when it cooled. Then the water-pipes that had been laid about the town in anticipation of a water-supply were connected to ceilings instead of taps at kitchen-sinks, and to lamp standards in the streets instead of fire hydrants. The valve was then opened and there you were! There Roma was at any rate, the first town in the world lit by natural gas.

[56] Wopfner (1988: 376) describes exploratory drilling for hydrocarbons near Coorong Lagoon in South Australia in 1866, but notes the possibility of even earlier drilling.

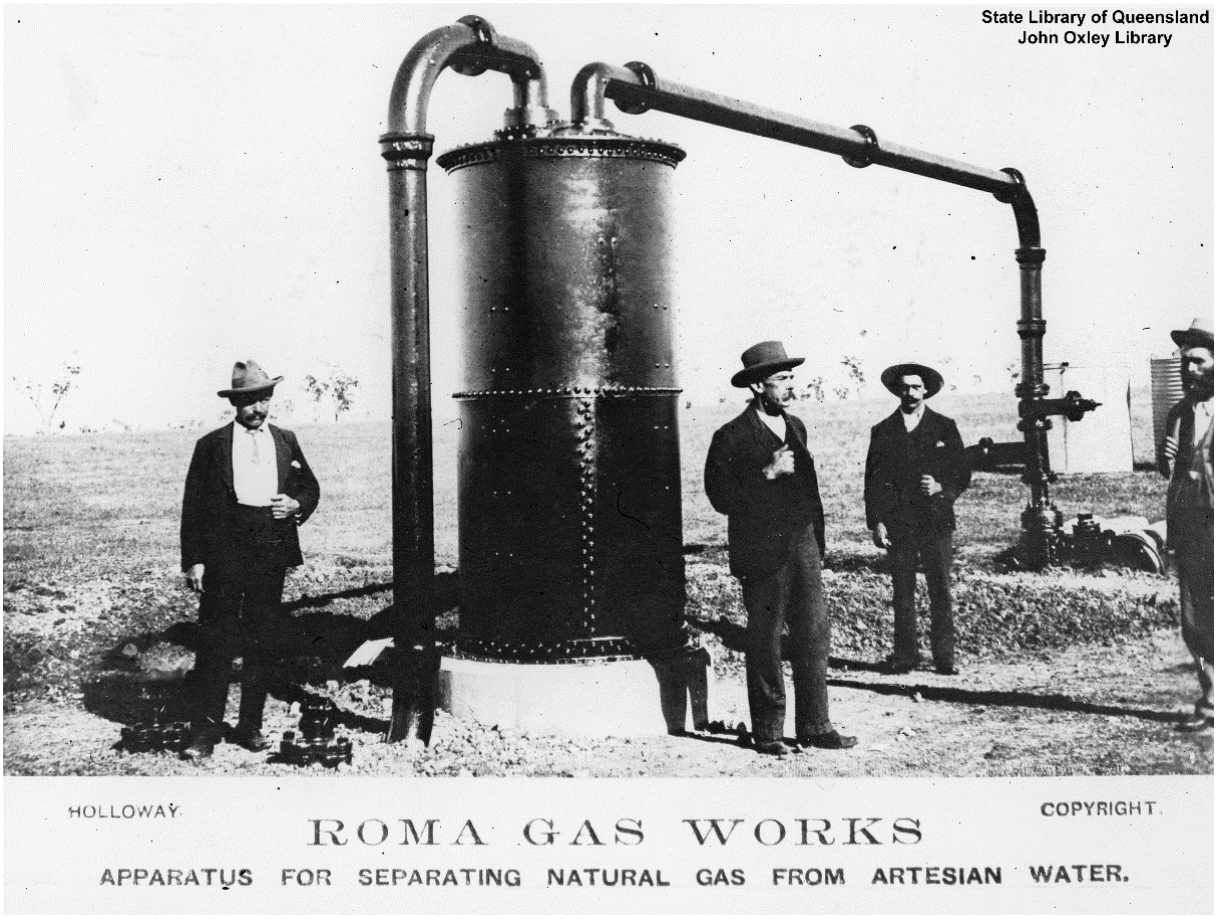


Image 15 Turning gas into a resource: apparatus for separating natural gas from artesian water at the Roma Gas Works, 1906 (source: SLQ)

Just as its discovery had come as a surprise, the gas mysteriously soon ceased flowing. In efforts to maintain the supply, more bores were drilled and gas was found once more in October 1908. This blow-out, too, caught fire and the gas was burning for almost seven weeks before it was brought under control (Wopfner 1988: 371, 376–378; Traves 1965: 4–7). The Western Star and Roma Advertiser reported the incident on Wednesday 28th October 1908 (source: National Library of Australia N.S.):

ROMA OIL BORE ON FIRE.
Immense Pressure of Gas Struck Yesterday.
Strong Indications of Oil Apparent.
The Gas Catches Fire and Creates a Terrific Blaze.
Destruction of about £1,200 Worth of Machinery.
Attempts to Overcome the Flames.

A sensational climax to the efforts of the Roma Mineral Oil Company to discover petroleum supplies at Roma was experienced yesterday morning. … The roar of the escaping gas was deafening even 50 yards away. … The gas continued to rush from the casing, the noise resembling the rush of steam from the escape pipe of an engine, only intensified a hundredfold. … The flame shot up to a height of 40ft. or more, and none could get nearer to it than 50 yards, so intense was the heat.

This "history full of trials and tribulations" (Wopfner 1988: 379), which relied on drilling that was mostly "done more or less blindly" (Reeves 1947: 1342) and with limited geological knowledge (*ibid.*; Scott 2008: 1), continued over the next decades and non-commercial quantities were recurrently discovered at Roma in 1927 and 1934. A gas absorption plant produced petrol from the gas's condensate that was sold locally as motor fuel. However, Australia continued to be reliant on hydrocarbon imports and remained a late-comer in terms of domestic oil and gas production.[57] While exploration was for a long time hindered by Australia's remote landscape, challenging climate and lacking infrastructure, it was especially limited geological knowledge that made "petroleum exploration more a matter of believes and opinions than of informed discussion and scientific consideration" (Wopfner 1988: 371, 376–378; also Towler *et al.* 2016: 253). In this sense, it was the absence rather than presence of scientific understandings and technological innovation that played a central historical role.

After the Second World War, exploration gained new momentum despite Reeves (1947: 1371), a consulted US geologist, resignedly noting that:

> the prospect of finding commercial oil fields in the area … is not very promising. … But in view of Australia's need of indigenous supplies of oil, any area offering the slightest chance of yielding appreciable volumes of oil should be thoroughly explored. … The prospect of developing commercial supplies of gas in the vicinity of Roma also are not very good.

Nonetheless, advancing drilling technology and accumulating scientific research, as for groundwater exploitation, increasingly allowed for the transformation of the unknown underground into a manageable and exploitable vertical territory. Wopfner (1988: 377–378) argues, though, that it was especially official state and federal responses to the dependency on imported hydrocarbons that changed the Downs' hydrocarbon resource environment. The 1957 federal Oil Search Subsidy Act introduced tax reductions for subscriptions in oil shares and subsidised drilling operations by 50 per cent on the condition that any geological information was subsequently publicly released (*ibid.*). This institutionalisation of exploration efforts and creation of epistemic networks to share and distribute scientific research illustrates how official measures contributed to the becoming of hydrocarbons as exploitable resources. Furthermore, it demonstrate, similar to the prickly pear invasion, the various interconnected domains and actors involved in the making and maintaining of complex resource environments.

In the 1960s, some commercially viable oil and gas projects were developed in or near the Darling Downs. Revived exploration near Roma also led to the drilling of two gas wells in 1960, so that a year later gas was supplied to Roma for electricity generation (Wopfner 1988: 379). Moreover, the development of further reserves allowed expanding beyond the immediate localities

[57] For example, the USA's first successful oil well had already been drilled in 1859 in Pennsylvania (Wopfner 1988: 371).

of production and consumption, so that "[b]y 1968, more than thirty conventional gas fields had been delineated on the Roma shelf, and enough gas had been proved up to justify building a natural gas pipeline to Brisbane" (Towler *et al.* 2016: 253). The 500km Roma (Wallumbilla) to Brisbane gas pipeline was completed in 1968 and started operating a year later (*ibid.*; Wopfner 1988: 379). Production from the Roma and other smaller fields throughout the Surat Basin increased steadily and peaked in 1995. Further fields were subsequently also developed in the Cooper and Eromanga basins in western Queensland and South Australia. Throughout the 1960s to 1990s, a networks of pipelines began to interconnect these various basins, fields and consumers, which created the eastern Australian gas market (Towler *et al.* 2016; Wopfner 1988).

At the same time, oil had been struck near Moonie in the Western Downs in late 1961 (Moran & Gussow 1963). Recoverable quantities were technically and economically viable and, after constructing a pipeline to Brisbane, commercial production commenced in 1964. This created the long-desired first domestic commercial oil field. For Wopfner (1988: 379–380), this:

> marked the birth of indigenous hydrocarbon production. The discovery of the Moonie field enormously stimulated oil search in Australia as a whole and especially in Queensland. Everyone wanted a slice of the cake! … [E]xploration drilling culminated in 1964 and 1965, when 180 exploration wells were drilled in that state, but results were generally disappointing.

The Moonie oil was refined in Brisbane and marked the dawn of a new era of frontier narratives and ideologies of heroic progress. In 1963, Queen Elizabeth II honoured the discovery of the Moonie oilfield by revealing a plague near Brisbane's now struggling oil refineries and reportedly commented that "the discovery of oil will open up new frontiers for industrial initiative and capital enterprise and point the way to a prosperous future for all people of Australia" (de Rijke forthcoming).

Yet, apart from the much celebrated Roma shelf gas and Moonie oil field, only minor discoveries were made in the Surat Basin over the subsequent decades. In foreshadowing a future of CSG to come, Commonwealth geologists thus concluded a geological survey of the sheet underlying the Chinchilla area pessimistically (Exon *et al.* 1968: 87–89):

> 18 holes have been drilled on the Sheet, and no worthwhile hydrocarbon shows have occurred. … The two early holes … reported hydrocarbons, but probably most of these shows were methane from the coals of the Jurassic Injune Creek Group. … The only hydrocarbon show in all these holes was gassy water … . The authors believe that there could be hydrocarbon accumulations in small fields in this area, but the drilling already completed, with its complete lack of shows, is discouraging.
> Several attempts have been made to establish coal mines on the southern part of the Chinchilla Sheet area, along the Brisbane-Roma railway. Coal occurs commonly … , but in general the seams are fairly narrow (mostly less than 10 feet) and consist of finely interbedded band of coal and shale. That the coal is high in volatiles is shown by numerous

> reports of occurrences of occluded coal gas … . However, occurrences are scattered, and the volumes of gas are not economically significant.

While still operated by Santos today, the quantities of 'flowing gold' from the Moonie oil fields have decreased significantly and Roma's conventional gas production peaked two decades ago. So Exon *et al.* (1968) were properly justified in their pessimistic technical and economic assessment of future conventional oil and gas production.

However, the unconventional hydrocarbon revolution over the last decade has shown the economic value of these not 'worthwhile' (coal seam) gas shows. The abovementioned assessments then illustrate how resources are not mere physical substances but are historically situated und socio-culturally co-constructed, particularly through scientific understandings and enabling technological innovations (Richardson & Weszkalnys 2014). In the following section, I thus consider the becoming of CSG in Queensland and especially the Western Downs as a desirable resource that mobilised complex international networks of techno-scientific know-how, extraction technologies and capital investments.

3.2.2. The Becoming of Coal Seam Gas

The connection between water, coal and gas is of course intimate and nothing unexpected (cf. Towler *et al.* 2016: 253). The *Queensland Government Mining Journal* provides ample material on, for example, odourless methane being a constant risk in many underground coal mines (e.g., the incident report from an Ipswich coal mine in August 1977) or the occurrence of gas in water bores (Denmead 1960; Gray 1967). Unsurprisingly, attempts have been made throughout recent history to harness the gas associated with coal mining, as done during the 1940s in an abandoned colliery underneath Sydney harbour (Towler *et al.* 2016: 253). However, these attempts did not result in commercially significant operations until the emergence of unconventional extraction technologies.

The history of the utilisation of these technologies in Australia does not start in the Surat Basin, but the northerly adjacent Bowen Basin. Pioneered in the United States in response to the first oil shock in 1973, the unconventional gas industry arrived in Queensland in 1975 when Houston Oil and Minerals Australia (HOMA), well-known as wildcatting legends in the industry, used novel techniques at their Shotover well to extract and sell gas from a coal seam before it was mined. Returning a year later, the company re-opened the well to specifically explore for CSG, thereby constructing Australia's first exploratory unconventional gas well (Keogh 2013a, 2013b). With only little flow after initial shows, however, Shotover was soon abandoned and the company moved south-east where it drilled two new wells, Kinma 1 and Carra 1, near the town of Moura. HOMA also acquired Moura 1, an old oil exploration well, from the Queensland Government. By 1977,

testing had been conducted at all three wells with disappointing result at Kinma 1 and Carra 1, but with some shows at Moura 1 where one engine could be run entirely on produced gas. However, large quantities of poor groundwater had to be extracted prior to any gas flow (*ibid.*), presaging an often debated facet of unconventional gas developments.

Moura 1 also became the trial site for another now-controversial extraction technology: hydraulic fracture stimulation. HOMA commissioned fellow U.S. American company Halliburton, which had developed and conducted the first hydraulic fracture on an oil well in March 1947, and during July 1977 Moura 1 was 'fracked' (*ibid.*). The well "was killed with a 1% KCL solution and the tubing and packer were pulled from the well. … The Hydro-Frac operation was then carried out with 5 500 HHP pumping units and a Blender" (Porter 1977: 2–3). However, the technology and science behind it were relatively new and the specific geological knowledge limited. Halliburton's reports thus describe months-long site testing and extensive laboratory simulations (HOMA 1977: 10). Similarly to the trial and error of groundwater and hydrocarbon drilling outlined above, Halliburton acknowledged that "[t]here are many unknowns in a vertical fracture design procedure. Therefore, the calculations involved are based upon certain assumptions" (*ibid.*: 17; cf. Chapter 5.2.). Results from these four early exploration wells were eventually unsatisfactory and Keogh (2013a) even argues that:

> The process of hydraulic fracture was not just a failure, but conducted on a science that had never been tested in Australia, was ponderous at best, and by Halliburton's own admission had "many unknowns". There was also the role of large multinationals providing "experience" … and conducting these tests while having limited knowledge of the Australian landscape. … At the first four wells environmental concerns was not a priority.

Those four wells foreshadowed the next resource revolution on the Downs and the debates that would follow.

It was not until two decades later that CSG turned into a desired resource rather than the mere by-product of coal mining. Following successful developments in North America, approximately 30 CSG-specific wells had been drilled in the Bowen Basin by 1990, which increased to 160 wells in 1995. Commercial production thus became viable and domestic supply started in 1996 (Towler *et al.* 2016: 254). The success in the Bowen Basin and also progress in the U.S. Powder River Basin, where gas has been extracted from similar coal deposits, provided the technological capabilities and financial incentives for CSG projects in the Surat Basin. Political support for major gas developments was also evident with Queensland's then-Premier Peter Beattie releasing a media statement on 3rd June 1999 titled *'Queensland is a gas, gas, gas'* in which he highlighted above all employment, economic growth and energy advantages. CSG extraction unsurprisingly gained momentum quickly.

The Argyle field was the first significant development in the Surat Basin in late 2000 and commercial production began in 2006 from areas between Dalby, Chinchilla and Miles (Towler *et al.* 2016: 254; Keogh 2013c). Large capital investments of over AUD 80 billion were made by four major proponents with the aim to establish liquefied natural gas (LNG) plants some 500km away near Gladstone that would convert CSG into an exportable resource for international markets.[58] The industry thus grew rapidly so that, "[b]y 2007, CSG production exceeded conventional gas production in Queensland. … In 2011, the Surat Basin had overtaken the Bowen Basin as the chief supplier of natural gas in general, but of CSG in particular" (Towler *et al.* 2016: 254). In light of these substantial investments and rapidly progressing projects, the Western Downs Regional Council rebranded itself and trademarked the label of 'Energy Capital of Queensland' (AWD 2016):

> Emerging from a collection of rural townships with their roots in agriculture, the Western Downs Regional Council area has become a hive of activity and growth through continued agriculture, manufacturing and resource diversification. The energy resource sector, which comprises coal, coal seam gas, coal seam gas water, ethanol and power station development, has seen the region gain the mantle of the 'Energy Capital of Queensland', while still maintaining its rich agricultural heritage.

In 2015, downstream operators eventually commenced exporting LNG overseas and at the time of writing approximately 9000 wells have been drilled throughout the Surat Basin (GasFields Commission 2017).

The pace and scale of CSG projects have, at least in the near term, created a variety of more or less direct positive but also negative socio-economic impacts within the region and nationally (Measham & Fleming 2014; Measham *et al.* 2016; OCE 2015; Rifkin *et al.* 2015a, 2015b; Towler *et al.* 2016: 267–268).[59] Fleming and Measham (2015) have cautioned that such resource booms do not necessarily translate into collectively experienced net-benefits for the populations of host regions who bear the majority of impacts (also Freudenburg & Krannich 2003; Jacquet 2009; Jacquet & Kay 2014). Across the Surat Basin, Fleming and Measham's (2015) regional economic analysis found that CSG developments had positive economic impacts on associated sectors like construction and related (technical) services. However, no lasting spillover benefits appear to have materialised for retail or other non-mining services, and a range of agricultural businesses have reported negative impacts. Perhaps the primary regional benefit is thus the inflow of financial capital as local taxes and compensation for landholders who have signed agreements with the CSG industry (*ibid.*; cf. Cavaye & Kelly 2016; Everingham *et al.* 2015; Marinoni & Garcia 2016; Towler *et al.* 2016: 267–268).

[58] See Towler *et al.* (2016: 255) for detailed project profiles and company involvements.
[59] See also the University of Queensland's CSG-specific Boomtown Indicators project (here).

This compensation is, by state government mandate, individually negotiated within Conduct and Compensation Agreements (CCAs) once operators wish to assess private land for 'advanced activities'. However, CSG projects are spread over a large geographic area and unlike conventional extractive industries they do not necessarily displace landholders but aim to 'co-exist' with existing land uses. CSG developments thus affect a large number of landholders within these emerging agri-gas fields (de Rijke 2013a; also Cavaye & Kelly 2016; Measham *et al*. 2016; see Chapter 1.2. –3.). This new spatial and temporal scale of unconventional resource development generally increases the potential of conflict over the terms of this co-existence within an already intensively managed landscape and also challenges existing impact models (*ibid.*; Jacquet & Kay 2014; Stedman *et al.* 2012). More specifically, though, CSG projects consequently require a large number of CCAs to be negotiated (GasFields Commission Queensland 2016, also 2017):

> As at 30 June 2015, about 2,188 landholders in Queensland had negotiated a total of 4,906 CCAs with the onshore gas industry. Compensation already paid under these CCAs including upfront and annual payments is estimated to total $238 million … and can range from small payments for minor works to over $1 million for major gas field developments.
> Many landholders have also negotiated in-kind outcomes such as new fencing, roads, grids, sale of gravel and water, and in some areas have also gained access to treated CSG water for agriculture.

Many of these landowners reside in the Western Downs and adjacent regions. Since the exact terms and amounts of their compensation can be highly variable and are often subject to confidentiality agreements (see Chapter 6.2.), I cannot comprehensibly analyse the economic aspects of CSG developments and its associated controversy in this thesis. However, anecdotal evidence from fieldwork and exchange with other researchers suggests that affected landholders are compensated from AUD 250 to over AUD 12,000 a year per well, with average agreements likely located within the AUD 2,500–10,000 range.[60] While smaller blocks might host a single well, some landowners with larger properties signed CCAs for up to 100 wells (AgForce 2017; cf. Boulle *et al*. 2014).

Direct financial and in-kind benefits can therefore be substantial to those landholders and industry presentations frequently include selected farmers or graziers who highlight these profitable arrangements. Furthermore, the significant number of CCAs in Queensland is often discursively employed by proponents and supporters to emphasise the successful and beneficial co-existence of CSG projects and agricultural industries. However, whether the mere quantity of such agreements can be utilised to infer wider social acceptance is debatable (AgForce 2017; Boulle *et al*. 2014; Lacey & Lamont 2014; Turton 2015). In any case, the significant differences between landholders with and those without CCAs may lead to what Jacquet (2012: 679) describes in the North

[60] Compensation amounts depend *inter alia* on the level of CSG activity and, in no small part, on the landholder's ability to negotiate (cf. Price 2017a; 2017b).

American shale gas context "as a 'have vs. have-not' debate between landowners who may receive direct benefit … and those who will not receive such benefits, yet may bear the costs of traffic, industrialization, and possible environmental or health effects". During CSG developments, direct benefits then primarily flow to landowners with CCAs and sectors associated with the industry, while negative effects, such as decreased housing affordability or potential environmental impacts, are experienced collectively by a greater number of residents (Rifkin *et al*. 2015a, 2015b). Measham *et al.* (2016) therefore note the possibility of an asymmetrical allocation of the costs and benefits of CSG as part of a 'within country' resource curse. Bearing in mind these social and environmental challenges, it "could reasonably be argued that these new forms of energy development carry more potential to change local economies, ecology, and social relations than any other phenomenon seen in recent (and not so recent) history" (Stedman *et al.* 2012: 391). As such, CSG has emerged as the most recent agent of change to the resource environment of the now Energy Capital of Queensland (Everingham *et al.* 2015; Towler *et al.* 2016: 268; see Image 16).

Image 16 The most recent 'agent of change': CSG drilling rig near Chinchilla (left) & CSG well near Dalby (right) (source: author 2015)

This brief historical overview followed the post-settlement transformation of the Darling and Western Downs from a pastoral, to an agricultural and extractive frontier. I particularly emphasised the inseparable entanglements of various surface and subterranean substances (cf. Bryant & George

2016; Neale & Turner 2016) and attended to the human social (inter)actions that turn those substances into resources, but which are, conversely, themselves shaped by intricate socio-cultural, historical and material relationships. CSG developments are then but the most recent episode in a complex resource history that is characterised by contests over scarce water supplies, techno-scientific innovation and active environmental management. Debates about the manufactured risks and potentially unanticipated consequences of large-scale resource developments and intensifying land use have, as such, not just emerged with the CSG industry. At the same time, unconventional resource developments create novel social and environmental challenges. CSG risk debates must therefore be placed within this situated, interconnected and constantly changing resource environment. Understanding these complexities and interconnections is important especially since, as Keogh (2013a) notes, the next frontier potentially already emerged with the first exploratory shale gas well completed in late 2010 in the Cooper Basin in Central Australia.

4. Making Sense of Environmental Impacts from Coal Seam Gas: Between Experience and Projection

Rather than assuming from the beginning of discussion … that science unconditionally deserves privileged status, we need to consider just how relevant and important scientific understanding is within everyday life.

(Irwin & Wynne 1996: 8)

Well, the truth is there, we're observing it, we're living it. … And you can't teach that in universities.

(Female regional town resident, interview May 2015)

In the first third of this thesis, I set the scene for my research by exploring its conceptual foundation and the historical background within which CSG emerged in the Western Downs. In the following chapters, I move on to discuss the question of 'getting the science right' through an analysis of the empirical material generated during ethnographic research in this context. To address this question, it is essential to begin by asking how interlocutors come to know CSG and to elaborate on the role of scientific knowledge. For much of the early stages of this fieldwork in the gas fields, however, a recurring and initially baffling theme emerged in my notes, namely the discrepancy I felt between the various ways that CSG was experienced by many local residents — including myself while in the field — and the CSG as it was sometimes conceptualised and debated in meeting rooms, reports, and presentations back in South East Queensland's urban centres.

In April 2015, for instance, I attended a CSG-specific research event in Toowoomba, the 'eastern gateway to the Surat Basin', which brought together academic researchers and staff of various Queensland government departments. Most of the event's presentations and discussions evolved around groundwater models or conceptual schemata of social aspects related to CSG developments. After two interviews with former and current Western Downs residents that same night, I drove some three hours west the next morning to follow a local landholder's invitation to attend the annual Wandoan rodeo. During our interview, she described how on her nightly drives home she would regularly encounter the glaring light domes caused by nearby gas flares without knowing their exact location. Intrigued by her account, I decided to take a detour after the rodeo and followed her description. After a short drive out of town, I passed one of the region's endless rolling hills and immediately encountered at least half a dozen light domes that quietly illuminated the night sky for kilometers. Another twenty minutes of driving along smaller and smaller dirt roads had me pull up next to the closest flare, a mere ten meters from the edge of two grazing properties. With the car's engine and lights turned off, all that was visible and audible was the soft flickering

and sizzling of the flare. Heading closer to the fence line, one could feel the flame's warmth and smell a light, yet somewhat chemical odour. In stark contrast to the previous day, I could not help thinking about what I was actually breathing and recalled some residents' critical question of whether I would like to live near a well or flare.

In revisiting the adjoining pages of my fieldwork notebook where notes from the research forum meet those from the rodeo and 'flare gazing' event, it appears that two, almost distinct CSGs emerge from those lines. While especially embodied ways of knowing are not easily, if at all, conveyable in text and conventional means of academic writing (cf. Parr 2010: 1–23), my notes repeatedly refer to 'abstract' or 'potential' CSG that was quite distinct from 'actual' or 'realised' CSG. Put differently, the abstract CSG of meeting rooms where graphs and tables were frequently used to, for example, understand and discuss volumes of produced water across large geographical areas stands somewhat in contrast to the CSG I came to know through sensuous experiences in the field. As a result, asking about the role of science in knowing CSG may lead to rather distinct responses.

A re-engagement with this theme was later triggered after a keynote speech by social anthropologist Tim Ingold on 'Designing Environments for Life' at a conference in Aberdeen in August 2015.[61] He described a gap between experienced environments that are inhabitable and projected environments of exhabitation; or, worlds "whose reality is given quite independently of our experience of it" (Ingold 2014a: 234) and that therefore "can be occupied, but not inhabited" (*ibid.:* 242). This insightful conceptual distinction prompted me to return to the questions around sense-making of CSG's (potential) environmental impacts and the multiple CSGs emerging from my field notes. Particularly helpful in this regard is Ingold's framework of "globes and spheres" as typologies of environmental awareness and the privileging of, frequently science-based, ontologies of detachment over local ontologies of engagement (2000: 209–219, also 2016). For Ingold (2014a: 242), these ontological imbalances create a "gap between the earth-sky world of our experience and the global environment of technoscience". I here noticed a potential link to themes emerging from my own fieldwork.

My aim in this chapter is to unpack this discrepancy within my empirical material by critically utilising Ingold's framework, among others, and to argue for the complex interaction of different ontologies in the process of sense-making of CSG.[62] However, rather than readily accepting a narrative of binary or dichotomised ontologies and their mere interplay, I consider how the case of CSG illustrates that, at least locally, they are often inseparably entangled. CSG is thus never 'only

[61] See Ingold 2014a; also 2014b.
[62] I keep Ingold's terminology and use 'ontology' primarily to conceptualise different forms of environmental awareness. Beyond this, I do not mean to engage with the 'turn to ontology' by some anthropologists such as Descola, Viveiros de Castro or Latour (see Kohn 2015).

experienced' nor 'exclusively projected' through techno-scientific discourses. In this sense, phenomenological sense-making of CSG is difficult and often depending, on the one hand, on indirect proxy-experiences of either other natural phenomena linked to CSG or through additional material clues such as associated infrastructure. On the other hand, it relies on complex models, abstract scientific conceptualisations and technical procedures; or elements of what Barry (2001, 2006) termed 'technological zones'.

Bringing both aspects together, I will conclude this chapter by highlighting the importance of an often neglected balance between the underlying ontologies of engagement and detachment. That is, it is important to consider the scope but also limitations of locally experienced as well as scientifically projected ways of knowing CSG. In doing so, I wish to avoid what Ingold (2011: 114) describes as the "enforced separation of knowing from being", but likewise acknowledge the significance of projected environmental knowledge. Hence, the central aim in this chapter is to position CSG-specific scientific representations by demonstrating their simultaneous inevitability and insufficiency. However, I finish in the last section by foreshadowing the political dimensions and power imbalances that can arise from a predominance of projected ways of sense-making and associated ontologies of detachment. This argument is crucial as the thesis moves towards the question of 'right science' and the politics of knowledge and ignorance. Let me begin this task by focusing on the ontological properties of CSG.

4.1. A View from the (Gas) Field: CSG as Transcendent Quasi-Matter

CSG is naturally trapped underground and consists primarily of odourless and invisible methane. Once at the surface, this minimal materiality only allows for limited direct sensory experience and, without specific measuring instruments, makes CSG a substance beyond immediate phenomenological detectability. Referring to anthropologist Mary Douglas's well-known notion, de Rijke (2013c: 17) already suggested an understanding of CSG as polluting 'matter out of place' that can create severe anxiety and uncertainties for affected residents. However, I encountered a large range of responses regarding the ontological presence of CSG even between different local interlocutors.[63] For some, nearby CSG developments were indeed associated with the omnipresence of 'out of place' gas, which fundamentally altered their lived environments. For others, conversely, it may barely be present or an issue of concern.

[63] I am aware of the problems associated with potentially homogenising concepts such as 'local'. De Rijke (2012: 12–19) carefully employed the notion of endogenous and exogenous identities in his work on a South East Queensland dam controversy and highlighted their heterogeneous character to avoid such essentialisations. I address the politics of representation when discussing the politics of (non-) knowledge in Chapter 8, so it may suffice to note that I use 'local' in the widest sense as an analytical actor category (see Chapter 1.7.).

In particular, a number of concerned residents described how the commencement of CSG developments has affected the relationship with their immediate surroundings. A local resident and mother of two, for instance, emphasised how living in a gas field has radically changed her environment:

> So either I'm going to breathe it in or drink it. I'm to accept that my environment is now going to be polluted to a manner that will categorically damage my health and my children's health, and I'm supposed to not be a nutter and … accept that?
> [Interview May 2015]

Other local accounts echo these resentments by frequently referring to areas of CSG developments as 'ground zero' or 'the front line':

> My life for 10 years has been gas. … In every aspect of life [, we have been affected].
> [Male landholder, Senate hearing transcript, Dalby 17th February 2016: 16 & 23]

> Please let me show you around the front line. … I pinch myself every day, saying, 'Is this a nightmare that I am living?' It is extraordinary, which is why part of this submission was to beg the people making this decision to come and see for themselves, because we are gasland refugees.
> [Female landholder, Senate hearing transcript, Brisbane 27th July 2015: 22 & 28]

As a result, I encountered multiple families and individuals who left the Western Downs altogether primarily due to health and environmental concerns associated with now 'living in a gas field'. For example, a landholder and mother of two, who only moved to the Western Downs some two years earlier, described her despair in an open letter sent to government officials in March 2015: *"Our home was a beautiful place. It was our home. … until we had to move the children for their safety. … No one can prove to me that the gas [is] NOT making us sick"*. Surely, uncertainties and similar psychological impacts can arise with any environmental change resulting from, for instance, large infrastructure or resource developments (see, e.g., the notion of solastalgia in Albrecht 2005; Albrecht *et al.* 2007). However, some interlocutors' reference to now living in the inescapable ubiquity of a gas field hints to more fundamental changes to their perceptions of reliable and meaningful environments (see Chapters 2.1.1. & 6.2.). As such, these empirical materials contain testimonies of profoundly altered environments, or what Parr (2010: 3) describes as "embodied 'lostscapes' residents mourned" (also Willow 2014). While for some such severe impacts appear to have already occurred, it was still a 'disaster waiting to happen' for another group of concerned actors. Unsurprisingly, one counter to such felt or feared to be immanent impacts that can be observed in the Western Downs is political resistance to government and corporate power (cf. Albrecht 2005: 54; Chapter 8.1.):[64]

[64] For an account on resistance to CSG developments in the Western Downs that pre-dates my fieldwork see Makki (2015).

Image 17 'Stop + Smell the Democracy': opposing the felt environmental changes from CSG extraction (source: author 2015)

Figure 5 'Against Fracking the Future': creating shared online spaces of resistance to CSG developments (source: interlocutor's facebook account 2015)

For other interlocutors, however, CSG appeared to not have much of a presence or be a cause of concern even when developments occurred in comparably closer proximity. This became apparent to me when a male farmer refused an interview request about gas seepages in the river that boarders his property (see Chapter 5.3.). Suggesting indifference, he told me: *'As far as we're concerned, they are just bubbles in a river. No health impacts, nothing. It doesn't affect us at all'* (informal conversation March 2015). Similarly, another male farmer and key actor with a number of regional CSG-specific non-governmental organisations opposed the 'anties' for exaggerating the risk of pollution from CSG projects:

> Oh, it's minor compared to the things we face. … So, I tend to look at the big picture. Surely, it's easy to have concerns, but everything we do in life has a certain amount of pollution. I mean, BTEX [a group of carcinogenic chemicals that is present in small quantities in coal seams] in smoke, and you drink alcohol or speed. … I got more heavy metals in my bloody phone than there is in the environment [from CSG extraction].
> [Telephone interview May 2015]

During interviews and informal conversations with these interlocutors, I generally got the sense that they did not view their environments as significantly impacted or that changes had become normalised to an acceptable degree. Conversely, after encountering the anxieties and fears of some residents concerned about environmental pollution and human health, I have no doubt that their everyday lives are altered and disrupted by now living within the omnipresence of a gas field (cf. Auyero & Swistun 2008; Snow *et al.* 1998). But how is it possible to make sense of this wide range of almost conflicting sense-making around CSG developments?

One revealing response to this question focuses on the ambiguous ontological status of CSG. Especially for local actors, this status leads to difficulties in sense-making and CSG is thus not immediately matter that is either in or out of place. Instead, I understand CSG as an elusive, placeless 'quasi-matter' that becomes present as it becomes known. Fitting this point is Richardson and Weszkalnys's (2014: 22) conceptualisation of resources as materials that become into existence within "an entanglement of processes and practices of abstraction, homogenization, and stabilization". It is thus important to avoid a "dualism of material-versus-symbolic" (Herzfeld 2014: 3; see Chapter 2.1.1.) and locate the knowing of CSG at the intersection of the epistemological and ontological. Considering CSG as becoming known *as* a substance can help to explain the range of sense-making revealed above.[65] Within this process of becoming, however, local interlocutors are faced with the elusive phenomenological properties of CSG. As anthropologist of the senses Howes (2012) notes on 'sensing the unseen', CSG can be regarded as matter that emerges "on the margins

[65] German philosopher Böhme's (1993) work on the concept of atmosphere is insightful. He notes, "[a]tmospheres are indeterminate above all as regards their ontological status. We are not sure whether we should attribute them to the objects or environments from with they proceed or to the subjects who experience them. … Atmosphere can only become a concept, however, if we succeed in accounting for the peculiar intermediary status of atmospheres between subject and object" (*ibid.*: 114).

of perception, the 'just-out-of-sight,' and [it] thereby extends at the same time as it troubles the bounds of sense, or limits of the sensible". CSG may then for some actors barely be present or an issue of concern, while others know it as transcending boundaries and being an omnipresent matter out of place.

In this sense, I also already noted that, unlike conventional resources extraction, CSG's infrastructure requirements dissolve the clearly defined boundaries of the 'inside and outside' spaces of extraction (Measham *et al.* 2016; see Chapter 1.3.).[66] Multiple interlocutors therefore emphasised the need for aerial perspectives or drone and *Google Earth* satellite footage to grasp the full extent of gas infrastructure. For instance, at a research forum on co-existence between the agricultural and CSG industry, one male speaker and Western Downs farmer encouraged audience members to *'take a flight, gives you an understanding of the industry you just can't get driving around'* (September 2014). This, he later explained, was intended to oppose visual representations of *"an innocuous little gas well hidden amongst trees that you wouldn't notice"* (interview April 2015). CSG can further also transcend boundaries due to its elusive material properties as it emerges from the underground and (potentially) escapes into the atmosphere, or as the gas and associated substances may migrate through subsurface aquifers (see Chapters 5.3. & 5.4.). Two local landholders thus voiced concerns about possibly unknown impacts from CSG extraction at separate occasions:

> But the thing is that there is no magical barrier between that man's property and my property that is going to stop the noise and the VOCs [volatile organic compounds] and the dust so that they are not going to land on my roof and poison my children. So it is a community issue that should never be on the basis of the individual.
> [Female landholder, Senate hearing transcript, Brisbane 27th July 2015: 25]

> The methane seep in the Condamine River - … I think it is happening throughout the scrub. I think it would be pretty naive not to think it was happening through the scrub. The reason for that [cleared area around wellheads] is that if there is a gas seep the wind can get at it and dissipate the gas. In the scrub … that gas will be trapped in the long grass. It will stay there until it is ignited by a spark … . We do not know where these gas pools are and we have no way of finding them except by using one of these - a cigarette lighter.
> [Male landholder, Senate hearing transcript, Dalby 17th February 2016: 23]

These accounts highlight the elusive and potentially transcending physical properties of CSG, which can prompt a wide range of perceived environmental changes, concerns and uncertainties.

This insight is supported by the findings of an ongoing AgForce Queensland survey of landholder sentiments of CSG and mining.[67] These findings show that *'concerns don't stop at the*

[66] As a local landholder organisation states in an educational factsheet: *"If you own land between Goondiwindi and Gladstone [almost 700km to the north], CSG development is coming to a place near you and with all likelihood your doorstep in the next 20-30 years"* (BSA 2011a: 1).
[67] AgForce is a peak organisation representing Queensland's rural producers.

boundary fence' and that many landholders are concerned about cumulative impacts on a regional scale and also future impacts. As a result, the AgForce team emphasised that, similar to my own findings, such concerns about manufactured risks from CSG extraction cannot be explained as merely 'Not In My Backyard' sentiments (AgForce 2017; also Everingham *et al.* 2014: 126 & 129; see Chapter 8.1.). Adding to these findings is my observation that the above accounts demonstrate how CSG's physical properties and the spatio-temporal transboundary character of its (potential) impacts create difficulties for actors who try to make sense of CSG developments, thereby contributing to problems of knowing. The resulting understandings can prompt diverse concerns, which *prima facie* might, in some instances, be at odds with scientific explanations.

It thus becomes clear that enquiring into the role of science within the CSG risk controversy must entail a thorough examination of sense-making within a larger environmental perspective. As Irwin and Wynne (1996: 15) note, "the study of knowledge and beliefs about the environment offers a pressing example of the handling of science in the public realm". Throughout the remainder of this chapter I will develop such an environmental perspective by critically exploring Ingold's two ideal types of experience and projection as poles that define a spectrum rather than binary positions. In particular, I consider how as a result of its minimal materiality, CSG is never 'only experienced' nor 'exclusively projected'. This has important consequences for the role of scientific representation and abstractions, making them inevitable yet insufficient for knowing CSG locally. I begin by attending to experienced CSG.

4.2. The Limits of Experience: Everyday Phenomenology and CSG by Proxy

CSG developments do not emerge in isolation but within local lifeworlds. This holds for the surface as for the underground. As demonstrated in Chapter 3, in many parts of the Western Downs groundwater exploitation for agricultural production has already established a 'verticality' (Braun 2000) that incorporates the underground into the horizontal territory of inhabited environments. Local actors therefore make sense of CSG within this existing context. This section addresses the various modalities through which CSG is experienced in everyday lifeworlds either directly through phenomenological cues[68] or by proxy of other natural events or symbolic means. In doing so, I aim to also highlight the limits of experiencing CSG, which will point towards the importance of projected ways of knowing CSG in the next section.

To be sure, my intent in this section is not to thoroughly engage with CSG through anthropologies of the senses (Classen 1997; Howes 2005; Howes & Classen 2014; Ingold & Howes

[68] I here refer to the "sensuous ways of interacting with the world [that] are best distinguished as phenomenological or corporeal embodiments" (Parr 2010: 10). These often resist communication in word and text but are important for knowing environments.

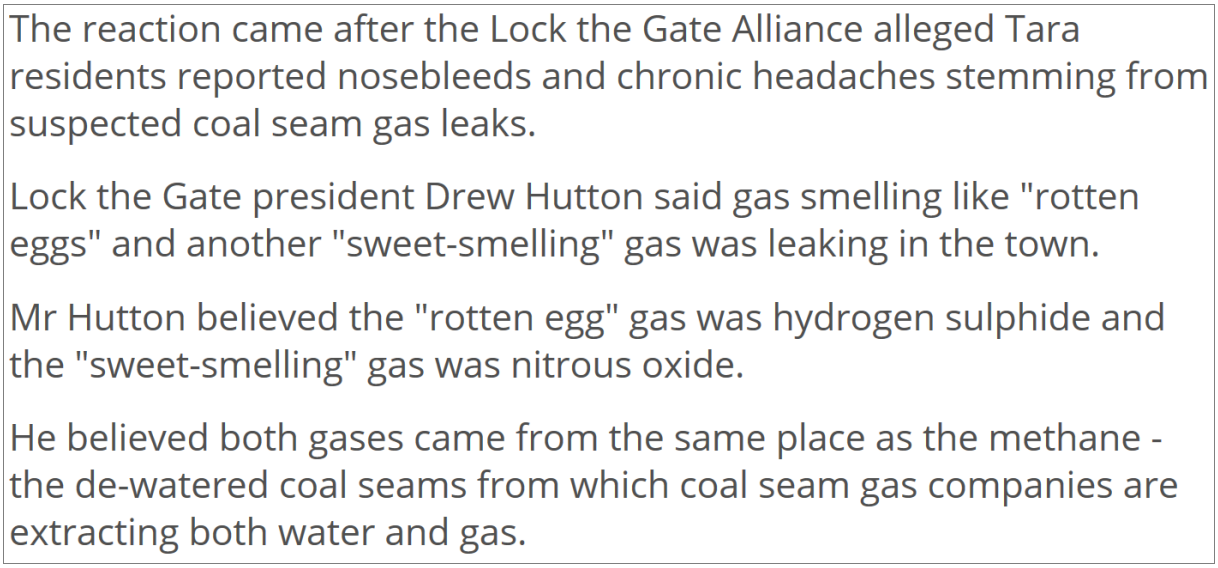
2011; Pink & Howes 2010). Rather, I aim to elicit an understanding of the interplay between experience and projection in the process of sense-making of impacts from CSG. My approach focuses on the entanglements of 'technologies, environments, and the everyday' (Parr 2010) to consider how environmental changes may be experienced. Such an empirically-focused environmental perspective can enrich the anthropology of risk knowledge outlined in Chapter 2 and allows to position scientific knowledge claims within CSG risk debates.

Sensuous experiences of CSG were frequently highlighted by local interlocutors and also opposing outsiders visiting the Western Downs. These experiences occur often simultaneously through a variety of senses from directly smelling odours, to hearing noise or seeing light pollution. The following accounts and materials illustrate this direct phenomenological sensing of gas and the embodied corporeal knowledge through which CSG 'becomes' locally:

> You get the odour from this one [CSG well] as well. I got a good kick from it last time I was down here. You just got an odour in the air and get a headache straight up. … So this is where the low impact thing comes in. There's no low impact, it's all high impact.
> [Male farmer with significant CSG infrastructure, property tour April 2015]

> We are worried that the toxin[s] we can smell are entering our dam and water tanks.
> [Female landholder with nearby CSG infrastructure, open letter March 2015]

> They [flares] can go for nights and nights. From home we can see probably six in the distance. … When they first started [we thought]: 'Shit, there's a fire down there'. That's what it looked like, a bushfire way in the distance. I started ringing up and [they said] 'It's only a flare'. 'What are they?'
> [Male grazier affected by coal and CSG developments, interview May 2015]



The reaction came after the Lock the Gate Alliance alleged Tara residents reported nosebleeds and chronic headaches stemming from suspected coal seam gas leaks.

Lock the Gate president Drew Hutton said gas smelling like "rotten eggs" and another "sweet-smelling" gas was leaking in the town.

Mr Hutton believed the "rotten egg" gas was hydrogen sulphide and the "sweet-smelling" gas was nitrous oxide.

He believed both gases came from the same place as the methane - the de-watered coal seams from which coal seam gas companies are extracting both water and gas.

Figure 6 Sensing gas: 'Nosebleeds linked to CSG in Tara' (source: *The Chronicle*, Toowoomba 5th June 2012)

Image 18 Sensing gas: CSG flares illuminating the night sky (source: interlocutor's facebook account, 2016)

Among many of my local interlocutors, the direct phenomenological engagement with gas developments and embodied corporeal knowledge was thus important for knowing CSG.

Throughout ethnographic research and interviews within the region, especially with those living 'out on country', it became clear that such phenomenological sensing is not merely another way of coming to know CSG but indeed a crucial aspect of 'actually' understanding CSG. For instance, I was often asked whether I had already seen and heard certain infrastructure in person; landholders would recall the unanticipated sensory impacts once activities commenced on their properties; or other actors' diverging accounts were criticised since they had not directly experienced CSG activities. Those opposed to CSG were thus frequently surprised how I could attempt to maintain a neutral position after my ethnographic fieldwork or took it for granted that, once experienced personally, impacts would undoubtedly lie in plain sight. At the end of a three-day group tour through the region, for example, one female attendee was sure that a visiting state politician did not need to be lobbied because he *"had been here, he had seen it"* (April 2015). Whether opposed or not, the importance of 'being there', 'living it' and experiencing CSG emerged as a strong theme:

> Well, the truth is there, we're observing it, we're living it. … And you can't teach that in universities. You can put the point across or read it in a textbook, but until you experience it you can't … . We go and talk to those landholders and then they [interested 'outsiders'] get it. And once they see it, you can't unsee it. … And when you stand around wells and it's bubbling up through the ground or the vent pipes they are hissing away doing its didgeridoo thing, you can't unhear that. And the smells, when the smell is bad and you get a headache and the funny taste in your mouth, you don't forget that. See, you got to use those five senses and all these [expletive] that work in the company … they've never been here, they just go and spruik. … It's just easier to sit back in a posh office and label everyone as being scaremongers and hippies and activists and all the rest … .
> [Actively opposing female regional town resident, interview May 2015]

> The ones that live in the towns that were benefitting from it, they don't have, they take the money and run. They don't have to live amongst this [expletive]. They don't have to think about environmental consequences. … They are oblivious to it … . It's about financial

> impacts for the people in the towns. It's not about the environmental impact. They don't really understand or even think about it.
> [Concerned male grazier without immediate CSG activity, interview June 2015]

> And he [my husband] ask him [CSG company's engagement officer]: 'Father to father, would you live here?' And he said 'No'.
> [Female landholder with nearby CSG infrastructure, post-interview conversation June 2015]

The state politician who attended the mentioned gas field tour similarly recalled how directly experiencing the impacts of CSG activities had left a profound impression on him:

> I fundamentally cannot be comfortable when I witness … those large flares. What are the volatile organic compounds that come out of those that people are breathing? …
> I certainly saw a lot more evidence, emotion, psychological, bloody mindedness, intrusiveness, than I probably expected. I didn't expect to see the sheer impact to that community, the amount of wells, the amount of infrastructure. You know what, and it really still disturbs me today … the amount of activity on that poor guy's farm. You could not believe that is a co-existence model at all. It isn't, it's not. It's total invasion, intrusion. …
> And the fact that we could actually smell gas on that farm was quite a, that was another thing I didn't expect to see.
> I didn't expect to see the level of infrastructure. It's just amazing, I love big infrastructure, I love it, because I see it as prosperity, I see it as jobs, I see it as taking a natural resource into something tangible. When there is so much behind it though, isn't there? The infrastructure is invasive, it's polluting, and it's environmentally destructive and damaging. So all those things probably took a bit of getting used to seeing all of that. … It was just unbelievable, the sheer magnitude of that industry.
> [Interview April 2015]

Through these accounts, one can grasp the importance of immediate, lived experiences that — to recall Ingold (2000: 209-219) — form the basis of ontologies of engagement.

However, such immediate corporeal knowledge is limited due to the elusive material properties of CSG and its underground location. I therefore encountered another way of sensing CSG, albeit less directly, through what some interlocutors believed to be associated environment changes or other material cues. At a locally held CSG-specific workshop in February 2015, for instance, a landholder described to me how she could tell by the behaviour of her bore — its water flow — whether nearby CSG wells were operating or turned off for servicing, despite being outside the Immediately Affected Area (IAA) where impacts are forecast to occur. She was thus critical of the precision of the groundwater model developed by the Office of Groundwater Impact Assessment (OGIA), which is described in the next section. This knowing of CSG and of impacts from its extraction 'by proxy' is also apparent in environmental events that are attributed to CSG extraction. At various occasions, concerned interlocutors referred to suspicious substances such as *"black rain"* or sticky dust on cars that *"had this other something in it"*, which they attributed to nearby CSG activity (cf. Auyero & Swistun's (2008) notion of toxic uncertainty). These causal links are

usually denied by industry representatives. Likewise, gas seepages that have been occurring since 2012 in the region's main river have received publicity as a sign of possible impacts from CSG extraction (see Chapter 5.3.):

> WITH fears of "toxic black rain" infecting Tara families broadcast across the nation, Origin says it is creepy crawlies, not coal seam gas, causing the issue.
>
> Concerned Tara father of two Steve Ansford appeared on a national TV current affairs program with claims Origin's Ironbark CSG project had been smattering his home with a black, tar-like substance since August.
>
> Mr Ansford said his kids had been suffering headaches, nosebleeds and ongoing lethargy since the "black rain" started falling.
>
> But an Origin spokesperson said third-party biological testing of the mystery substance in October identified it as lerp.
>
> Lerp is crystallised sugars and amino acids produced by insects.

Figure 7 CSG by proxy: Company rejects fears CSG cause of 'toxic black rain' (source: *Chinchilla News*, 28th November 2013)

Image 19 CSG by proxy: gas seepages in the Condamine River (source: *Lowe, Flickr* 2013)

Crucial is how the sensory experience of such environmental changes, and subsequently also their symbolic and discursive utilisation, can become a source of phenomenological knowledge that, at least locally, forms an integral part in the sense-making of CSG.[69]

[69] CSG can *vice versa* become a resource for making sense of environmental or somatic changes. For example, I was staying with a family who opposes nearby CSG developments and my nose began to bleed. While for me, this was the result of a week-long cold and dryness in the air, all three present adults were certain that it was a reaction to atmospheric pollution from leaking gas

Similar to such observable environmental changes, CSG can also become known by proxy through associated material and symbolic cues. For instance, references were frequently made by interlocutors to the industry's infrastructure to, sometimes tacitly, suggest the potential presence of gas. As Everingham *et al.* (2015: 54) already noted, in the Western Downs:

> Physical infrastructure that is changing the landscape includes not only the CSG wells, but also pipelines, telecommunication towers, mine tailings dumps and dams … . These facilities are clearly regarded as intrusive and as indicating the scale of the resources industry which is engulfing agricultural space.

What many residents thus "thought would be a limited intervention in the landscape is being experienced as a juggernaut" (*ibid.*: 57). These experiences are influenced by the prevalence of 'Danger' or 'Do Not Dig' signs that signal the location of now mainly buried pipelines. Rather than out of sight and out of mind though, such burial practices and the signifiers that remain in plain sight on the surface create a 'visible invisibility' (Barry 2006: 248, 2009):

Image 20 CSG by proxy: the 'visible invisibility' of CSG infrastructure (source: *Buckingham, Flickr* 2011)

This presence is a constant reminder of known impacts but also uncertainties and unknowns associated with the CSG industry.[70] The same holds true for the noise, smell and mere presence of vents at high points in the CSG pipelines, which are integral parts of CSG infrastructure (e.g., here).

infrastructure nearby (field notes April 2015). See also Chapter 5.3. for how debates over the 'naturalness' of certain environmental changes — its unrelatedness to CSG extraction — is an integral aspect of the CSG risk controversy (cf. Rayner & Heywood 2014).

[70] CSG infrastructure can also mirror social relation by (re-) creating political and economic inequalities. On the politics of energy, infrastructure and resource extraction see Barry (2013); Boyer (2011, 2014); Clarke (2015); Rogers (2011, 2015); Smith & High (2017); Sovacool (2011, 2012); Strauss *et al.* (2013); Szeman (2017); Szeman & Boyer (2017).

Yet again, such cues only allow for limited sense-making due to the intangible ontological properties of the gas itself and elusiveness of buried infrastructure. The account of two landholders in the grazing area in the northern part of the Western Downs is insightful in this regard. Here, the three major transmission pipelines, each pipe being about one meter in diameter, now underlie many properties on their over 500-kilometer pathway to the coast. I visited their property in April 2015 during the post-construction rehabilitation phase. This rehabilitation phase has been frustrating for some, possibly many, landholders due to drought and perhaps inappropriate strategies employed by the CSG companies. Important for this chapter is their response to my question of whether gas was currently flowing through the pipeline. They were unsure and voiced their concerns about not knowing what was happening right underneath the surface of their property, which highlights the difficult sense-making of CSG and its potential impacts.

This horizontal integration of the underground's 'verticality' shows how, locally, the underground, surface and atmosphere cannot be regarded as separate spheres. Rather, the entanglements of vertical and horizontal territory indicate that both form part in the sense-making of CSG by proxy within the totality of interlocutors' dwelled-in environments. Another example further illustrates this point. An irrigating cotton farmer explained to me how he did not trust many of the hydrogeological models that predicted only limited interconnection between the coal measures targeted by CSG companies and the area's overlaying primary groundwater aquifer. His concerns persisted until he had the opportunity to walk along hundreds of meters of a horizontally laid out drill core and saw the 50 meter thick layers of impermeable rock. This, he said, reminded him of the water-containing capacity of his concrete water tank (interview May 2015). Material and symbolic cues associated with CSG extraction therefore play an integral role in the sense-making of CSG.

A third and final important aspect of knowing CSG by proxy — one that leads towards the projected CSG discussed in the following section — is the application of monitoring equipment and technological devices to make CSG sensible and thereby knowable. Especially critical interlocutors often utilise such devices in order to make the directly imperceptible sensible, frequently in combination with other phenomenological cues. In a publicly available video, for instance, a local landholder discusses gas in his bore water and, with a gas meter in his hand, tells the viewer: *"If you think that the CSG industry is safe …, look at the bubbles and have a listen to the machine"* (Crane, Youtube May 2015). The device in his hand detects the odourless and invisible gas that would otherwise have remained unnoticed and instead transforms it into an audible and visible sensory experience. Other equipment I encountered ranged from comparably simple gas meters, to Geiger counters and even sophisticated Forward Looking Infrared (FLIR) cameras:

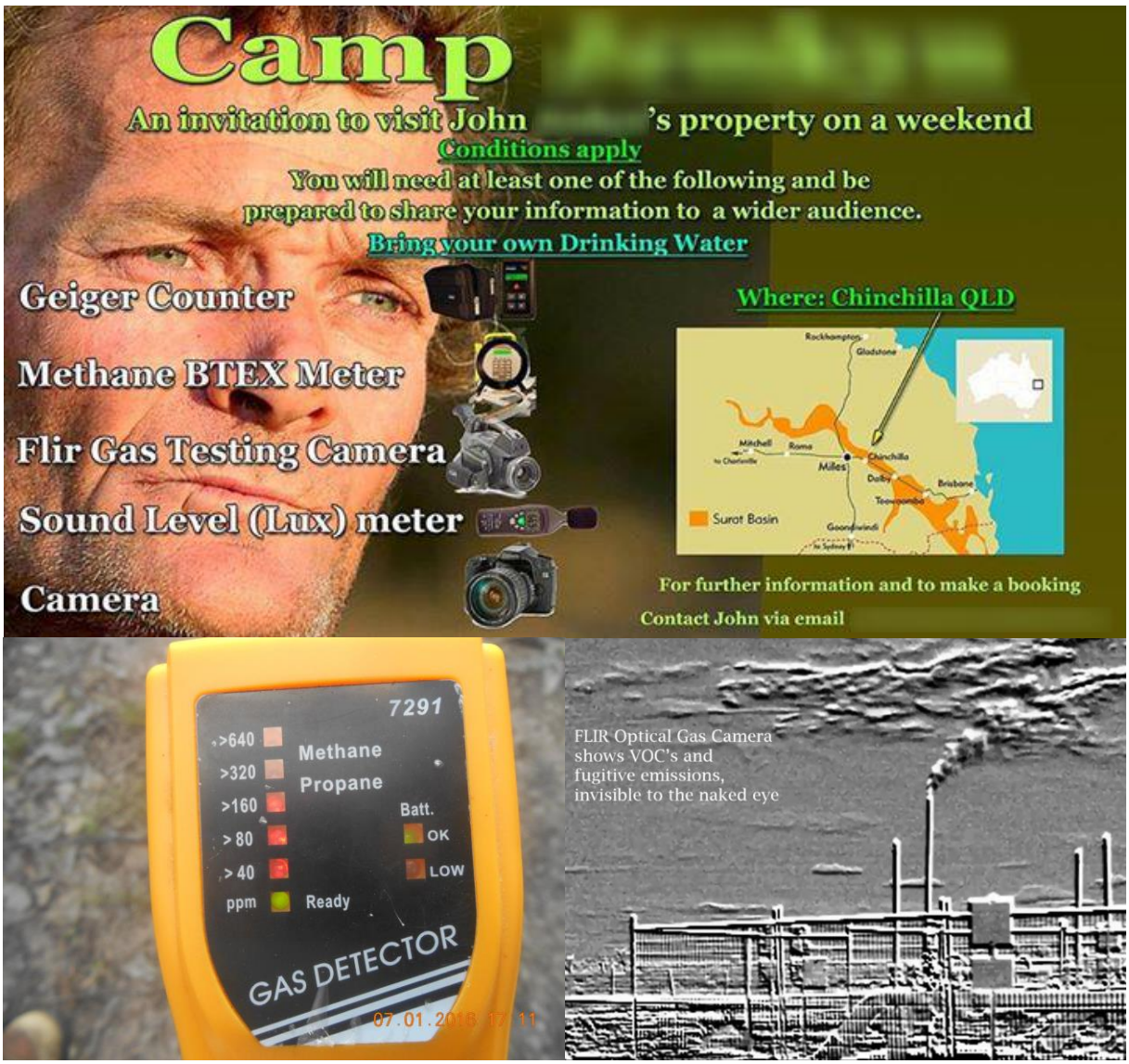


Image 21 CSG by proxy: shifting the margins of the sensible through technological devices (sources: interlocutor's facebook account 2015 & 2016; *People 4 The People, Youtube* July 2015)

Such devices were utilised to detect and thereby make knowable CSG. This subsequently allowed for CSG to become an object of discussion and possibly resistance. In this sense, we can grasp the material and discursive dimensions of CSG-specific knowledge practices (see Chapter 2.1.1.).

While one can here already notice a more abstracted way of sense-making, knowing through these devices essentially becomes another embodied form of engaging with CSG. As such, I observed less pronounced instances of what Parr (2010: 5) describes as an "attending to the proxies for insensible danger" through the use of measuring instruments. Some of my interlocutors thus turned to technological devices as phenomenological proxies in order to make sense of CSG and its impacts. Apart from specialist industry and government personnel, these devices were usually purchased privately. While my ethnographic data allows for indicative rather than generalisable insights, I suspect that, of those, it is primarily a small number of concerned and actively opposing local residents and interested 'outsiders' who use such measuring instruments — likely not just to

merely know CSG but also as ‘scientific evidence’ to substantiate claims. This raises questions of who can afford, legitimately operate and strategically utilise the readings of such equipment (see Chapter 7 & 8). The crucial point to highlight here, however, is that knowing by proxy of technological devices is an important aspect of CSG-specific sense-making.

As for the abovementioned ways of knowing CSG phenomenologically, this sensing by proxy is limited by the elusive ontological status of CSG. The readings and results derived from such devices thus frequently require further interpretation and complex abstractions to actually ‘make sense’ in the absence of more direct physical cues. One engaged female landholder explained:

> Interviewee: What are the VOCs [volatile organic compounds]? Because my little monitor doesn’t tell me what the VOCs are. Just that they are VOCs. Are they Benzene? Which is one part in a million? I’m getting 19 parts per million. The exposure to Benzene is one part per million. So that VOC that is coming out of there must be coming out of that well. … But I thought they said all their gas is 98% methane and 2% other stuff.
>
> Interviewer: What is the other stuff?
>
> Interviewee: I don’t know. … ‘It’s all fine, it is nothing, it’s just a well, it’s just methane gas’. You people are [expletive] crazy. Well, that’s the science, explain that to me. No, I found that out myself, no one will tell you that.
>
> [Interview May 2015]

Concerned residents and landholders are therefore not necessarily more certain even if they can employ technological devices.

The accounts in this section highlight the importance of phenomenological and embodied encounters with CSG once developments commence within interlocutors’ dwelled-in environments. In this sense, I propose to expand Ingold’s (2007: 14) understanding of materials to environments as a whole, namely that “[t]hey are neither objectively determined nor subjectively imagined but practically experienced”. Corporeal knowledge and the immediate experience of CSG thus matter within what Nash (2006) coined the “inescapable ecologies” created by modern societies’ applications of technological capabilities. That is, a realisation that “human beings were not simply agents of environmental change; they were also objects of that change” (*ibid.*: 7). As noted by many interlocutors, making sense of CSG from within given lifeworlds therefore requires the experience of being there. Utilising Ingold’s typology of environmental awareness (2000: 209–219), I here refer to experienced CSG. Such experiential knowledge is derived from direct phenomenological sensing, by proxy of (thought to be) associated environmental changes, and through technological devices.

Yet, I have repeatedly noticed the limitations of knowing CSG through phenomenological experience and moved towards more abstracted ways of engaging with CSG. As indicated above,

once the margins of the sensible are reached, scientific representations and conceptualisations become increasingly important. It is therefore necessary to clarify the role of the sciences and projected ways of knowing in the process of sense-making.

4.3. Beyond Experience: Projected CSG and the Technological Zone

In addition to the experiences of CSG, I was also confronted with a different CSG, personally and throughout data analysis. During document research or workshops in Brisbane, a more 'abstract CSG' frequently emerged. I am particularly referring to abstractions beyond the phenomenological through which CSG also becomes knowable, and thereby contestable and debatable. Braun (2000) has described the construction of such knowledge spaces as deeply cultural and historical practices of representation that as "particular modalities of 'seeing' and 'knowing' nature" often rest on the modern sciences' externalisation of nature (*ibid.*: 18 & 39). In other words, a way of understanding environments beyond immediate experience and, to use Ingold (2000: 209–219), from a projected global perspective. Let me develop this point with reference to some indicative empirical examples.

I have already considered the resource history of the Western Downs and the vital importance of surface and groundwater in Chapter 3. Unsurprisingly, knowing water-related impacts from CSG extraction has been a central theme during my ethnographic fieldwork and attending events such as a 'CSG Groundwater Field Day' (June 2015) or the '2015 Queensland Water Summit' (September 2015) became a regular activity. At these events, the primary focus was often the CSG-specific groundwater model developed by the Queensland Government's Office of Groundwater Impact Assessment (OGIA). This model is aimed at predicting groundwater impacts of CSG extraction in a geographical area the size of Germany. OGIA reports these predictions in their *Underground Water Impact Report* (UWIR), which it first published in 2012 and updates every three years. Presentations and debates at the events I attended particularly centred around OGIA's ability to accurately predict groundwater impacts. Assessing this ability in the latest 2016 UWIR requires working through almost 300 pages. In doing so, one is faced with numerous tables, maps and conceptual models:

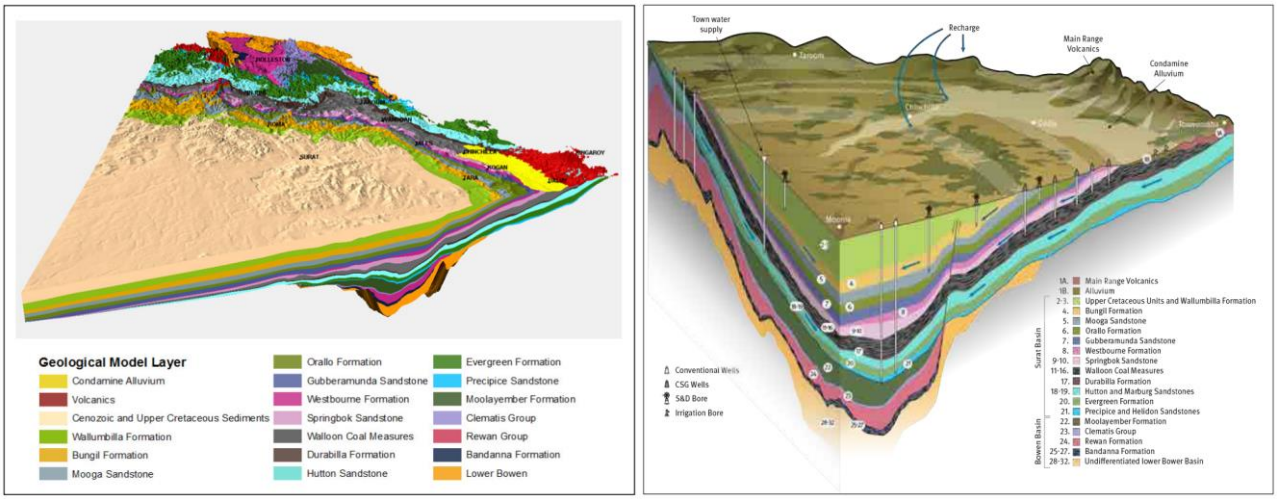
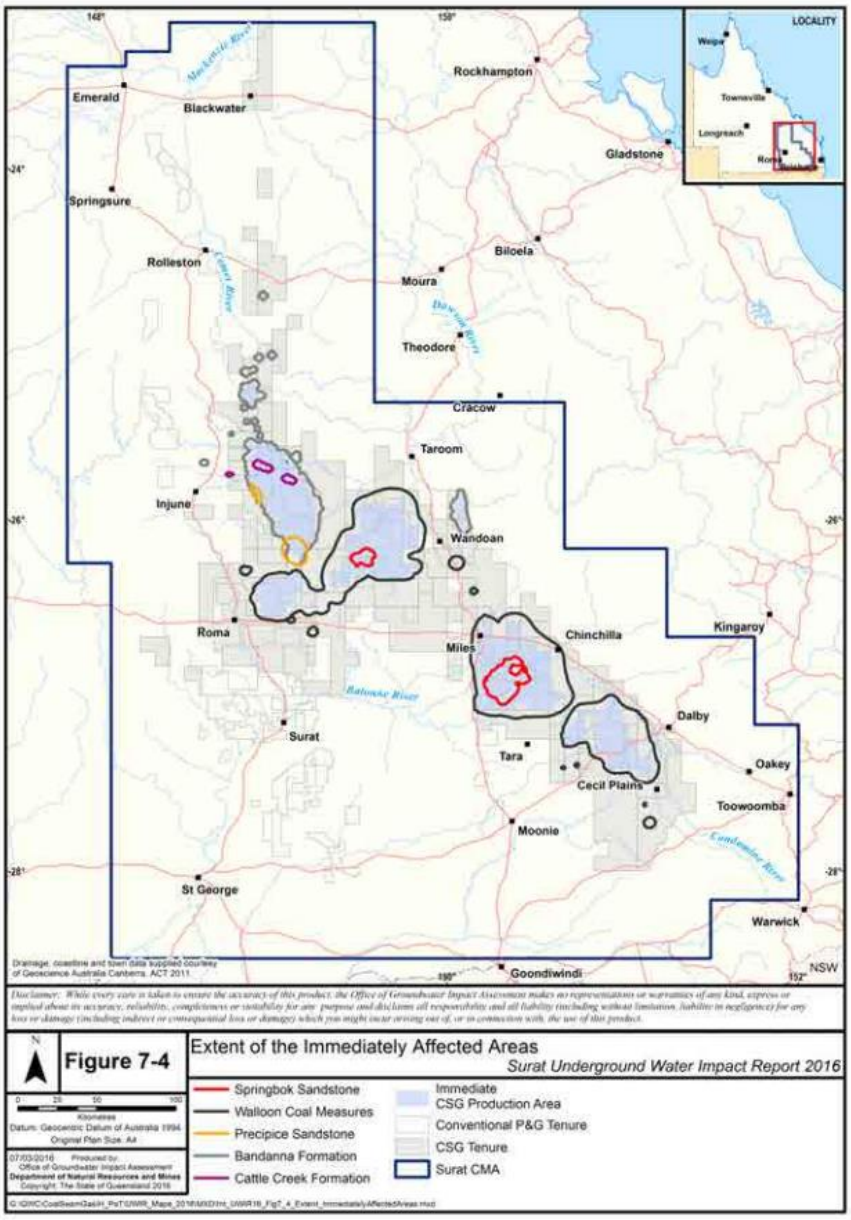


Figure 8 Projecting the underground: conceptual models of the geological layers and groundwater systems of the Surat Basin (source: OGIA 2016: 32 & 79)



Map 8 Projecting impacts from CSG extraction: extent of the modelled Immediately Affected Area (IAA) within the Surat Cumulative Management Area (CMA) (source: OGIA 2016: 84)

The UWIR's central area of interests is the conceptually defined Surat Cumulative Management Area (CMA). This CMA demarcates the extent of groundwater modelling efforts and sets the boundaries of projected groundwater impacts in terms of Immediately Affected Areas (IAA) and Long-term Affected Areas (LAA). Within these boundaries, CSG companies are required to negotiate Make Good Agreements (MGA) for the loss of groundwater with bore-owning landholders. In this sense, OGIA's modelling work and the UWIR have become a key resource for understanding and debating impacts and risks from CSG extraction. For instance, a male landholder and former president of a key regional CSG-specific NGO described the UWIR as their *'science bible'* to the audience of a large CSG research forum (September 2014), which highlights the central role of such groundwater models.

Judging from the above representations and sheer number of acronyms in the previous paragraph, one is confronted with a rather different understanding of CSG than in the preceding section. In contrast to the direct, yet limited, experiences of CSG, these representations create a knowledge space wherein Western Downs-based and outside actors alike can grasp the geographical and (hydro)geological extent of CSG developments. As such, the UWIR *inter alia* functions as a "boundary object" (Star & Griesemer 1989) that enables communication and cooperation between a number of diverse and heterogeneous actors groups. More fundamentally, however, I regard such representations as producing horizontal and vertical territorialities that conceptually order the material qualities of the surface and subterranean to generate 'legible' and knowable environments (Braun 2000; Hastrup & Skrydstrup 2013). Since in many 'Western' cultures reason and cogitation are linked to the visual — the dominant form of sensing (Howes 2012; Macdonald 2003: 4; Parr 2010: 10), Shortland (1994) describes such practices, especially within modern geology, as 'making visible' the darkness of the underground. In doing so, he highlights the intrinsic connection between geology and politics, and how relations of power are mirrored in the making of the underground. A similar perspective has already been employed productively in the context of the GAB and CSG extraction by de Rijke *et al.* (2016: 10) to analyse the subterranean "as a domain in which multiple forms of socionature hybridity emerge, and actors contest knowledge, rights and belonging". In this sense, the UWIR and other representations are integral elements in the sense-making of CSG and its becoming as a resource. They further function as boundary objects through which the extraction of CSG and its (potential) impacts can be meaningfully debated and negotiated.

Such representations are thus indispensable in rendering and stabilising CSG as a knowable, exploitable and ultimately manageable resource. Following King's (2005) work on the divergent experiences of marine environments and her notion of 'paper fish', one may similarly speak of 'paper CSG' to conceptually and analytically separate these representations from the experienced

CSG described above. However, in line with Ingold's typology I refer to 'projected CSG' that creates cognitive reconstructions and global views. Unlike the abovementioned experiences that prompt direct engagement, global perspectives are based on ontologies of detachment (Ingold 2000: 209–219). Two further examples wherein CSG "emerges as reality from elegant models that contemplate the globe" (Minnegal & Dwyer 2008: 80) illustrate — not least in their very names — such global and detached views:

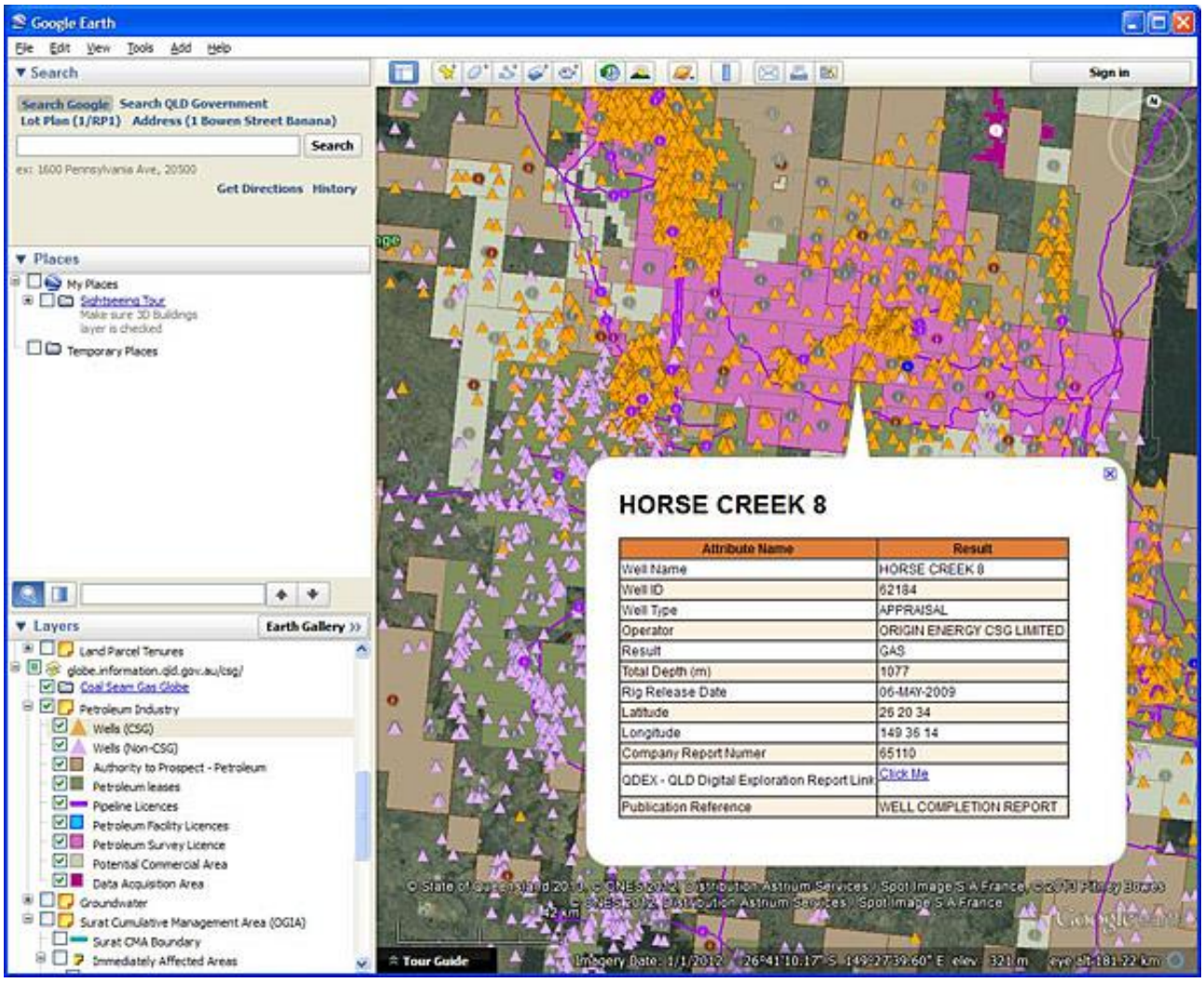


Figure 9 Projected CSG: Google Earth and the Queensland Government's CSG Globe layover showing CSG tenements and well locations (source: Qld Govt 2017)

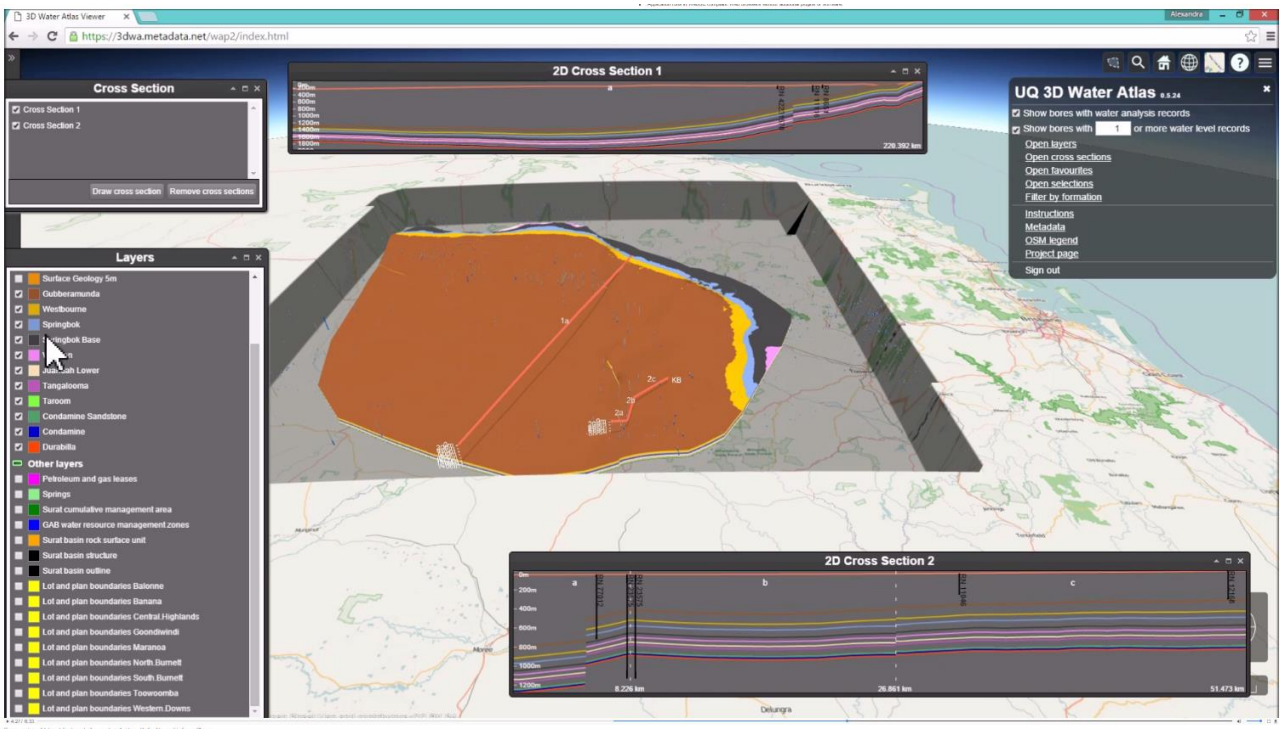


Figure 10 Projected CSG: the University of Queensland's 3D CSG Water Atlas (source: Water Atlas, UQ 2017)

In bringing this projected CSG into relationship with the experienced CSG and moving towards an understanding of the role of the sciences, it is important to consider how these practices of representation are rarely carried out locally but primarily by specialised scientific, technocratic and administrative experts who debate and regulate CSG in distant 'centres of calculation' (Latour 1987: 215–257) and thus often 'in absentia' (King 2005: 353).

Anthropologists Minnegal and Dwyer (2008: 80) are critical of such representations in the context of Australian fishing management and argue that:

> the abstractions promoted by science appear to be at a far removed from reality. They constrain possibilities rather than facilitate them. They are stories emanating from people who, it seems, have little direct contact with the world that fishermen experience, but, rather, occupy a virtual world of symbols … ; a world in which 'there is no Nature' any more.

This transcendence of geographical boundaries and the knowledge space those practices create are fittingly described by Barry's (2006: 239) concept of 'technological zones' or "forms of space which are neither territorially bounded nor global in their extension" and "within which differences between technical practices, procedures or forms have been reduced, or common standards have been established". Willow and Wylie (2014) already insightfully employed this spatial metaphor in the context of US shale gas developments and noted that these are zones "to which only certain people have access and in which space and time are marked differently" and that thus create a "distinction from the surrounding landscape" (*ibid.*: 228). In this sense, one might regard such

(scientific) representations of the physical world as restrictive — enabling access and engagement for some actors but not others (see Chapter 7.2.).

The findings from my ethnographic fieldwork can productively be interpreted through this perspective. For example, one can observe a (partial) reconfiguration of the existing territoriality of the Western Downs' landscape with many of the socio-politically distinct regions affected by CSG now grouped together and referred to by the underlying geological structures that hold the gas: the Surat Basin and Bowen Basin. In fact, several interlocutors critically noted how what used to be the agricultural Darling or Western Downs has recently been reframed as an area of hydrocarbon and mineral extraction, the geological Surat Basin (also Everingham *et al.* 2014: 124). These views appear to also be substantiated by the trademarked re-branding of the Western Downs Regional Council as the 'Energy Capital of Queensland' or the advertising of the region's main urban centre Toowoomba as the 'eastern gateway to the Surat Basin'. Such territorial reconfigurations follow, of course, economic as much as scientific reasons.

More important for the present focus, however, is the argument that technological zones are access restricted, which — as I shall demonstrate — is an important recurring aspect of projected CSG and the role of scientific knowledge. In this context, the notion of restricted access concerns both interlocutors' cognitive abilities and also power relations that enable or prevent participation (see Chapter 2.2., 7.2. & 8.3.). To avoid jumping ahead of this chapter's argument though, it may suffice to note the indispensable yet simultaneously restricted character of projected CSG as it emerges within these technological zones:

> We are having conversations that require a deep understanding of technical and scientific issues in the absence of most people having that understanding … .
> [Male regional natural resource manager, interview April 2015]

> Well, we don't give pathways into the model, we don't anticipate that people and local community will run the model, that's just not going to happen. So it is a case of explaining what has been done, how we've done what we've done and what the outputs are. … we went through some trouble to design this [information brochure], so it's readable by a lay person; that would be someone who is interested enough to put some effort into it. They are concerned about this and interested enough, they are local and worried about their water supply, they can read or somebody in the family would be able to explain to them.
> [Male senior hydrogeologist involved in UWIR modelling, interview April 2015]

> Farmers have got to really take models in blind faith, because they are never going to understand them. And half the people in the department never understood them … some of the people working in groundwater never understood them.
> [Male independent hydrogeologist with extensive CSG-specific expertise, interview June 2015]

While the outputs of CSG-specific centres of calculation, such as the UWIR and other representations, may be publicly available, the above accounts illustrate how access to the technological zones of their production can ultimately remain restricted.

However, multiple interlocutors have highlighted the need for those affected by CSG developments to directly engage with these technological zones in order to detect (potential) impacts and, crucially, have them recognised within the administrative and legal sphere. While I will thoroughly examine this aspect of the debate in Chapters 7 and 8, it is necessary to briefly demonstrate this apparent contradiction and foreshadow the ambiguous role of scientific knowledge. For this purpose, it is insightful to highlight the role of projected ways of environmental awareness in understanding and monitoring of groundwater impacts, which primarily occurs at the intersection between projected and experienced CSG by proxy of technical equipment. At several occasions, interlocutors stressed that being able to notice and subsequently claim impacts on one's bore(s) should be a priority for irrigating landholders. Important are not necessarily individual measurements at any given moment in time, though, but their representation over time and conceptualisation across the larger system of interacting groundwater aquifers:

> They are getting the monitoring in place now. The monitoring should have been in place bloody 20 years ago … . I always say, the thing that triggers everything is what the impact is. And you can't know what the impact is unless you actually measure what the water level was prior to starting and measure every so often to see what happens.
> [Male independent hydrogeologist with CSG-specific expertise, interview June 2015]

> Monitoring is so important. You want us to manage any concerns or issues, we need to know what's happening. … It's a major asset on a property and you can tell so much from monitoring the way it reacts over time. You actually develop a sort of feeling for the performance of the bore, you know whether the performance is dropping off.
> [Male senior government hydrogeologist, AGM of regional NGO October 2015]

The ability to engage with the restricted epistemic spaces of CSG-specific technological zones is therefore crucial for irrigating landholders who are involved in the debate.

These accounts resonate with those of actors who seek to have acknowledged the impacts they already know through direct experience and by proxy. While some of those interlocutors were certain that such impacts are occurring, the apparent challenge is to have them legitimately translated into 'paper impacts' (cf. Checker 2007). This struggle was illustrated during a gas field tour that was, among others, attended by a state politician. Two local residents described their despair and frustration about not having, for them obvious, environmental and health impacts recognised when they presented two large piles of various documents and test results to support their claims. Put on the spot, the state politician responded that he was supportive, but then pointed to the piles of documents that stood for this family's struggle and noted: *'We need to make this into*

something. … It only needs to be a one-pager. … We probably need to just reference the work that's already happening as a simple line. I assume that gives us a body of evidence that is tangible. … We need to get it into some sort of order' (April 2015). By 'tangible something', the politician referred to something quite different to the already all too tangible CSG-related impacts as experienced by those two residents. Rather, similarly to the recognition of groundwater impacts, the politician emphasised the importance of 'realising' those impact within the standardised procedures of administrative and legal institutions; that is, 'on paper'.

Such exchanges highlight the significance of projected ways of environmental awareness not merely for knowing CSG, but for being able to (re)articulate claims in particular formats. These formats create legitimacy and can thus achieve desired outcomes. Fundamentally, then, knowledge is not merely an externalisable possession, but forms part of people's capacity to interact socially. In this sense, CSG and its impacts may become real for a group of landholders while creating more widely recognised knowledge claims depends on what is "accepted as real for them and for others" (McCarthy 1996: 23, italics omitted) — the other being often a bureaucratic and political audience. Making acceptable claims through appeals to projected ways of environmental awareness is thus an integral part of knowing legitimately as opposed to being regarded as ignorant. This finding will be crucial throughout this thesis.

In concluding this section, I demonstrated how engaging with projected CSG is simultaneously restricted for many actors yet indispensable for individuals' sense-making. Projected ways of environmental awareness are subsequently also crucial for CSG's becoming within the institutional knowledge spaces that transcend given local boundaries — for example, within government or industry. It is important to bear in mind these insight as they have important implications for the role of scientific practices. Before considering these implications, I must wrap up the discussion of sense-making of CSG by addressing the relationship between experienced and projected CSG.

4.4. Conclusion: Hybrid CSG and the Predominance of Detachment

To briefly recap, this chapter began analysing sense-making of CSG based on a discrepancy between different CSGs as they emerged from my ethnographic field notes and research. I conceptualised this discrepancy through Ingold's work on typologies of environmental awareness and addressed the scope and limitations of both experienced and projected CSG. This insight can be summarised in a simple figure that clarifies these views:

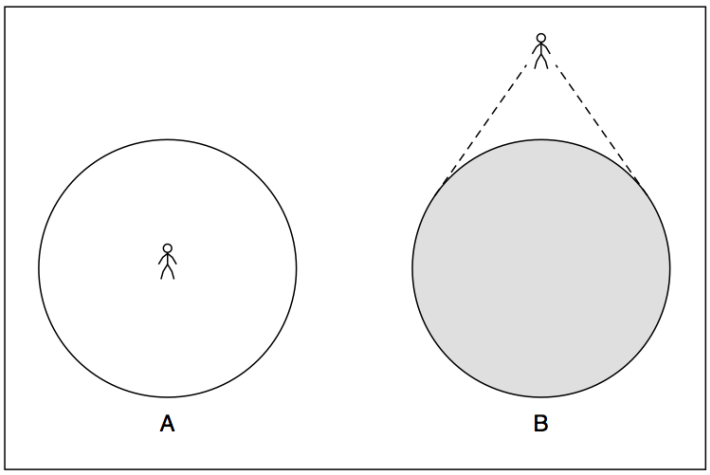


Figure 11 Two views of the environment: (A) as a lifeworld of inhabitation and experience; (B) as a globe of exhabitation and projection (source: Ingold 2000: 209)

In considering these two views, however, I cited a number of empirical examples where such clear-cut distinctions appear to be misleading. In light of CSG's elusive material properties and location underground interlocutors (need to) draw on a large range of direct corporeal knowledge, by proxy experiences and also projected maps, scientific testing and abstracted representations to make sense of CSG. The interplay between such different ways of knowing is illustrated by a further example (my emphasis):

> I said to him [another resident] 'Please don't drink your tank water, read the pollution data … on the government website'. Where do you think that stuff goes? What goes up must come down and that's why people have got contaminated tank water out there. *We know, we've seen the particulate matter, we've had it tested, we know*.
> [Female regional town resident, interview May 2015]

Following these insights about the interplays of experienced and projected views, I propose that actors within CSG-specific sense-making processes variously draw from a wide spectrum located in between rather than at the poles of experience and projection. I therefore concur with Rapport and Harris's (2007: 327) suggestion to focus on 'pathways of knowing' as "a way to postpone the daunting distinctions of … body as against mind; affect against intellect".

The resulting inseparable entanglements can be conceptualised as 'hybrid CSG' that is never only experienced nor exclusively projected. Instead, CSG becomes known locally in multifaceted ways. As such, "people may simultaneously experience multiple contexts but … biases will occur in predominant contexts and, hence, in ways in which people express understandings of their 'place' in the world" (Minnegal & Dwyer 2006: 16). Wynne (1995: 374–375, also 1996b: 41) similarly holds that everyday cognition involves a multidimensional variability of reasoning that can follow a rationality of ambivalence. Put simply, this means that, outside of particular scientific settings, non-specialists make sense of complex issues through various, not always mutually consistent, ways of

knowing. Their resulting knowledge is thus often diverse and possibly ambivalent (Satterfield 2002). Cohen (1993) makes a similar observation on the apparent difference between local and what he terms 'extraneous' or 'expert' knowledge. Instead of constituting distinct ways of knowing, he argues that (*ibid*.: 32 & 33; also Martin 2013):

> just as a multiplicity of meanings may lurk behind a common symbol, so a multiplicity of 'knowledges', which may not easily be reconcilable, informs common 'knowledge'. … Localities thus either capitulate, discard and even, perhaps, repugn their 'traditional' knowledge; or they may make a syncretic accommodation between local and extraneous knowledge; or they may subtly subvert the extraneous.

In this sense, it is misleading to suggest a fundamental distinction between scientific projections and phenomenological experiences. These categories are, first and foremost, analytically valuable.

The implication for either way of knowing is to acknowledge their importance within CSG-specific sense-making processes without neglecting their limitations, some of which I analysed in this chapter. CSG therefore, on the one hand, emerges within inhabited lifeworlds and is experienced through locally situated corporeal knowledges. In this sense, "[l]ife is local. Without the local, we have no standpoint by which to make sense of the world near us or the world within which the local is embedded" (Weinberger 2011: 193). This point is echoed by Irwin and Wynne (1996: 218) who emphasise the sensitivity of local contexts by regarding the local as "the site of renegotiation of the 'universal'" (also Cohen 1993: 39–40).[71] Regarding local residents' specific understandings of risks, Auyero and Swistun (2008: 369) then argue that the "cognitive heuristics people use to select and digest information about their environment - and thus their perceptions of hazards - are relationally anchored in everyday routines". Immediate experiences are therefore an integral part of locals' sense-making of CSG and its risks.

At the same time, however, the elusive qualities of CSG's ontological status create a need to utilise technological devices to know CSG by proxy and to engage with projected CSG through the transcending global views of, for example, abstract 3D geological models. Following the insights drawn from the technological zone concept and indispensability of projections, one can, on the other hand, appreciate that "[n]o place is merely local" (Parr 2010: 3). To grasp CSG developments and their transcendence of surface and subterranean boundaries therefore also requires a detachment

[71] Merleau-Ponty's (2002 [1945]) argument for a phenomenological understanding is interesting here: "All my knowledge of the world, even my scientific knowledge, is gained from my own particular point of view, or from some experience of the world, without which the symbols of science would be meaningless. The whole universe of science is built upon the world as directly experienced, and if we want to subject science itself to rigorous scrutiny and arrive at a precise assessment of its meaning and scope, we must begin by reawakening the basic experience of the world of which science is the second-order experience. Science has not and never will have, by its nature, the same significance *qua* form of being as the world which we perceive" (*ibid.*: ix).

from the immediately localities of experience, which is where scientific knowledges and global views enter the picture.[72]

Parr (2010) succinctly summarises the inseparable entanglements of this hybridity of local experience and global projection by highlighting that "[w]e make sense of our habitat through the sensations our technologies and actions allow, at least as much as we do through conceptual frames, symbols, and signs" (*ibid.*: 17).[73] Rephrasing this argument through Ingold's globe and sphere typology, sense-making of CSG, as described here, therefore involves elements of both ontologies of engagement and detachment. In repeating a central argument of this thesis, it is thus worth emphasising that 'science matters' and I have now clarified how so. That is, "[r]ather than assuming from the beginning of discussion … that science unconditionally deserves privileged status", I have considered "just how relevant and important scientific understanding is within everyday life" for those who "attempt to fashion useful knowledges from 'external' and 'indigenous' sources" (Irwin & Wynne 1996: 8 & 213). This insight brings me back to Ingold's binary typology.

I have already proposed to regard Ingold's distinction between experience and projection as analytically useful ideal types, which will emerge within the empirical only through complex entanglements. I am therefore hesitant to fully accept what Ingold (2014a: 242) criticises as "the gap between the earth-sky world of our experience and the global environment of technoscience". Rather than problematising scientific discourses and ontologies of detachment *per se*, I argue for an appreciation of their indispensability in making sense of CSG. Ingold's problematisation becomes useful, though, in the latter parts of this thesis where I move on from immediate sense-making and into the power-related questions that arise with diverging knowledge claims within the CSG risk controversy. Minnegal and Dwyer (2008: 79) here speak of the difference between:

> worlds where probabilistic risks may challenge modes of action and understandings but where there is seldom an experience of the truly indeterminate. It is when those two worlds [of local experience and distant projection] collide that difficulties arise and do so to the detriment of the less powerful players.

Therefore, the point to highlight about environmental risk controversies, such as CSG developments, is that they are not necessarily characterised by a clash of fundamentally dissimilar ways of sense-making. Instead, these are merely different paints on the same pallet. Issues do emerge, however, when the entanglements analysed in this chapter are disregarded and particular forms of knowledge — usually framed as scientific — are promote at the expense of others, which is frequently accompanied by ascriptions of ignorance.

[72] I am primarily developing a local perspective, but scientific practices are themselves not entirely detached in that, for example, scientist also experience and sense environments (O'Reilly 2016). As indicated, I thus employ analytical ideal types in this chapter.
[73] The philosopher Whitehead (1926a: 3 & 29) similarly reminds us: "Natural science is the science of nature. But - What is nature? … We may not pick and choose. For us the red glow of the sunset should be as much part of nature as are the molecules and electric waves by which men of science would explain the phenomenon".

The production and utilisation of such knowledge and ignorance claims thus deserve scrutiny. One must, for instance, ask 'whose knowledge' and 'to what end' (Satterfield 2002: 97; see Chapters 7 & 8). In doing so, I tentatively follow Ingold's (2014a: 236, also 2016) argument that "scientific and inhabitant knowledge occupy two poles in a hierarchy of power, with science at the top and inhabitants at the bottom …, where the flow is unilaterally from the 'top down' rather than the 'bottom up'" and where locally experienced knowledge can be "reduced to evidence, answering to systems of governance and regulation not of their own making but imposed from above by more powerful interests". In such a context, homes, for instance, may become *'sensitive receptors'* (e.g., Arrow Energy 2012) and experienced impacts need to be made *'into something'* to warrant official responses, which can create local disenfranchisement and (re)produce challenging power imbalances. These epistemic power relations, in turn, rest on the scientific idea of an immutable 'universal Nature' as counterposed to the, tacitly assumed to be inferior, subjectivity of the local (O'Reilly 2016: 29; also Chapter 2.3).

Notwithstanding numerous ethical and moral issues, the resulting unilateral epistemic flows may not necessarily be problematic if those making and utilising scientific knowledge claims were indeed able to satisfactorily answer locals' questions arising from environmental changes associated with techno-scientific developments; that is, by presenting a 'unified' response that can settle associated risk debates (cf. Irwin & Wynne 1996: 1–17). While these questions must, of course, be considered individually for any given context and particular technological application, the next chapters demonstrate that, in the case of CSG developments, such a unified and satisfying response has not been given for all actors. As I shall argue, empirical accounts can be diverging and some actors' positions have also changed over time. This makes the questions around unknowns and risks complex, and epistemic power imbalances an issue that deserves detailed examination.

In moving onto this part of the analysis, it then remains to note the general potential for such epistemic power inequalities wherein, as Ingold contends, projected ways of knowing and ontologies of detachment dominate locally experienced lifeworld encounters and ontologies of engagement. Rayner and Heyward (2014: 128–129) similarly refer to the scientisation of nature. In addressing the complex politics of water and communities, Bryant and George (2016: 89) provide one instance of such a scientisation and its epistemic power inequalities within environmental risk debates (also Neale & Turner 2016 & Chapter 8):

> Questions of power, politics and social location will shape what is determined as risk, which opens up possibilities for polarizing and contentious 'definitions' but also gives power to specific knowledges over others. For example, … Indigenous knowledges about water flows and risk to the environment are given less credence in Australia and elsewhere than those of governments or irrigators. What risk is and the way it is discursively constituted, engaged with and legitimised (or delegitimised) has consequences for how water institutions govern,

> which water allocation practices are set in place and the environmental management and intervention programs implemented.

Epistemic inequalities and their ramifications are not just found in the context of indigenous peoples' knowledge. Irwin and Wynne (1996) similarly refer to a conventional, science-centred public deficit model within which a lack of public education rather than scientific or expert knowledge is problematised. The next section considers whether such perspectives are a factor in the CSG controversy.

5. Problems of Knowing: Coal Seam Gas and the Natural Sciences

Will the wells run dry before peer-reviewed science can explain what is coming out of them? Only time will tell.

(Maher et al., The Conversation 8th December 2014)

Welcome to the uncertainty of subsurface geophysics and geology.

(Grant King, then Managing Director Origin Energy The Australian 9th January 2016)

Over the last three chapters, I have positioned the sciences within the wider conceptual, historical and epistemological contexts in which the Western Downs' CSG developments emerged and have come to appreciate the central role of scientific representations and knowledge for the sense-making and management of CSG. This included considering the potential for a predominance of ontologies of detachment and deficit models of the science-public relationship (see Chapters 2.3.1. & 4.4.). As I shall show below, such tendencies can be observed within the discourses surrounding CSG extraction. This prompts the question whether certain scientific responses to the ongoing risk controversy exist and are merely (un)intentionally ignored by some interlocutors or simply not communicated appropriately. For instance, are groundwater-related impacts and associated environmental changes sufficiently understood by scientists and continuing public debates thus simply the result of miscommunication? Addressing these questions is the objective of this chapter.

I begin by showing that deficit model discourses exist in relation to the need to know that arose with CSG developments. This is followed by a critical consideration of the role of groundwater modelling as a central scientific procedure to address this need. The primary aim is to demonstrate that, in some areas of concerns, CSG-specific scientific accounts cannot be regarded, firstly, as entirely unified and, secondly, as (yet) providing definitive answers to the environmental risks associated with CSG. In the third section, I explore this argument through the example of gas seepages in the region's main river, the Condamine. The widely publicised 'bubbling of the Condamine' serves to illustrate the interplay between knowledge and ignorance in the context of CSG. The argument that follows these insights is that more scientific research is necessary yet insufficient for fully addressing CSG-related uncertainties about (potential) environmental impacts. Simple deficit models are consequently misleading and, at least for some interlocutors around the time of my fieldwork, uncertainties and problems of knowing CSG's impacts persist not instead but partly also because of increasing levels of scientific research. I therefore continue the analysis of the

role of the sciences through what Irwin and Wynne termed a "relational focus" (1997: 7); that is, by considering the social and political contexts of these knowledge claims.

5.1. The Need to Know: CSG, its Public and Scientific Deficit Models

I have already elaborated on how CSG developments created a need to make sense of environmental changes and associated risks, which highlighted the important role of scientific representations within these sense-making processes and also for the becoming of CSG as a manageable resource. Following these insights, this section critically examines whether scientific knowledge claims can indeed satisfy the need to know created by CSG developments, particularly focusing on associated risk concerns. As such, many interlocutors appeared to agree that developments might proceed in some form or another if the industry could be proven 'safe'. For example, a key regional CSG-specific landholder NGO stated early on in its 'Not at any cost' blueprint for sustainable CSG operations that *"[s]cientific studies must precede any development*" and that "*[s]ubject to appropriate scientific research, purified CSG water may be re-injected … [and] no CSG operations to be conducted … until scientific studies and CSG technologies … can assure all stakeholders that there will be no adverse impacts"* (BSA 2011b). Yet, what constitutes 'appropriate' levels of scientific research, acceptable levels of 'safety' and who is included in 'all stakeholders' remain open questions (see Chapters 8.2.–3.).

Most proponents seem to answer these questions by frequently emphasising the large amounts of existing scientific studies or the industry's long domestic and international history. For instance, the Australian Pipelines and Gas Association's chief executive remarked in April 2015 that *"[t]he science is in"* (The Australian Oil and Gas Review, 17th April 2015). Similarly, a proponent's locally available information leaflet likewise assured the reader that *"[i]t is clear that the CSG industry will not drain the GAB and will have negligible impacts on total storage volumes"* (obtained March 2015). Albeit more or less tacit, this also appears to be the position officially held by a number of relevant federal and Queensland government departments. For example, as approximately one quarter of the 20,000 predicted CSG wells had been drilled in 2015, the Australian Government's Office of the Chief Economist noted that "*[t]he evidence to date shows that there have only been negligible impacts on water and air quality*" (OCE 2015: 1). Judging from these accounts, one might expect that those actors involved in debates ought to be satisfied with the existing level of (scientific) research and understanding.

Somewhat unsurprisingly then, I encountered a recurring theme wherein opposition to CSG extraction was often (dis)regarded as unscientific, emotive or even ignorant (also Espig & de Rijke 2016a: 88; de Rijke 2017). Such accusations are certainly not unilaterally made by proponents (see

Chapter 7 & 8). However, they are much clearer articulated and frequently stressed in response to opponents, and I therefore here focus on proponents' accounts. Within these, it is often emphasised that those opposing CSG are either misinformed and excusably unable to grasp relevant scientific resources, or deliberately seek to distort the debate. Three examples illustrate this theme:

> And yet, despite being the linchpin of the Queensland economy and one of the state's most crucial employers, resource development generally is under constant attack from green activists. With gas, one of the primary points of attack is the f-word: 'fracking'. … Scaremongering tactics from politically and fundraiser-motivated activists have sought to mislead the truth on the impacts of fracture stimulation … . Fracture stimulation continues to be accused without scientific foundation … . Yet, time and again, scientific enquiry comes to the same conclusion, that technical challenges and risks of fracture stimulation can be managed through a well-designed regulatory regime … .
> But if they [activists] are serious about the country's future, they need to listen to the country's leading scientists and not the increasingly hysterical chatter on social media that tries to pass itself off as informed debate.
> [Male chief executive of extractive industry representative body, opening conference speech November 2015]

> It appears that there is limited gain in the government or the company's continuing to present the robust evidence based science in the traditional manner or [sic] research and reporting. We should not stop scientific research - as it is invaluable in the ongoing process of environmental innovation and improvement; however we stop publishing our complex findings and adopt at the methods [sic] that have been successful for the promotors of the anti-CSG messaging so far, through the exploitation of the general public's instinctive process of 'natural thinking'. … When presenting our scientific knowledge, we need to address the likelihood of the risks and consequences, in a way that is simple and logical, and therefore easily accepted by the 'natural thinkers'. We cannot assume that the general public will ever think the science of CSG [sic] or take the time to read and educate themselves on the industry, and therefore we need to do this for them.
> [Male commercial consultant, 'Demystifying science' presentation at industry event June 2013]

> APPEA submits that the benchmark of good policy is science. It is therefore unfortunate that the bill before this committee fails to reflect the inconvenient truth of scientific consensus.
> [Male APPEA representative, Senate hearing transcript, Canberra 28th July 2015: 51]

These accounts contain clear signs of deficit perspectives as described at the end of the preceding chapter. Within these perspectives, debates over risks and uncertainties are primarily caused by mis- or disinformed members of the public rather than being a legitimate part of CSG developments.

Such an observation is certainly not unusual within the wider Australian context. As Kearnes and Miller (The Conversation, 12th December 2013) critically note:

> There is a tendency in Australian science communication to assume a 'deficit model' of public understanding of science. The assumption is that public concerns over technological change … are a product either of public ignorance or 'irrational' cultural values. The

> punchline is that this presumed 'deficit' in public understanding needs to be corrected by education and communication programmes.

Stilgoe (2007: 51) rephrases similar observations in his argument that conceptions of scientific rationality can become extended to imply public irrationality (also Jasanoff 2012: 25–32; Wynne 1996a: 68). This highlights the often problematic traditional relationship between the sciences and their publics whenever the demarcation of science is sought to be established by ascribing scientific illiteracy to a public laity (Edwards *et al.* 2007: 8–10; Irwin & Wynne 1996: 1–2; see Chapters 2.3.1. & 8.1.). Similar perspectives can certainly be found in the accounts above, which appear to suggest a scientific consensus and certainty regarding the questions raised by CSG developments; that, indeed, 'the science is in' and merely not understood or ignored by opponents.

As one might suspect, these views were not equally shared across the different actor groups. Interestingly, I generally did not notice such pronounced unilateral perspectives on the public understanding of science with those interlocutors who are at the very fore of these CSG-specific scientific practices. A senior hydrologist and former environmental monitoring coordinator with one of the four major CSG proponents told me:

> The other thing I learnt a lot was: don't underestimate people's understanding of science, they know what is happening on the ground.
> [Interview April 2015]

In this sense, many of the hydrologists or hydrogeologists I encountered tended to regard public understandings of science as more nuanced and, generally, also reflected critically on levels of scientific understandings.

With this in mind, I can address the central claim of deficit model perspectives, namely that the science is in. While this claim must be temporally positioned, it became apparent from the data primarily generated in 2015 that many interlocutors from various backgrounds noted how an appropriate level of converging scientific accounts was only slowly emerging. Others still considered there to be significant uncertainties, conflicting scientific accounts, or an altogether lack of scientific research. Such views were still prevalent at a time when most proponents' Environmental Impact Statements (EISs) — an important avenue for the dissemination and discussion of CSG-specific scientific knowledge — had been approved.[74] The following examples illustrate these responses:

> We're probably in a better position now in terms of data and information than we were six years ago when CSG first got rolling, so part of the challenge with your question is time. … if you went back five years, … the people who are involved in producing the EISs for the

[74] On the environmental approval process for CSG projects in Queensland, including the role of EISs, see Swayne (2012) and de Rijke (2013b).

> companies and some people in state government who are assessing those EISs would say 'yep, we have an understanding, we have a scientific understanding of what is going to happen'. But in hindsight, most of that you would probably call a technical prediction, it wasn't actual 'we really know'. … The scientific precautionary principle was not used almost at all in my opinion. Lots of the licenses were given out and still to this day are 'yep, go ahead and we'll figure out if there's an impact over time' … . Are we figuring it out? You have to say slowly but surely – I don't want to use the word surely, slowly but progressively … . We had the first three or four thousand holes in the ground before a cumulative groundwater assessment was done.
> [Male NGO-based senior natural resource manager, group meeting May 2015]

> The fundamental problem that I have is that … I can find as many counter-reports from peer reviewed scientists, consultancies, industry, government, that indicate that there is not a problem. … The industry will say it is safe, the departments are saying it's safe. We have a very passionate and evidence-based small demographic claiming it is anything but safe and appropriate. … You do a Google search and you can find any number of reports that are already done. … I can go on Google and find two reports to say two different things in a heartbeat. … I can get a consultant to tell me that everything is fine. I can give you consultants to tell me the place is a pile, it's a cesspit of toxins. … Again, this is the debate we're still having in 2015. Is it safe, is it not?
> [Male state politician, interview April 2015]

> We know there isn't [sufficient scientific research]. When you know how many Ph.D. students there are, why would Ph.D. students be investigating something that already had answers to it? … If it was all hunky dory and all already sorted? That's just stupid thinking for them to think that we're that stupid. But it's not … the CSIRO [Commonwealth Scientific and Industrial Research Organisation] is still investigating, it's obviously not sorted.
> [Opposing female landholder, interview May 2015]

These examples indicate that the status of CSG-related scientific research and knowledge claims is thought to be ambiguous by a wide and diverse range of actors.

Contrary to those advocating deficit perspectives of public understandings of science, though, I got the sense that many of my interlocutors who problematise the sciences are not merely unable to grasp appropriate and certain scientific accounts or willingly ignore them (cf. Lamberts 2017a). Rather, their accounts variously portray the sciences themselves as a fragmented, evolving, conflicting or incomplete resource for making sense of CSG's (potential) impacts. Many interlocutors were also faced with an "experts' dilemma" or "confrontation of expertise and counter-expertise" (Grunwald 2003; see Chapter 2.3.3.). As a result, I found that one overarching theme was persisting uncertainties about CSG projects' risks. The next chapter demonstrates that these uncertainties have sparked a large range of responses. Crucial for this section is the insight that regarding 'the science' as 'in' can be problematic in the context of CSG developments.

However, one may still contend that such problems of knowing result from scientific knowledge claims being miscommunicated or misrepresented once they transition into the public realm. I was

therefore intrigued to engage with those conducting relevant natural scientific research to see if uncertainties were an 'outside' public issue or whether scientists held similar concerns.[75] In the next section, I consider these findings by focusing on the accounts of groundwater-related researchers and industry professionals. This focus is warranted since grasping distant underground processes and projecting them into an anticipated futures is central to the development of CSG and it is also a crucial element of the associated risk controversy.

5.2. Manufacturing (Un)Certainty: Projecting Tomorrow's Underground

Throughout this research project, I had the opportunity to also engage with hydrologists, hydrogeologists and reservoir engineers either directly or by following invitations to technical workshops and meetings. Some of the findings from this research are already noted elsewhere (Espig & de Rijke 2016a: 86–87), and I will expand on them in this section. My primary aim is to demonstrate that uncertainties have — albeit in different form, yet contrary to a deficit perspective — also occurred or persisted among scientific and technical experts. That is, among some of these actors, too, knowledge about potential impacts and risks remains unsettled. However, knowledge claims that enable actions and that can form the basis of decision-making are necessary, especially for industry professionals and those administering it in governmental departments. I will therefore in particular attend to the reduction of uncertainties within CSG-specific groundwater modelling practices. These are crucial for managing the industry and for negotiating its impacts. This critical analysis will further highlight the role of the sciences in the context of problems of knowing associated with CSG developments. I will then anchor this analysis empirically through the case of gas seepages in the Western Downs' main river in the next section.

I introduced and discussed the crucial role of computational modelling for sense-making processes in the last chapter. These models form the basis for important aspects of government and industry professionals' decision-making and actions around CSG developments. A number of interlocutors in those professions emphasised, for example, how CSG well locations, relevant risk assessments, or the application of stimulation techniques — including hydraulic fracturing — were built on (hydro)geological models. The subsequent management of impacts often follows a 'by exception' or 'by deviation' approach; that is, operations commence and continue unless unexpected monitoring results contradict predicted outcomes. This approach similarly applies to the overarching 'adaptive management' strategy the Queensland and also Australian government chose to follow (cf. Hunter 2015). As a male representative for the Department of the Environment stated:

[75] I have already highlighted the problematic notion of too easily demarcating the sciences from its publics (see Chapter 2.3.). I revisit this aspect of the CSG risk controversy in Chapter 7 and 8. Suffice to note here that I refer to 'public actors' and 'scientists' with these conceptual insights in mind.

> We use the Office of Groundwater Impact Assessment's cumulative impact model. The companies then go away and look at that model and the way that the drawdown in certain areas would play out over their production schedule. They then use the model to set precautionary triggers. … The models tell the company, because the companies are the ones out doing the monitoring … . If there is a significant deviation from that, then they need to put in certain mitigation measures. The models are updated every three years with new data. [Senate hearing transcript, Canberra 28th July 2015: 6]

Environmental models are, therefore, an integral part of the sense-making and management of CSG developments.

With such emphasis placed on environmental models, one may critically ask whether these models are adequate representations of natural processes. In this regard, some interlocutors within the relevant natural science disciplines usually highlighted the improved and still improving quality of CSG-specific modelling. However, many still held concerns about the scale of the modelled geographic area, the complexity of hydrogeological and ecological systems, the assumptions and ambiguities of the modelling process, and the need to understand modelling output as conceptual working tools that are subject to review and improvements over time. A university-based hydrogeologist and an independent hydrologist, who both have extensive experience with Queensland's CSG projects, noted these uncertainties when asked about potential groundwater impacts:

> That's the million dollar question. I still don't think we know definitely and perhaps we never will, but at least the way I see the structure now … you'll see some very good studies. … The majority of the consensus would be that we are doing, well, we have got the appropriate monitoring in place. … And we are learning more about the [groundwater] system as a whole ... because we haven't started with zero knowledge. … We're learning about nuances. But so far they aren't making radical changes to what we think is going on or should be going on. ... We're catching up. … I tend to take it as encouragement, instead of going 'oh we know nothing', because I don't think we know nothing. We don't know as much as we should ... . [Female university-based senior hydrogeologist, interview May 2015]

> No, I don't think we've already caught up [with the industry's scale and pace]. But I think they are still working on this. ... The model isn't magical. … There is a fellow at [university name] who has done a significant review of the groundwater models, and [it] basically says there are seven models and none of them agree. But we knew that.
> [Male independent senior hydrologist, interview June 2015]

These accounts highlight improvements but also a persisting degree of uncertainty. As such, they resonate with findings from numerous groundwater researcher meetings, field days, industry conferences, and public workshops I attended.

On these occasions, I commonly encountered a desire for certain modelling outputs, but obstacles for building such models were frequently noted. For example, a company-based modeller

contended at an industry conference in November 2015 that '*the best model is a nice and simple one*', which is why they had separated the water and gas modelling — the so-called two- or dual-phase flow during CSG extraction — due to their combination being '*too complex*'. A common theme at these events was then attendees discussing the significant challenges associated with modelling highly complex natural processes and, in the case of the Surat CMA, the cumulative impacts from dozens of gas fields across a geographical area of some 360,000 km^2, approximately the size of Germany. To cope with these '*prohibitive complexities*', one modeller based at a specialised consultancy, stated that the model area had to be broken up into more manageable sub-models and how '*some tweaks had to be built in [the model] to mimic reality'* (February 2014). Another university-based modeller explained such tweaks as '*substitutions to reduce complexity and computation time*' (December 2015). Following these examples, one can notice numerous obstacles to adequately modelling CSG-related groundwater impacts.

Modelling practices thus appear to be characterised by *a priori* assumptions, simplifications and compromises that allow for the representation of complex natural processes. Such prerequisites include decisions on relevant variables, the setting of appropriate parameters, or the selection of suitable modelling programmes. Consequently, modelled outputs and their presumed uncertainties are open to interpretation as emphasised by an OGIA staffer during a hydrogeologists' association meeting in April 2016. The hydrogeologist noted how their office had gone '*back to the drawing board'* for the second UWIR model. They had done so since the first model had been '*based on other people's interpretation*'. Since '*people interpret things differently*', they had now built a new model '*based on their own interpretation*'. These characteristics are insightfully described in the account of another senior hydrogeologist. He describes the construction of the UWIR model:

> The challenges, technically, when building the model: the start is the size. … Even though we simplify the very complex geology to the extent necessary to be able to model it, we still end up with a very big model. … Reservoir modellers use a thing called Eclipse [a particular modelling programme] to model reservoirs and that is very good at simulating dual-phase flow. … The dual-phase flow means that you got gas movement through the formations … and it simulates that well. But the platform is not well suited to regional groundwater flow modelling and there are other boundary conditions that you need to deal with when you build groundwater regional flow models, it can't be easily representative. … There is the business of building a model, which has got nothing to do with the particular bore, but it's about understanding how the system works so we can predict a change in the future. … Nothing is perfect as it is in terms of completion. … It's not possible to collect all the information to fully understand the system … until we know how the system responds to stress. You can't really work out how it's likely to respond to further stress, you can't get all the science in before you start developing. That's just the way the world works.

This hydrogeologist thus stressed, as other hydrogeologists and engineers did too, that particular aspects of any model can often remain vague or even indeterminate until extraction commences and actual monitoring data becomes available to 'calibrate' the model.

This may not be surprising given that the scale and pace of Queensland's CSG developments and its subsequent conversion to LNG is a world-wide novelty (see Chapter 6.1.; Ledesma *et al.* 2014: 42, 49 & 57). However, the senior hydrogeologist also highlighted the importance of incrementally improving research over time as already noted above:

> We're closing the gap. The gap developed a few years ago when the industry kicked off and it would have been better if we could have been more ready. But I think the gap is closing now, some fairly reliable assessments as to what is going to happen. The reality of it is emerging, isn't it. … I think that the predictions we made will turn out, for the most parts, fairly conservative [i.e., overestimating the CSG industry's groundwater use], as we try to do it that way.
> [Interview April 2015]

For this hydrogeologist, and others, the accuracy of modelled groundwater drawdowns and forecasted impacts from CSG developments has thus improved markedly. However, obstacles and limitations to the modelling process, as well as uncertainties, remain an issue of concern.[76]

Despite the improving quality of CSG-specific impact predictions, groundwater models can thus remain subject to scrutiny and ongoing criticism by some actors, especially due to the recognition of their ambivalent nature. For example, the Australian Academy of Technological Sciences and Engineering noted in a workshop communiqué: "Modelling the potential consequences of unconventional gas production is widely and appropriately used for forecasting likely impacts, but its effectiveness is often limited by uncertain parameterization and limited knowledge of rock heterogeneity and connectivity. Ongoing research is required to reduce these uncertainties and gaps in knowledge" (ATSE 2015). Based on similar concerns, an industry-based engineer thus cautioned the audience at a CSG-specific technical workshop in May 2016:

> Mother Nature can really make your life complicated. … The best protection is understanding what is going on. … [So] be cynical, really push around your results, really think about it. … Where behaviour doesn't match the model, that's usually where all the interest is; please pay attention to that. That's where the rubber hits the road. … I'm sure I don't have to tell you, but on the subsurface side there's just as many if not more scientific conundrums and massive

[76] I focus on groundwater-related aspects but similar uncertainties can also be observed within the oil and gas sector more generally (Espig & de Rijke 2016a: 87). Such uncertainties are apparent in the language of 'probable' and 'proven' reserves, the location of so-called 'sweet spots', and a corresponding 'hit or miss' rhetoric. For example, during a tour of one major gas processing facility in the Western Downs, the leading technical officer described how wells had their own 'identities', which is to say that some wells produce more gas than others or at higher levels for longer periods of time. For the technical officer, this was due to some hitting a better spot – a 'sweet spot'. However, the production level of wells did not appear to be easily predictable even within the same gas field (July 2015). In regards to modelling heterogeneous gas fields and identifying these sweet spots, one modeller therefore noted in a workshop how many models were '*not very good to explain the variability we see in [gas] fields'* (December 2015). At another occasion, an industry-based engineer likewise emphasised the innate uncertainties of oil and gas extraction by stating that: '*It's an art, not a science. We don't know what we are going to find, don't know where we're going to find it*' (April 2015).

> assumptions … and certainly for CBM [coalbed methane, i.e. CSG], which has its challenges for modelling. … Recognising when mathematics don't mimic reality is the first step in understanding.

These accounts provide insights into the assumptions and decision-making involved in groundwater modelling practices. Those models and their outputs thus not merely reflect physical processes but are best regarded as actively manufactured environmental representation (cf. Chapter 4.3.).

In response to this active construction, other interlocutors were even more critical of CSG-related groundwater modelling practices, particularly when forecast impacts do not correspond with (perceived) environmental changes or other models' predictions. For instance, the primary topic of concern at the 2016 AGM of a CSG-specific regional landholder NGO was the inadequacy of the second UWIR model for predicting local impacts. One member, a local feedlot operator as well as 'outside' engineering consultant, had therefore built an independent groundwater model. He stressed that, unlike assumed by the UWIR model, loss of groundwater was not uniform across the modelled area. By running his own model, he instead forecast greater impacts near the actual CSG wells within immediate proximity to his bores. The predicted drawdown to that particular aquifer thus varied greatly from 2.1 meters in the government's model, to 30 meters in a Schlumberger model,[77] to 50 meters in the model he built. With some despair he wondered '*where do we go from here, because I don't know'*, with another member commenting: '*How can they [Queensland government] say they manage water sustainably if they don't even know how much is taken?'* (October 2016). Within such disputes, one can grasp the manufactured character of groundwater models and, once actors become aware of this, the possibilities for uncertainty and possibly contestation.

Readers with expertise in (groundwater) modelling would likely respond to this insight by noting that forecasting regional impacts across a large geographical and geologically diverse area is rather different to predicting local impacts to individual bores. As I noted above, the UWIR "*has got nothing to do with the particular bore, but it's about understanding how the system works so we can predict a change in the future"*. Different models thus serve different purposes and accuracy on a regional level might not imply precision on a local scale. As such, landholders might be concerned about predictions for local impacts on bores, CSG companies about water and gas production cycles of a set of wells, whereas government actors require regional predictions to make decisions concerning the cumulative impacts across the entire management area. This discrepancy is another significant ramification of the transcending characteristics of CSG developments that requires to distinguish between local and global perspectives (see Chapters 1.3. & 4). Important to highlight in this sections, however, is that these empirical findings demonstrate that the outputs of modelling

[77] Schlumberger is the largest provider of technology and services to the oil and gas industry.

practices are not simply 'crystal balls' into the future but are themselves shaped by numerous assumptions, interpretations and value choices. This makes it necessary to consider the purpose and limitations of environmental models.

In a groundwater-specific lecture series I attended in 2016 (see here), hydrologist and atmospheric scientist Ferré therefore stressed the need to understand the underlying processes of model building practices, especially funding and time constraints. He began his seminar with an insightful haiku: '*Our data is sparse, Our models are incomplete, But, we must decide'*. He argued that it is impossible to consider all potential variables and that *a priori* decisions on what to measure and model are essential. A model is consequently '*a set of choices how to represent a system … it defines what we think we know about the system'* (August 2016). These representations are then potentially limited by what Pilkey and Pilkey-Jarvis (2007: 29) describe as situational biases to stress how "our thinking is so obscured by our present state of knowledge and known conditions and observed trends that we are blinded to the future". These biases can create 'expected universes' that significantly influence how a model is simplified and subsequently 'tweaked' or calibrated (*ibid.*: 82–83). That is, large quantitative models can include "thousands of input parameters, hundreds of thousands of lines of equations in hundreds of computer codes, and hundreds of linked mathematical models in the system: complexity built upon complexity, assumption built upon assumption" (*ibid.*: 55; also Anderson 1983). Models can thus enable one to predict future outcomes with some certainty, thereby providing grounds for decision making and action. At the same time, modelling practices require the reduction of complexities, similar to what Wynne (1995: 374) described as the scientific "attempt, cognitively and materially, to reorganize the diversity and open-endedness of problems and settings into a uniform, quasi-laboratory version that can be subjected to standardized, universal, and precise analysis and solution". This may limit, intentionally or not, the possibility to foresee unexpected outcomes and unanticipated consequences.

If some actors become aware or suspicious of such limitations, disputes can emerge over uncertainties and unknowns. For instance, on *Rural Resources* — a website operated by private farmers in the Surat Basin — landholders who are approached by CSG companies are cautioned that *"[t]he problem is not the known impacts, but rather the unforeseen impacts that will occur. It will be hard to address the issue of compensation for such unknown effects"* (Price 2017b). It is worth here recalling Jasanoff's (2002) notion of how a love of quantification and predictive ambitions can "promote a peripheral blindness towards uncertainty and ambiguity. Analytical attention focuses on the known at the expense of the unknown, leading to possible overconfidence in the power of prediction" (*ibid.*: 374; also Beck & Wehling 2012; Frickel & Edwards 2016; see Chapter 2.1.2.). Modelling can thus be regarded as epistemic constructs that exemplify how a

concept of irreducible ignorance is frequently absent in modern science, which is based on the assumption that ignorance is essentially reducible by scientific research (Faber & Poops 1993: 124 & 127). However, Pilkey and Pilkey-Jarvis (2007: 130, 152 & 204) stress how accurate numerical predictions of the future are essentially impossible and emphasise that quantitative models are not 'crystal balls' (also Hunt & Welter 2010). Those immediately affected by potentially unanticipated consequences are thus frequently critical of scientists and experts' ability to predict future impacts.

Models are then the result of practices that order and reduce complexities and render the future knowable through the probabilities of risks. These risks are, however, not objective uncertainties but what I described as normative statements (see Chapter 2.2.1.). As such, models may not reflect natural processes accurately. Hunt and Welter (2010: 477), for example, argue that;

> All models … confront this common problem - the natural world will always be more complex than can be included in a model. Thus, there will always be an 'unknown unknown' of structural error … from not being able to represent all salient complexity of the natural world, due to deficiencies in characterization efforts and decisions about spatial and temporal simplification made in the name of obtaining tractable models.

This itself is not necessarily problematic; after all, it has been widely acknowledged that "[e]ssentially, all models are wrong, but some are useful" (Box & Draper 1987: 424; also Pilkey & Pilkey-Jarvis 2007: xiii & 188–189). It is therefore important to critically ask why some models and their output are deemed useful, by and to whom, what purposes these models fulfil, and how they gain epistemic authority — that is, enquiring into those models' 'social life' (Hastrup & Skrydstrup 2013). Different aims, purposes and values are then themselves not problematic.

Issues can arise once the predictions of large quantitative models are taken at face value and advocated by some actors as 'reality' *per se*, which neglects models' limitations and forecloses further debate.[78] In such contexts, unequal risk positions or the effects of uncertainties on those most affected by potential environmental impacts can become lost in a 'language of objectivity' (cf. Mercer *et al.* 2014: 284–285; on risk positions see Beck 1992). In a university-based hydrological research groups' seminar that I attended in June 2014, modelling specialist Clement therefore similarly asked 'complexities in groundwater models: when (and perhaps why) should we say enough is enough?' Fundamentally, he argued against modellers '*selling a crystal ball*' to policy makers and clients. Instead, he noted that:

> Basically we have no idea in groundwater [modelling]. We bring in the hydrologists to bring some pretty pictures. That's only the physical complexity, the chemical side is totally

[78] If this happens unintentionally, one may speak of what Whitehead coined the fallacy of misplaced concreteness or "the accidental error of mistaking the abstract for the concrete" (1985 [1926b]: 64). Chapters 7 and 8 consider the intentional political utilisation of such scientific knowledge claims. It may suffice here to note how environmental policy debates that are dominated by quantitative models can foreclose participation for a large number of actors. As Hébert and Brock (2017: 56) note: "As quantification becomes the means through which environmental claims are staked, it reinforces the authority of scientific expertise at the same time it foregrounds other ways of knowing and establishing authority".

> different. …Then you bring in the biologists, the micro-biologists. … On that big a scale [of a regional groundwater model], I can draw the line anywhere I want to make it good.

In a corresponding paper, Clement (2011: 627) therefore warns against promoting mathematics and quantitative groundwater modelling as a "mysterious substitute to educated common sense". His comments highlight that groundwater modelling experts themselves can be critical of the production and naïve utilisation of models. Some actors' claims that 'the science is in' and their intended effects thus deserve scrutiny (see Chapter 8.1.).

Following these insights, one can grasp the ambivalent nature of such modelling practice and can appreciate that risk concerns cannot merely be ascribed to a deficit in the public understanding of scientific accounts. Instead, these findings highlight that groundwater research inevitably involves constraints, incomplete data, simplifying assumptions and the ongoing negotiation of complex uncertainties (Barnes 2016). They also indicate that challenges to those models not just emerge from 'outside' the sciences, but — albeit in different form, yet perhaps most substantially — from 'within' the sciences themselves (cf. Chapter 2.3.3). Another empirical examples illustrates these points. In 2012, the Australian Government established the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) to provide scientific advice to policy makers on the potential water-related impacts of CSG and large coal mining development. One year later, the IESC's considered one CSG proponent's EIS and remarked:

> Given the concerns raised regarding the uncertainty of drawdown predictions, further data is required to improve confidence in modelling of the likely impacts of drawdown … . Limitations in understanding the groundwater dependencies of these water-related values, and in modelling of likely groundwater drawdowns … , mean that the draft Environmental Impact Statement does not adequately address the groundwater impacts … . The Committee does not consider that the modelling undertaken is adequate and includes a number of limitations … . This raises concerns about the robustness of the drawdown predictions made using the numerical model. Furthermore, there is a discrepancy between the drawdown predicted by the Arrow model and Office of Groundwater Impact Assessment (formerly Queensland Water Commission) model which requires resolution.
> [IESC report, 20th February 2013: 2–3]

In the assessments of another proponent's applications to expand an existing and develop a new CSG field, the IESC's experts similarly highlighted:

> The scale, the early stage and the geographic extent of the proposed project development, together with other significant coal seam gas projects in the region, creates considerable scientific uncertainty about potential impacts on surface water and groundwater and associated ecosystems. … Methods applied are appropriate to understand regional impacts, … however the methods used are not sufficient for understanding local-scale impacts, particularly to ecological assets. This results in a high level of scientific uncertainty associated with the local scale impacts and the mitigation of those impacts.
> [IESC report, 18th November 2014: 2]

> As expected when modelling complex environments, there are limitations associated with the groundwater model that introduce a level of uncertainty with the model outputs. … Knowledge gaps, uncertainties and data limitations within the Environmental Impact Statement (EIS) have been identified by the IESC. … There is low confidence in the water balance modelling and therefore the produced water management system.
> [IESC report, 8th August 2017: 1, 2 & 4]

Modelling practices and scientific research can thus be perceived as limited and uncertain also due to specialised experts' critical assessments rather than due to public misunderstandings.

These empirical materials show that, firstly, modelling outputs can, like any scientific research, be incomplete or contradictory. Furthermore, they demonstrate the potential for a critique of science by science, which indicates a success rather than failure of the scientific method. In doing so, scientists and professionals themselves can, paradoxically, highlight or even create rather than dissolve uncertainties (Minnegal & Dwyer 2008; Sarewitz 2004). It is therefore crucial to appreciate that groundwater models follow specific purposes in making CSG-related impacts knowable, while themselves being subject to limitations, uncertainties and even inconclusiveness. I propose that such models can thus be regarded as constructs of 'manufactured (un)certainty' (Beck & Wehling 2012: 46; Beck in Yates 2001: 99; Hastrup 2013; Stilgoe 2007: 48–49; Zehr 1994: 215; see Chapter 2.2.2.).

This is not to condemn these practices. After all, as "modes of bounding and quantification that tame uncertainties into more calculable probabilities" (Hébert 2016: 121), they are central components of the scientific response to the questions raised by CSG developments. However, "[t]he outputs from models that deal with natural resources are", as Minnegal and Dwyer (2008: 79) fittingly remark, "filtered through the management agencies to people whose working lives depend upon those resources". In other words, models have crucial implications for political decision-making as well as individual's everyday actions and lives (Hastrup & Skrydstrup 2013). Bearing in mind the potential (unequal) ramifications of unanticipated impacts, it is thus essential to not take modelling outputs at face value but to critically consider the contingencies and limitations involved in model building and interpretation processes. A senior industry executive acknowledged this insight at a company-sponsored gas field tour of their facilities when he noted '*the model is only a starting point, understanding the actual impacts requires more than that'* (October 2013). In the next section, I therefore consider how actors make sense of environmental impacts in uncertain contexts where scientific responses remain contested, inconclusiveness or contradictory.

5.3. Surfacing Problems of Knowing: The Bubbling of the Condamine

So far, I have shown how the natural sciences associated with understanding and predicting CSG extraction's impacts remain ambiguous in parts and may not be 'in' to a degree that can conclusively explain related environmental changes on either a local or regional scale. As a result, problems of knowing have persisted in some instances and for a variety of actors. One example that allows to explore these persisting epistemic problems is the occurrence of gas seepages in creeks and rivers in areas of CSG development, with the bubbling Condamine — the Western Downs' main river — being most striking and widely publicised. The development of CSG reserves and associated mobilisation of gas underground may or may not be a factor or cause of these environmental changes; impacts from CSG extraction might, for instance, work in tandem with existing cumulative impacts from agriculturalists' (over)use of groundwater (see Chapter 3.1.2.). These causalities remain to be determined, but some of my interlocutors closely linked CSG developments to the bubbling of the Condamine, whereas others questioned or denied any connections. I examine this case to further understand problems of knowing environmental changes associated with CSG developments and the ambiguous role of scientific responses.

Landholders adjacent to the Condamine towards the south-west of Chinchilla first reported gas bubbles to the Queensland state government's CSG Compliance Unit (then LNG Enforcement Unit) in May 2012. The unit's initial investigations revealed multiple locations along the river where gas seepages could be observed:

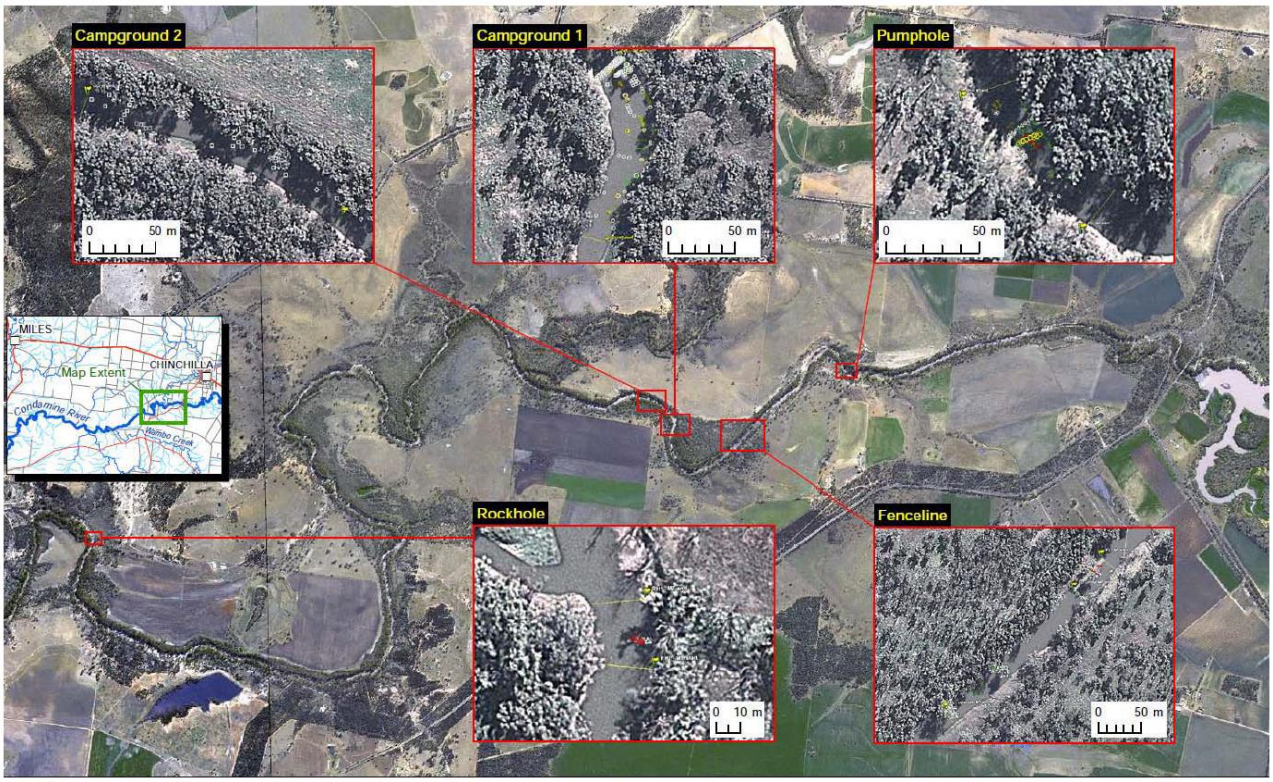


Figure 12 The multiple locations of the Condamine gas seepages (source: LNGEU 2012: 29)

Image 22 The bubbling Condamine near Chinchilla (source: *David Lowe, Flickr* 14th July 2013)

The unit found that ”[a]necdotal accounts would appear to support the regional incidence of gas migrating to the surface, although the current activity would appear to be more vigorous than previously observed”. However, the findings did “not provide definitive evidence of the sources or cause of the Condamine River gas seeps” and the unit acknowledged that “[i]t is recognised that the source and cause of the Condamine River gas seeps is unlikely to be determined in the short-term, and that a long-term approach to find more science-based answers to the phenomenon is needed” (LNGEU 2012: 4–5). In cooperation with the Compliance Unit, the tenement holding CSG company therefore commissioned an international energy consultancy with further investigating the persisting occurrences of gas bubbling. While providing further assessment strategies, the resulting technical report from February 2014 was essentially still inconclusive and stated that “work was not intended, and should not be expected to provide immediate conclusions in the absence of sound scientific data” (Norwest 2014: ES-I). This prompted the tenure holder to state on an official information sheet that “[t]he exact cause is not known and Norwest has made recommendations for further assessment” (APLNG 2015: 2).

Numerous other consultancies and also the federal government’s agency for scientific research, the CSIRO, became subsequently involved in further research, but the causes for the seepages remained to be determined. The then Chief Scientist to the Queensland Government, Dr Geoff

Garrett, therefore selected "four eminent scientists" to independently review existing reports. Their eight-page review, too, comments that "[t]here is currently insufficient information to identify the causes of the recent gas seepages in the Condamine River area" and that "[f]urther investigations are warranted" (Apte *et al.* 2014: 3). Interestingly, the report also notes that "[t]here will always be scope for additional research and monitoring" with further studies *inter alia* needing to be judged on "the required investment in the research versus the potential value of information/insights acquired" (*ibid.*: 8; cf. Chapter 7). At the time of writing, almost five years after initial investigations commenced, the official 'multi-agency response by Government' and also the industry-commissioned investigations regarding the bubbling of the Condamine provide only vague answers and the potential cause of the seepages remain uncertain.

Unsurprisingly, the seepages received widespread interest from the print, online and social media both domestically and overseas. For instance, they have inspired an active anti-CSG BubblingRivers Twitter user and also informed news accounts on proposed unconventional gas extraction world-wide (e.g., in Germany and Colombia). The Condamine has also featured frequently in the regional and national print media over the last five years with news stories reflecting the ambiguous and inconclusive findings of the government's and also proponent's reports. Images of the bubbling, and recently also burning, Condamine have also become a powerful symbol outside the Western Downs as they get variously employed by a range of actors to highlight what they regard as the apparent, yet ignored, environmental impacts of CSG extraction and the shortcomings of scientific research:

Government report points the finger at CSG as cause for bubbles in the Condamine River

A GOVERNMENT report has shown that the spectacular bubbling of the Condamine River could have been caused by coal seam gas after all.

Mystery remains over why Condamine River is bubbling

QUEENSLAND has another mystery that science still can't pin down: the bubbling of the Condamine River.

Mystery of gas bubbles in Condamine River still murky

TWO years after gas seeps were discovered bubbling in the Condamine River, Australia Pacific LNG can not confirm their cause.

Condamine River on fire in CSG mining area

Footage shows huge flames erupting from methane gas bubbling to the surface of the Condamine River, a result of ongoing coal seam gas mining in the region, some locals say.

River on fire in Greens MP's video is natural, not fracking, says CSIRO

Jeremy Buckingham says scientists 'making excuses' for CSG industry after footage shows him touching off sheet of flame on the Condamine river

Figure 13 Unsolved mystery: ambiguous media accounts of the Condamine gas seepages (sources: The Courier-Mail *2nd August 2013* & *11th April 2014*; *Chinchilla News* 10th April 2014; *The Border Mail* 23rd April 2016; *The Guardian* 24th April 2016)

Image 23 A powerful symbol: the bubbling Condamine set on fire by a Greens politician and local landholder (source: *Buckingham, Flickr* 12th April 2016)

'The Bubbling Condamine' (to the tune of 'On the Banks of the Condamine')

In days of old the tales were told of the mighty Condamine
Of how the shearers there would meet by waters so sublime
Times were tough, the work was done by honest men so fine
What would they say if they beheld the bubbling Condamine?

Old folks say the river once flowed clear and clean and level
But now a bubbling gas appears, directly from the devil
And what has brought about this change where waters once flowed fine?
Foolish men are fracking for gas by the bubbling Condamine

Before the white man came to stay the black man did survive
For more than fifty thousand years they kept the land alive
They lived in peaceful unity until that dreadful crime
We're witnessing an open wound in the bubbling Condamine

What can we do, what can be done, we cannot look away
For years the methane has leaked out, looks like it's here to stay
Escaping into the atmosphere, our warming planet crying
What have you stupid humans done to the bubbling Condamine?

And well you may be wondering how this could ever be
How come these crooks have been allowed to plunder all they see?
Elected representatives are drinking expensive wine
While on their watch they have approved the bubbling Condamine

And as if this scene is not enough to stop these wicked men
They're looking to expand their reach, to frack and frack again
It's time we all stand up us one and link arms in a line
For the sake of this land that we love and the bubbling Condamine

Figure 14 Making sense of environmental change: a rewritten interpretation of a classic folksong (source: *Davey Bob Ramsey*, performed in Lismore 31st January 2016)

The bubbling Condamine has then been a recurring theme since I began this research project and especially during my ethnographic fieldwork.

In light of the inconclusiveness of existing scientific accounts, I encountered a diverse range of responses from local and outside interlocutors alike regarding the potential causes and 'naturalness' of these seepages. As their fragmented and partially conflicting explanations came to fittingly exemplify the problems of knowing created by CSG developments, it is insightful to discuss them in this chapter in more detail to further empirically anchor the present argument about the

ambivalent status of the natural sciences in this context. Let me begin by considering the range of local responses.

The small number of landholders immediately adjacent to this part of the river expressed mainly annoyance and disinterest towards the ongoing (mis-) use of the incident, especially in the wider media. For example, one landholder declined an interview request by noting that *'they are just bubbles in a river'* that did not concern them. Another used both hands trying to list all the representatives from government departments, company staff, consultants, media reporters, university researchers, and activist groups that had approached them in order to explain why she had no interest to engage further with the issue (March 2015). However, the bubbling of the Condamine and also some nearby creeks is an ongoing concern for some local actors who see them as clear evidence for the impacts of CSG extraction. At the same time, other interlocutors critically remarked how gas occurrences in waterways and bores had always been an issue throughout the region. The following conflicting local accounts and the anecdotal knowledge they cite reflect these findings:

> When I put up the photos of the bubbling creek [on Facebook], one person in particular said there has always been gas in the water and that they could light up their bores. Yeah, that happened in places, but … the Condamine River, where you see that spectacular footage of the boiling water, go and talk to the old guys here and they will tell you. I've spoken to enough of them now and … they virtually all used the same words: 'I'm 65', or 'I'm 70', or the last one 75 years old. He said 'I've been on that river since I was a little kid. I know it like the back of my hand. We fished that river forever and my father before me'. And he said, 'I've never seen bubbles in the Condamine … that's when I know something was wrong because the bubbles only started after the drilling started'. So they know, they've made that association.
> [Active female anti-CSG regional town resident, interview May 2015]

> When I was growing up, you had a shower, you turn the tap on, and what comes out was gas … you'd be sprayed with gas. And you could smell it in the water and I know the person who was doing the water years and years ago and there was something wrong with one the bores and what they found is it was stopped by a heap of gas and if you lit that, it would go up in the air. And that was long ago before CSG.
> [Publicly available interview with female landholder, Youtube World101x May 2015]

> There's the bubbles in the creek and the Condamine, too. One bloke's got bubbles in his dam. Now [name of CSG company] have bought the properties adjoining the river on one side and they reckon they're going to try to stop the bubbles. … Well, it's gas coming out. They are fracking holes down there and they must have a frack that went underneath the river, because there's coal underneath the river, you can see coal in the banks down there. But they say it's a natural occurrence and been happening forever. ... They didn't put that in their EIS, did they? If it had been naturally occurring, it would have been there and they would have put it in their EIS.
> [Male grazier affected by coal and CSG developments, interview May 2015]

> I don't know how much of it is truth and how much is not … because here you hear stories of gas coming up in dams and all that sort of stuff, bores. Well, [name of relative] when they had their family property, … every time it rained the bore would pump gas. A big heap of gas would come up out of the bore. Now that was just their regular water bore. So, he said one day the gas came so hard and fast that it blew the side out of the turkey nest [water pond]. So gas has always been there at some level. … Nobody's ever taken any notice.
> [Female regional town resident, interview May 2015]

Local accounts on the gas seepages thus varied with some suspecting CSG activity as the cause and others regarding them as occurring naturally.

Indeed, references to gas occurrences in bores and waterways throughout the Surat Basin can be found in historical records and anecdotal accounts. For instance, the GasFields Commission Queensland[79] published an online information sheet that lists almost two dozen examples of *Historical evidence of landscape gas seeps in Qld coal basins* (N.S.; see here). Archival research of the *Queensland Government Mining Journal* also provides multiple case of such occurrences, with one government investigator's report stating (Gray 1967: 394–398; cf. Chapter 3.2.):

> On 14-3-67, gas blew out from a water bore … being drilled near Brigalow, on the eastern flank of the Surat Basin. … Gas and water shot out of the hole to about twice the height of the drill tower, that is, about 30 feet. … Since 1916, at least eleven gas occurrences have been reported in wells drilled for water and petroleum in the Brigalow area. … All are of minor significance.

Even for the Condamine itself, one local grazier in his 70s casually remarked that he could vaguely remember a local newspaper article discussing bubbles in the river some 50 years ago (conversation April 2015). The issue of gas seepages in areas of CSG developments thus remains uncertain and open to multiple interpretations. These conflicting local accounts illustrate the resulting ambiguities regarding the 'naturalness' of these gas seepages, which corresponds to the observations made by Makki (2015: 115–116) who asked 'Condamine Bubbling: A Reality or Myth?' (also Manning 2013: 120–151; more generally Rayner & Heywood 2014).

The inconclusiveness of official responses and conflicting anecdotal explanations do, however, not merely affect the problematic sense-making of the Condamine bubbling itself. Rather, the resulting uncertainties that confront particularly local actors in such instances can have wider ramifications for the comforts and ontological securities usually associated with the sense of place and belonging emerging from known and reliable environments (Albrecht 2005; de Rijke 2012; Willow 2014; also Chapters 4.1. & 6.2.). Manning (2013: 122) highlights this insight in his description of adjacent landholders' reaction to the Condamine bubbling: "Whether natural or artificial, it was something new for the Pascoes, who worried that if the bubbling continued and the

[79] An 'independent statutory body formed to manage and improve sustainable coexistence among rural landholders, regional communities and the onshore gas industry' that was established in July 2013.

recent wet weather stopped, the Blackfella hole — a permanent waterhole that has never run dry, even in drought — might be too contaminated for their cattle to drink". Furthermore, the unsolved problems of knowing emerging from such inconclusiveness can raise suspicion about the understanding of environmental changes associated with CSG generally. For example, a male senior government hydrogeologist noted that "*there is more concern now about gas emissions from water bores and a lot of the focus is on the gas, some suspicion that if gas can get out, then water can get down and … cause the impacts to be greater than this model from OGIA predicted*" (interview April 2014). In this sense, knowledge of what remains unknown — what I conceptualised as non-knowledge (see Chapter 2.1.2) — can become an important aspect of environmental controversies.

In addition to the concerns voiced by some local interlocutors, a number of university-based researchers have therefore also highlighted potential shortcomings in the scientific understanding of the impacts from CSG extraction — an actor group one may less easily label as scientifically 'deficient'. For instance, Monash University-based environmental engineer Mudd (The Conversation, 1st June 2012) stated in an opinion piece soon after the seepages began receiving publicity: "Personally, I would find it hard to be convinced that CSG had nothing whatsoever to do with the gas bubbling away in the Condamine … - but I await evidence, not claim or counter-claim. Show me the data and let the facts speak for themselves". Earlier in the same piece he noted, however, that "[t]he basic problem … is that groundwater risks may take many months, years and decades to reach their climax. This means that we are yet to truly see the impacts and this allows some in the debate to argue 'no data, no impact'" (see Chapter 7.2.). More recently, Mudd substantiated these claims by noting a lack of scientific research and potential for (un)intentionally ignored uncomfortable unknowns around CSG developments (cf. Hess 2015; Rayner 2012), repeatedly giving the bubbling Condamine as a point of reference:

> [T]here are still some key weaknesses ... . To be fair, some of the work that was done for those is some of the most advanced hydrogeological or groundwater work that is being done, but there is still no methane monitoring. One of the big problems with all of that is that it does not allow us to really understand what we are seeing on the ground or in the rivers, so to speak, up in Queensland, and then understand what is causing what. Without that good baseline data and without good ongoing monitoring, it is certainly impossible at the moment to go through it and understand who is causing what and how things are happening. … I am certainly quite familiar with a lot of the reports, but, without ongoing monitoring and data, there is lack of ability to answer some of these questions, which are, at the heart, very complex scientific and technical questions to address. Without that, it makes it nigh on impossible. … At the moment, based on my knowledge of the hydrogeology, the reports and some of the studies that have been done, I think it is a wait-and-see situation. It is a very difficult area to model accurately, but that is what we need to do. … If you have gas coming up, say, through the Condamine River, I certainly believe that CSG is a strong contributing factor in that, and studies that have been done to date certainly do not dismiss that in my mind. … What is not being done is really getting a good handle on this increased methane

> mobilisation through the geology, and I firmly believe the Condamine is a great example of that. I also think the mobilisation that we are seeing in various agricultural bores through the region is an example of that, and that is not being monitored and is not being included in any estimates.
> [Senate hearing transcript, Dalby 17th February 2016: 40–44]

While explicitly phrased, Mudd's assessment is certainly not the only critical scientific accounts, especially when CSG developments initially commenced. Regarding the responses to the discovery of the Condamine bubbling, Monash-based public health specialist Carey (The Conversation, 20th November 2012), for instance, criticised that "denials from industry followed swiftly, but science was notably absent, despite it being plausible that coal seam gas was the source", and that generally "we don't know what these gases are because we are not identifying and measuring them" (also Manning 2012: 131). Similarly, hydrogeology and groundwater expert Kelly (The Conversation, 7th November 2011) has also stressed the prevailing inconclusiveness of CSG-related scientific groundwater research on multiple occasions. He cautioned early on within the emerging CSG controversy that "we know what we don't know, let's do something about it" and that "[o]nce a problem is detected it could be too late" (*ibid.*). In a co-authored piece, Kelly and Iverach (The Conversation, 3rd May 2016) remark almost five years later that "[e]ven if the gas seep is natural, it suggests that we do not know enough about how gas exploration could affect this precious resource". They conclude that (*ibid.*):

> the Condamine River gas seep is a concern because it suggests that we do not know enough about the groundwater system in the region. … To date, only 17 out of hundreds of geological faults and no abandoned leaky wells have been incorporated into the regional groundwater model used to assess the impact of CSG production. Depending on CSG production and groundwater use, these could conceivably one day play a role in lowering the groundwater levels of the Great Artesian Basin and the Condamine River. … The gas seeps at the Condamine River may indeed be natural. The fact that there is so much confusion and debate about it highlights the need to provide the public with high-quality, scientifically defensible information.

These expert accounts thus emphasise that 'the science' of CSG-related groundwater impacts may yet not be 'in' and that consequently, as University of Melbourne-based sociologist Bice (Pursuit, 12th February 2016) contends, CSG concerns are "more than hot air" and that "the CSG debate is not over".

One must, of course, critically consider these researchers' specific fields of expertise and experience with CSG developments. I have also cited explicit excerpts and examples. However, it is important to bear in mind that many actors who are engaged in CSG debates, including myself, are likely not specialised enough in a given field to fully situate and judge those researchers' responses to uncertainties in CSG developments — for instance, groundwater modelling. With such scientific

discussions increasingly accessible to broader audiences, local actors and members of the wider public alike are frequently confronted with inconclusive or even conflicting 'expert accounts', which can perpetuate or heighten uncertainties; there might, indeed, be "too much science" that makes issues "too big to know" (Weinberger 2011; see Chapter 2.3.3.). Some scholars have therefore highlighted how diverse scientific research can create an "excess of objectivity" (Pielke Jr. 2007: 138–140; Sarewitz 2004: 388–390) wherein multiple, value-based positions in an environmental controversy can be supported by scientifically legitimate facts (see Chapter 8.1.). This section's findings illustrate how the resulting inconclusiveness can lead to partly contradictory local interpretations and growing problems of knowing.

Problems of knowing can therefore not be merely understood through a simplified deficit perspective that ascribes uncertainties to the public realm as opposed to the certainties of scientific research(ers). On the contrary, the critical assessment of modelling practices and concrete case of the Condamine bubbling have demonstrated that the role of the natural sciences in the context of CSG extraction is more ambiguous and that problems of knowing persist in large part also because of criticism from within the sciences. Such criticism might be sparked by different underlying purposes and intentions of scientific research (also Chapter 7.3.). Does this mean that one should simply disregard scientific endeavours as currently still incomplete?

5.4. Conclusion: Why (Just) More Research Won't Do and Is Yet Necessary

In this chapter, I have considered the status of some natural sciences in the context of CSG extraction. The example of the assessment and prediction of groundwater-related impacts demonstrates how ambiguities and uncertainties appear to persist for a number of local and scientific expert actors alike. The specific cases of groundwater modelling and the Condamine gas seepages exemplified the wider debates over (scientific) knowledge gaps and inconclusive studies. Both academic and commercial research have therefore indicated that unknowns are a topic of concern across multiple aspects of CSG extraction. For example, some researchers assessing potentially undetected and thus underestimated 'stray' or 'fugitive' gas emissions resulting from CSG extraction have highlighted "a lack of reported studies about the impacts of free gas on water bores" (Klohn Crippen Berger 2016: i). There consequently remains "significant uncertainty about methane-emission estimates", which — similar to groundwater modelling practices — can rest on "out-dated assumptions" and thus "lack demonstrated reference" (Lafleur *et al.* 2016: 7; also Lafleur & Sandiford 2017). Likewise, Cook *et al.* (2013: 29) emphasise in an extensive research report that "there are knowledge gaps in the environmental and social areas that will require the collection of more data and additional research to ensure that the impact of the industry is minimal".

They further note that "other than for operational risks … there is little or no information available to quantify the likelihood of an environmental or health event occurring or the impact of that event" (*ibid.*). These examples appear to indicate that more scientific research is necessary, not just about potential impacts from CSG extraction but also cumulative impacts that may occur in tandem with those of the agricultural and other industries.

At the same time, it cannot be taken for granted that simply more research will resolve the ongoing CSG risk controversy. Sarewitz (2004) suggests that more science can, in fact, achieve quite the opposite and make environmental controversies worse. As he contends (*ibid.*: 396, original emphasis):

> As it pertains to environmental controversy, the word 'uncertainty' refers most generally to the disparity between what is known and what actually *is* or *will* be. Uncertainty, that is, reflects our incomplete and imperfect characterization of current conditions relevant to an environmental problem, and our incomplete and imperfect knowledge of the future consequences of these conditions. For a well bounded problem, these insufficiencies can to some extent be addressed (although never eliminated) through additional research, but there are many reasons why such an approach might not succeed, for example, when additional research reveals heretofore unknown complexities in natural systems, or highlights the differences between competing disciplinary perspectives, and thus expands the realm of what is known to be unknown. … Uncertainty is in part a manifestation of the disunity of science and the plurality of institutional and political players (and their competing value commitments) involved in the conduct and interpretation of scientific research. It is the location where conflicts between competing sets of facts and disciplinary perspectives reside.

More scientific research concerning environmental controversies, such as over CSG developments, therefore not necessarily settles risk debates (also Everingham 2013: 85). Furthermore, scientific research can prompt severe disagreement and opposition, particularly when conflicting positions are already established and political stakes are high (Stilgoe 2007: 48–49; see Chapter 7 & 8.1.).

This can be observed in some cases of CSG-specific research. Following their widely publicised report on fugitive methane emissions in the Western Downs, Maher *et al.* (The Conversation, 8th December 2014) noted that their "study clearly exposes the lack of knowledge in this area, leaving open the question whether CSG really is greener than coal". However, after being subsequently "attacked by the industry and even by the then federal resource minister, Martin Ferguson", they acknowledged that it "was no longer just a matter of science. … We were in the middle of a political and social firestorm". The researchers therefore wondered: "Will the wells run dry before peer-reviewed science can explain what is coming out of them? Only time will tell" (*ibid.*). This prompted Bice *et al.* (The Conversation, 10th December 2014) to respond by requesting "more and better science" and that this "urgent need for a beefed-up science and monitoring capacity should drive a new research agenda, providing trusted, credible information and analysis … to be shared

and supported by industries, governments, communities and the research sector". As this exchange illustrates, more research is clearly needed. Yet, findings are always contestable and it is not immediately apparent what may constitute such a shared and, importantly, trusted research agenda.

It is then certainly the case that, as the chair of the IESC ensured the audience at a public Senate hearing, "*an incredibly extensive program of research is underway*" (Senate hearing transcript, Brisbane 27th July 2015: 35). Nonetheless, there are still debates concerning the (un)certainties of currently available scientific accounts and if enough research has been conducted. Whether this is a failure or rather success of critical scientific enquiries will be the subject of the subsequent chapters, but a female regional natural resource manager's remarks are insightful:

> There's more questions unanswered than when we started, isn't there? Because we're discovering more things and becoming much more intelligent on the whole, how it actually works.
> [Interview, May 2015]

I am here reminded of Yearley's (2005: xiv) general observation that, on the one hand, "far from solving the questions once and for all, the recent experience of scientific testing ... is that it results in acrimonious and inconclusive conflicts among alleged experts". This resonates with the ambiguous role of the sciences examined so far.

On the other hand, though, it is important to appreciate how "official agencies are commonly left with no alternative but to demand 'more and better' science; yet there are few grounds for thinking that further steps down the same path will resolve the problems" (Yearley 2005: 138; also Sarewitz 2004). Following my research, such an argumentation is partly supported. However, I demonstrate in the next chapter that improving research can address some actors' concerns, at least partially and in specific areas. I therefore agree with Pilkey and Pilkey-Jarvis's (2007: 188) argument that only because a model — or any scientific research for that matter — is not perfect does not mean one ought to 'throw the baby out with the bathwater'. More scientific research is thus certainly needed but it remains to be seen whether this can fully settle ongoing risk debates about CSG developments.

In this sense, my interlocutors' accounts already provided glimpses of what more research should involve or how it ought to be utilised is itself part of the debate. I may thus conclude with the thought-provoking comments of a former senior public servant in the Queensland state government. He contended during our interview in July 2015 that:

> The argument that we need more science to prove or disprove this industry is totally a red herring if you ignore the institutional context in which the science is applied, the regulatory regime under which it's applied, the mindset of the people applying it, and the web of influence behind it.

I agree with his argumentation as it highlights that more research is necessary, but that it remains insufficient if the contexts within which scientific knowledge is produced and applied are ignored. It is therefore necessary to critically consider these broader social and political contexts. Over the next chapters I follow such a 'relational focus' (Irwin & Wynne 1996: 7; cf. Ingold 2016: 8; Marks 2009: 279) to further examine the question of what it might mean to 'get the science right'.

6. In Search of a Straight Answer: Dealing with Problems of Knowing

The cloth of meaning may have to be woven out of a myriad scraps and off-cuts, but woven it is, day after day, year after year.

(Worpole 1990: 44)

How do you know that you do not know?

(Chair, Senate hearing, Brisbane 27th July 2015)

Over the last two chapters I have developed the argument that scientific representations and research are indispensable for the sense-making of impacts from CSG developments. At the same time, not all actors appear to regard CSG-specific sciences as complete or irrefutable. Some see them as either initially or fundamentally unable to fully address the challenges CSG projects have created. This argument about resulting problems of knowing was grounded in the case of the Condamine gas seepages. Following these insights, I now focus on how CSG developments were experienced among my interlocutors in the Western Downs. In doing so, this chapter goes beyond scientific knowledge claims themselves and rather reflects on some broader aspects of the epistemic debates about CSG's risks, which certainly include but are not limited to such claims. From the perspective of the relationality of knowledge and ignorance developed in Chapter 2.1, I attend to how problems of knowing emerge within and can challenge the ongoing reconfiguration of reliable and meaningful environments. That is, I ask how are "subjects of knowledge engaging the other side of knowing? How is ignorance experienced, encountered and embodied" (Caduff 2015: 32) in their experiences of CSG risk developments.

This chapter focuses on four interconnected aspects that emerged as prevailing themes from my ethnographic research. I begin by examining responses to how CSG projects' scale and pace challenged government and public actors alike. The second section addresses affected interlocutors' search for a straight answer that, some felt, was hindered by instances of organised irresponsibility and secrecy. The resulting uncertainties and perceived regulatory shortcomings have *inter alia* resulted in significant distress and also prompted residents to leave the area altogether. However, others appear to have come to tolerate or even embrace the industry despite initial and ongoing concerns. The third section attends to those interlocutors' responses. Following these accounts, I conclude by situating this chapter's qualitative insights with the help of relevant quantitative research that describes general attitudes towards CSG developments in the Western Downs.

6.1. An Arms Race of Sorts: Outpaced and Beyond Capacity

A central theme in interviews and ethnographic research was interlocutors highlighting the scale and pace of the CSG boom in the Western Downs. In a Deloitte LNG industry review, the authors noted under the subheading 'What the industry must never do again' that within Australia — the "epicentre of LNG developments for the last decade" — companies got "swept up in a groundswell of enthusiasm and a 'get it done at any cost' mentality". This caused "an 'arms race' of sorts in assuring access to scarce resources" (Reid & Cann 2016: 4 & 10). The pace and manner of development created a large range of social impacts from labour shortages to housing unaffordability. However, this race and mentality also had profound implications for the questions around potential impacts and uncertainties regarding risks:

> When this whole tsunami started in 2010 nobody, nobody, not even the lawyers, had any experience in what was going to happen and what the impacts were. Yet we are supposed to work out this agreement [with CSG companies] right at the start before we know what the impacts are. The lawyers are starting to catch-up with things now because we are starting to see the impacts. But Joe Bloggs on his farm is not seeing it and it has been a real problem. [Female landholder and CSG-specific regional NGO representative, Senate hearing transcript, Brisbane 27th July 2015: 19]

> That's the nightmare about it, it's so fast and that's why they're pushing so hard. [Female landholder with nearby CSG infrastructure, interview June 2015]

These examples indicate that CSG projects' pace of development and associated uncertainties posed significant practical and psychological challenges for some local actors.

Such uncertainties and challenges were not merely an issue for landholders and local residents. Similar views were also expressed by industry professionals, consultants and researchers who, for instance, discussed the inexperience of some government departments and companies with unconventional gas developments on a large scale. While highlighting the now slowed down construction pressure and an improving understanding of impacts, many of these interlocutors were often critical of CSG projects' pace:

> The attitude was 'just get it done at any cost' and time is more of a critical factor than quality of work. … That embodies the weird controlled mayhem that was going on. [Male environmental management consultant, interview April 2015]

> It's the first time it's been done on this scale. … It was a bit of a race. Everyone wanted to be first. I speak for the CEO's of the companies, they all wanted to get in before the rules changed. Because it was very favourable early on. ... We described it as the big steam roller. … If we don't move fast enough to stay ahead of it, it's just going to get you. … Once they had invested the money, there was no stopping the project. [Male former industry-based senior hydrologist, interview April 2015]

> Well, yeah, but local government can't be blamed because it's cut out of the whole process. … State government rushed it. … It just tells me it was rushed. State's broke, [expletive] we've got to get through this, how much royalties, great, let's get it going. Push it through, push it through.
> [Male regional town resident & local business peak body representative, interview May 2015]

These accounts highlight that CSG projects were experienced as progressing (too) rapidly. However, the responsibility for this rush lies, first and foremost, with the Queensland State Government, which approves resource developments. The local council in the Western Downs has therefore been frequently by-passed in this regard (de Rijke 2013c: 15; Turton 2015: 62–63).

Crucial is that, following this initial rush, interlocutors from various backgrounds questioned whether the industry and government departments were able to adequately produce, understand and assess Environmental Impact Statements (EISs) and subsequently manage the industry's potential impacts. Some interlocutors particularly noted a by now decade-long decline of capacities within some state departments and the transitioning of expert public servants into industry. Such transitions were prompted by staff reductions in government departments as well as financial incentives from better-paid industry positions (cf. de Rijke 2013c: 15).[80] Recurring themes during my research were consequently concerns of government departments either fundamentally lacking capacities and time to adequately assess the scientific foundation of CSG projects, or an imbalance of these capacities skewed towards CSG companies. For instance, a female public servant in charge of the assessment of one CSG-LNG project noted how the staffers in the relevant department's unit had to '*take things at face value from proponents*', which was '*difficult sometimes, especially when you don't believe them'*. They thus *'felt constantly behind'* in their assessment (informal conversation February 2016; cf. de Rijke 2013b: 14–16). This perspective resonates with the accounts of other industry and government professionals who voiced similar concerns:

> It outpaced organisations that were far better equipped to deal with that sort of thing than any individual in the community. … we [the mayor of the Western Downs and I] were talking about how many EISs they were having to deal with … . He was talking about five or six at any one time, not just five or six in total. … And they were worried at the time that they didn't have the capability or the capacity to do it full justice. So I remember we got one delivered here … . It was 12,000 pages. It was ridiculous. Now tell me of anybody around, particularly regional areas, outside of the highly specialised knowledge of a university or government agency that can even begin to interpret that.
> [Male regional natural resource manager, interview April 2015]

[80] On budget and staff cuts in the Queensland government see, e.g., ABC News 2nd March 2017 or 14th April 2017. Following these cuts, some interlocutors noted the problematic transitioning of public servants. This 'revolving door' or 'brain drain' phenomenon has been subject to much public criticism (Readfearn 2015 or The Courier Mail 1st April 2013; see Chapter 8.2.) and was noted in the context of rushed impact assessments, alleged misconduct, and even corruption of senior public servants (e.g., Senate hearing transcript, Brisbane 28th November 2014: 1–10).

> Everybody from our side, from the environmental professional side, were saying 'there's just not enough people to do this job properly for all of these sites'. … The three companies would have had the most water experts in any one room at any one time for any government or industry…. Government had eight technical people and two managers in all of Queensland. … In perspective, we had 32 technical people … . So we were essentially educating the government on what we were going to do with that water. … The same time as the government was downsizing, all the companies were ramping up their side. … The same thing happened to me. I wrote the plan and then I had to implement it. … And that is where it became self-regulation: 'We're going to tell you what you need to do and you need to do it and tell us you've done it. And provide us the information.' … There was no one left above them [junior people in government]. … All the very senior people stayed in consulting and all the middle level, myself included, went into industry.
> [Male former industry-based senior hydrologist, interview April 2015]

> Interviewee: They [government department] haven't got enough capacity across the state and the [Great Barrier] Reef is a hot issue.
>
> Interviewer: Will it ultimately limit the amount of work that can, has to be done in the CSG arena? In terms of 12,000 public servants having been sacked?
>
> Interviewee: Absolutely. I left [department name] in 2007 or 2008, so that was the first round of redundancies. The day I left, 3,400 man years of experience walked out the door. It's been an ongoing war of attrition. The 12,000 was a big bang but it's been going on for over a decade. … So that whole capacity has evaporated as well. … I had 305 extension staff across the state … . There are 17 left in Queensland. … That's in less than 10 years.
> [Male agricultural sciences consultant, farmer and former public servant, interview March 2015]

These accounts indicate that some State government departments and also the local council may have been pushed to or even beyond capacity in assessing CSG projects. Such limitations are certainly not unique to the context of CSG in the Western Downs. State and provincial governments frequently struggle to effectively assess and manage impacts of large-scale resource developments (Measham *et al.* 2016: 107–108). As we shall see in the next section, however, a discrepancy between the responsibility to approve projects and capabilities to manage impacts can be problematic.

In light of the uncertainties created by the large scale, rapid pace and limited capacities across various institutions, a large number of interlocutors were consequently critical of the adaptive management approach taken to regulate the emerging CSG industry (see Chapter 1.2.). The official position of most state and federal departments appear to be based on "*essentially believing in the operation of the market and operation of science underpinning these things*" (Male representative Department of Agriculture, Senate hearing transcript, Canberra 28th July 2015: 18). Yet, my interlocutors often emphasised that, at least initially, such scientific understandings were regarded as lacking or that there might be an inability to detect and manage impacts in time. An adaptive

management approach thus remains "very much reactive type regulation" that acknowledges the potential for "unknown and unintended" consequences (Hunter 2015: 9; Swayne 2012: 184). As such, however, it requires a belief that adequate monitoring and research are in place and that potentially 'uncomfortable' scientific findings are not ignored. The following examples illustrate that this may have not been or still is the case for some interlocutors:

> We never had any of that science or any of that understanding when the approval was given … . To us, that was an absolute insult, and it couldn't be allowed to continue because we were under severe pressure as the groundwater users in the alluvium.
> [Male cotton farmer and regional groundwater NGO representative, interview May 2015]

> BSA's [Basin Sustainability Alliance] prime concern is that the attitude and policy facilitation of this industry occurs on a "suck-it-and-see" approach rather than trying to prevent damage from occurring in the first place and using science to inform development.
> [BSA factsheet, February 2011]

> What they've done in Queensland, they used that [adaptive management] to say: 'Well, we don't need to know all the answers up front, we can find them out as we go along'. But of course, once you set your industry up … and it's 6000 wells, doesn't matter what you find, you can't close it down. So they have gone ahead without knowing what the impacts are likely to be across a whole range of areas.
> [Male former politician and anti-CSG campaigner, public protest event July 2015]

Following these perspectives, we can grasp how uncertainties and unknowns were, at least initially, a concern for a variety of actors. Against a background of rushed developments, those unknowns and their intentionality became a point of contestation. As such, more prior scientific research or a slower pace of development might have also been viable alternative pathways. The rapid progress of CSG projects and associated unknowns were, consequently, not willingly accepted by a number of actors who argued that some uncertainties could, or should, have been avoided (cf. Beck & Wehling 2012: 40; see Chapters 2.1.2. & 8.2.).

A belief in 'science underpinning these things' is further also contingent on what some interlocutors variously described as the questionable legacy and track record of Queensland's extractive industries. In addition to outpaced and beyond capacity operating institutions, suspicions about uncertainties and unknowns also emerged as the result of a problematic history of environmental regulation concerning Queensland's mining industry (Hutton 2013). More recently, concerns about scientific shortcomings and government departments' inability to manage impacts also appeared to be rooted in known other instances of unanticipated consequences of gas extraction. As a result, placing faith into a reactive adaptive management approach has been difficult for some interlocutors:

> You get on Google and see the [expletive] that they have created over there [the United States of America]. Just start reading about the unresolved issues over there. … This adaptive

> management, bloody disaster rolls on, we just try to minimise impacts. … It's not about stopping any impacts, or reversing any impact.
> [Male grazier and CSG-specific regional NGO representative, interview June 2015]

> It's a definition of acceptable impacts. See, I rear and sell cattle. I'm liable for the contamination in the flesh of my cattle. … Why do I have to go out of business if my water becomes polluted? And I'm saying this because we've just had this underground coal gasification problem [UCG; a failed trial project near Chinchilla], which nobody expected. As you said, there was no baseline testing before that plant was set up because it wasn't CSG but UCG. ... So Hopelands, which was producing good quality, clean food now can't or may not be able to; there is a question mark over that. … Now, CSG is coming in and they're going to put in how ever many bores through that clay layer, so where's the protection for the landholders' agricultural interests?
> …
> If you can't realise that there is a problem with gas two meters from the surface, how vigorous are your actual policies and testing procedures? … You said so many times you got such strict policies and regulations in place, without actually realising something is wrong.
> [Two male landholders questioning a male government hydrologist, Local CSG-specific groundwater workshop June 2015]

Based on these examples, we can note how an awareness of related instances of unanticipated consequences from gas extraction can create suspicion about the adequacy of an adaptive management regime (cf. Auyero & Swistun 2008; see Chapter 2.1.2).

Therefore, some interlocutors, at least initially, questioned the ability of state government departments, companies, and also the regional council to comprehend and manage the impacts emerging from rapidly progressing CSG projects. Unsurprisingly, some interlocutors who were confronted with these developments and associated uncertainties demanded answers for a number of open questions. Their foci certainly varied as, for instance, bore-owning landholders likely have different concerns to town residents. These nuances are often absent in media accounts that amplify particularly vocal actors. However, I found that most interlocutors attempted to resolve the problems of knowing resulting from CSG developments in order to 'weave the cloth of meaning' (Worpole 1990: 44) and make sense of the new industry. In the next section, we therefore attend to this search for a straight answer.

6.2. No Straight Answer: Organised Irresponsibility and the Veil of Secrecy

The responses regarding the search for certainty and straight answers about CSG developments reflect a plurality of experiences and perspectives. However, we can identify a number of overarching themes that, related to the preceding section, highlight how many interlocutors were or still are facing uncertainties and partial knowledge. Two significant factors that contributed to these experiences are the ambiguous roles of interacting government departments and the frequent

vagueness of industry accounts. In this section we thus consider, what I themed, instances of organised irresponsibility and the veil of secrecy.

Interlocutors from various backgrounds noted that when they approached staff of government departments or companies their responses were often either strictly limited to their area of expertise and responsibility or they were advised to instead contact another department or unit. As a result, some interlocutors felt that they were sent around in circles or were not satisfied with what they regarded as specific questions remaining essentially unanswered. The following accounts illustrate these findings:

> The response that we got to a seven-page letter detailing all of the issues … was embarrassing, … particularly with regard to things like very specific information we've given them about actual harm. … It was three pages versus my seven pages. It's this: at arm's length, no actual depth, no investigation. … Please [government department] tell us what happened, please advise us? They have told us nothing. … And it's in free fall, hands off the wheel, choose your own adventure.
> [Engaged female landholder with nearby CSG infrastructure, property tour April 2015]

> They [CSG company] admitted breaching the noise limits, but the report from [department name] is that it is inconclusive; that there is not enough evidence that they are actually breaching. It just keeps going round and round in circles. … For [department name] to act on it you have to have a valid complaint to the administering authority about noise being made. Without us complaining to the administering authority … nothing is ever done. But then, on top of that, we have got to have a valid complaint. … And we could put a complaint in almost every night if we wanted to, but apparently our complaints are not valid. They have got to be validated by [department name]. So the circle just keeps going round and round.
> [Female landholder with CSG infrastructure, Senate hearing transcript, Dalby 17th February 2016: 17]

> And you ask them [a government department] questions about health impacts of CSG and they ask you a question for the answer.
> [Male regional town resident and church minister, interview May 2015]

> Who is taking responsibility for collating all this stuff? … Somebody, some person needs to be responsible. … So there are four or five government departments in there conflicting and belting each other up … . Half the government industries have skin in the game in this space and no one is ultimately saying or doing anything about the problems … . What he [local grazier] is concerned about is the way the department has written that has made it so ambiguous, so farcical that it doesn't make any sense. Hence he gets cranky, because he doesn't understand it — none of us understand it because the letter is a pile of rubbish. … And how poles apart are Natural Resources and Mines and Queensland Health? … So then you throw in the middle of that Environment and Heritage Protection, … then Agriculture … to muddy the waters.
> [Male state politician, interview April 2015]

A feeling of not receiving straight answers regarding environmental and health impacts and a general lack of clear responsibility were thus a recurring theme during my fieldwork (cf. Gill 2011;

Manning 2012: 172).[81] Whether or not these answer could be given is debatable. That is, we considered in the last chapter the difficulties in forecasting impacts, and projects' rushed progress surely contributed to these uncertainties. Some interlocutors further emphasised the fundamental indeterminacies of CSG developments. For example, exact infrastructure locations or the ultimate numbers of wells in a field can often not be determined *a priori* but are influenced by outcomes of ongoing extraction — indeed, a 'real open-endedness' (Wynne 1992: 117; see Chapter 2.1.2).

In an applied reading, I interpret these findings by borrowing from risk sociologist Beck (2009: 193) who argues that in contemporary ecological risk debates "[r]esponsibilities can indeed be assigned but they are spread out over several social subsystems". This, he contends, leads to "responsibility *as* impunity or: organized irresponsibility" (*ibid.*: 194, original emphasis) wherein "no individual or institution seems to be held specifically accountable for anything" (Beck 2005: 592; cf. Douglas & Wildavsky 1982: 79–82; Dwyer & Minnegal 2006: 10–12 & 20). This irresponsibility does, however, stand in contrast to the growing scope of human accountability created by manufactured risks. Put differently, decisions to intentionally apply technological capabilities increasingly require prior justification and clear responsibilities regarding its consequences (Beck 2005: 587; Renn 2014; see Chapter 2.2.2.).[82] In this sense, a number of interlocutors, especially those with concerns and submitted complaints, felt that uncertainties remained, often unnecessarily. They questioned what many viewed as lacking government oversight or clear coordination of the numerous government, industry and private actors involved in CSG developments. This caused problems of unclear responsibilities and accountability.

For some, this perceived irresponsibility appears to have resulted in a diminishing trust in the relevant governing structures similar to the observations of Lloyd *et al.* (2013):

> We are fairly critical of their Coordinator General and his department. … I said 'why don't you do some coordinating?', because they weren't. And that's what he should have been doing, coordinating. Because you have got cumulative impacts.
> [Male farmer and regional environmental NGO representative, interview April 2015]

> They changed it [the law] now so that they are not allowed to dust settle with this thing [untreated produced water]. But I said 'who polices it?' … Nobody. Absolutely nobody. So they are still driving around there with tanks of water. Who knows whether it's treated or untreated water? Nobody.
> [Female former landholder with CSG infrastructure, interview April 2015]

[81] Cf. Auyero & Swistun's (2008: 369–371) notion of the social production of toxic uncertainty *inter alia* through state officials' "labor of confusion and state (mis)interventions". Also, Scheper-Hughes's (1992: 272 & 294) observation of lacking responsibilities resulting from Brazilian state agents' "averted gaze" and "bureaucracy's deaf ear" for child deaths.

[82] Giving a straight answers might be equivalent to claiming knowledge. Since knowledge forms the basis of actions (see Chapter 2.1.1.), claiming knowledge could indicate that one accepts responsibility for the consequences of these actions. In contexts of uncertainties and unknowns, however, one might not be willing to accept such responsibility and refuse to give a straight answer. In this sense, Povinelli's (1993) analysis of the language of indeterminacy in an Australian Aboriginal community is insightful, particularly "the relationship among knowledge-claims, responsibility-culpability, and authority-status" (*ibid.*: 685; also Gluckman 1972).

These findings correspond to those of other researchers who found that landholders generally have low levels of trust in the CSG industry and government (AgForce 2017; Gillespie *et al.* 2016; also Chapter 8.3.). I propose that this distrust is, at least partially, due to the uncertainties arising from a felt absence of clear responsibilities and oversight (cf. Beck 2009: 45–46; Beck in Yates 2001: 101; Checker 2007: 120). At multiple occasions, I therefore encountered demands for clearer responsibilities and stronger leadership by government departments. For some interlocutors, this may be achieved by improving the government's 'one-stop shop', the CSG Compliance Unit. However, one of the unit's representatives was more critical and explained that they do take responsibility for conducted investigations and provide answers when requests are made. However, whether the unit's response was regarded as satisfactory is somewhat contingent on the client's initial expectations. He thus also noted that some clients may 'shop around' departments for a desired answer (interview, April 2015).

A male local council representative, on the other hand, regarded such irresponsibilities not necessarily as a social or organisational issue but associated them with the fundamental unknowns and indeterminacies surrounding CSG developments. The resulting inability to provide clear answers may be, from his perspective, excusable since it is essentially caused by irreducible ignorance of environmental impacts:

> In truth, the only way we are going to know is in 50 years when you look back. … In 50 years we will certainly look back and say we really screwed up something. … There will be a major issue, in terms of the environment. But … we do have good systems in place to measure that or to monitor that; it comes back to the responsibility of government. … I don't think there will be anyone to blame for the impact, all parties will have a Royal Commission and everyone will get in the room and say we did what we could. … A bit like when they first started using asbestos, it was great stuff. It's only 40 years down the track that you go 'yeah we've got a bit of an issue'. … You couldn't have done anything at the start, there was no way they could have known. … They wouldn't have even thought of it. … So we'll probably see an impact like that, … I hope not, but I would expect to see an impact like that because the whole industry has developed at such a fast rate. … But, I think we have responsible companies. … There is always going to be contention between the stakeholders, but I don't think that we've got an outcome or a research outcome that says this is exactly what will happen. But I don't think that is possible either.
> [Interview May 2015]

Whether and when clear answer should be available, and who ought to be responsible to provide them, thus remains an ongoing issue of debate. Perceptions of responsibility and the relationship between local and state actors are therefore multifaceted and can be subject to disagreement and change (Gill 2011).

However, a number of interlocutors who are affected by CSG developments, or those taking an interest, suggested that irresponsibility does remain a social and political issue, especially when government departments are regarded as having limited oversight of the industry.[83] Some interlocutors therefore addressed the perceived absence of adequate administration by either individually or collectively trying to hold industry and governmental actors accountable. For instance, one landholder argued at a CSG-related community meeting that the locally operating CSG companies *"need to be made accountable. No one else out here is going to do that. It's up to us, the community to do that, because there simply is no other overseer. There should be, but there isn't"* (April 2015). Likewise, a grazier and representative of a regional CSG-specific NGO criticised the Queensland government changing a specific Act that consequently restricts public objection rights to the extractive industries by noting: *"We are the watchdogs for our democracy and don't let any politician tell you otherwise"* (group meeting April 2015). In this sense, a felt absence of government oversight can, in tandem with scientific uncertainties, lead to insecurities and frustration among local residents and landholders (cf. Beck 2009: 45–46; Checker 2007). Some individual citizens and groups are thus compelled to scrutinise the CSG industry themselves, which can create a privatised form of risk management (Jasanoff 2002: 375; Rose 2006: 158). I will further address this finding below, but these observations are relevant here since they illustrate how felt irresponsibility plays a part in dealing with the problems of knowing arising from CSG developments, especially for those with concerns about potential risks.

Related to these insecurities and the issue of accountability is another cluster of recurring themes that concern what a female senator described as *"a veil of secrecy"* that hangs over CSG projects (Senate hearing transcript, Canberra 28th July 2015: 47; cf. Kinchy *et al.* 2016: 881). For instance, I frequently encountered critical responses to industry claims of commercial-in-confidence, confidentiality clauses that prevent landholders from discussing Conduct and Compensation Agreements, or an unwillingness to disclose information and provide responses to questions in writing. A male hydrological consultant thus recalled that *"the CSG guys seem to want to keep things close to their chest. They don't want to tell people much. I've had trouble getting information out of them, and they know I'm about as independent as you can get in this bloody system"* (interview June 2015). Interlocutors therefore often emphasised how secrecy made it difficult to make sense of CSG developments and diminished confidence in the regulatory processes. Meanwhile, others critiqued and resisted such secrecy:

[83] Due to the data limitation (see Chapter 1.5.4.), I largely omit industry perspectives regarding uncertainties caused by clear governmental responsibilities. From informal conversations, however, these appear to have also affected proponents and subcontractors. For instance, a number of company staff noted how ambiguous and changing regulations and roles, especially early on, made it difficult for proponents to comply with regulatory obligations.

> They [CSG company] have a business model that basically said people in the field cannot disclose any information without head office. So it all came from a very smooth spin doctor. And that just destroyed it. It put a hidden attribute on the information, who'd believe this coming from that person? That was really frustrating. … A farmer asked a very legitimate question and knew they had the answer, it was very simple. … And they basically said 'I'll have to get back to you on that', don't do that!
> …
> They [staff of the CSG Compliance Unit] are in a really difficult situation because they know a lot of what has gone wrong. And they aren't allowed to talk about it.
> [Male agricultural sciences consultant and cotton farmer, interview March 2015]

> One bloke [CSG company staff] said to me 'You can't tell anyone what you got' [agreed financial compensation]. I said 'I don't discuss my money, but I'll give a round figure'. 'You can't do that'. But I said, 'I'll send a smoke signal. I won't say it, they can read the smoke signal'. I said 'Grapevine, everyone living the grapevine'. [Neighbour's names] down there, they probably know what I'll be doing tomorrow and I haven't seen them for a fortnight. 'How would they know that?'. I said, 'It's in the country, that's all'.
> [Male grazier with nearby CSG and coal mining developments, interview May 2015]

Consequently, the information available to local and outside actors alike regarding, for instance, potential risks of extraction techniques or operational accidents is often limited, anecdotal, 'gossip' or uncertain 'hearsay'. The exchange between two Environmental Defenders Office solicitors and the chair at a public Senate hearing illustrates the problems of knowing and suspicions that may arise in these instances:

Chair:	How do you know that you do not know?
Dr Carmody:	We do not know whether they [hydraulic fracturing chemicals] are being used or not because there is no public disclosure legislation in Australia. ...
Chair:	If you do not know that they are being used because there is no evidence or information, how do you know that they are even being used?
Dr Carmody:	Literature that we have assessed or analysed indicates that the 23 are the ones that have been declared and that, necessarily, there are others that have not been declared because they have been labelled by the company 'commercial in confidence'. …
Chair:	Maybe you need to have a look at this from a different perspective. … Jumping to the immediate conclusion that there are a whole heap of chemicals being used here that are potentially dangerous is a leap of faith that perhaps puts an unfair, or a disproportionately negative, spin into the community about what is going on here. … That there is something going on that really is not. …
Ms Walmsley:	There have been gaps, and there has been a lot of confusion about what is being used. That has not been helped by companies who claim commercial-in-confidence on their CSG chemical recipes. … We do have evidence from groups … that after CSG operations have been in place certain chemicals have actually been found in local waterways and so forth. So we are doing this on an evidence-based approach. But there are

> certainly knowledge gaps and regulatory gaps, and I think that they are contributing to community concerns.
> [Senate hearing transcript, Brisbane 27th July 2015: 7–8]

This exchange indicates that, in addition to debates over known risks, uncertainties arise for some actors due to an awareness, suspicion or partial knowledge of what they or anyone do not know; in other words, due to non-knowledge (also Everingham *et al.* 2014: 125–126; see Chapter 2.1.2.). As discussed in Chapter 8.2., the interpretation of such uncertainties can subsequently lead to conflicting politics of evidence regarding environmental and health impacts.

A number of interlocutors with experience either from within or in dealing with CSG companies indicated — usually off record — that, at least in some instances and early on, such secrecy and control of information was a deliberate management decision. This was explained by an increasing corporatisation or takeover of CSG companies by major international oil and gas companies. This, *inter alia*, resulted in growing risk aversion and focus on controlling potential (legal) liabilities. Suspicions were further raised by frequent turnover in land access and liaison staff, which some interlocutors interpreted as strategies to avoid deepening interpersonal relationships, and liaison officers' inability to provide definite answers without consulting the company's legal unit. The following accounts provide some insights into this theme:

> The gas companies still do a lot of secret things. … If it's on your property and they do a frack, they won't give you any information about the frack. It's all secret information. … Why keep it secret if it's not a problem?
> [Male farmer and former CSG-specific regional NGO representative, interview April 2015]

> You will just start with one Land Officer and then you will get a different one. … So there is no bond … . They don't get attached to the family, and they aren't aware of your issue. So every time you start with another Land Officer there is another issue. … You just beat your head up against a wall. And you never get any affirmative answers. … You got this constant 'can we meet'; so there is no written agreements.
> [Female former landholder with CSG infrastructure, interview April 2015]

> The real world just doesn't work how they [company staff] think it does. And it is amplified nowhere more than in rural areas … . The bullshit meters are pretty good in rural areas. But my experience of community information sessions — where quite a lot of the answers are 'we don't know', 'we will know' or 'we don't know and here is why we don't know' — is that the majority of people can be satisfied. And companies think they should know everything and they are scared to open up because they think if they give an answer of 'I don't know' then it's going to tarnish them in some way. … The CSG companies have just been so commercial-in-confidence in nature and risk averse that they are shooting themselves in the foot every day, because … they feel they can't open up about anything.
> [Male environmental management consultant, interview April 2015]

These accounts reflect a wide range of aspects associated with the search for a straight answer and associated uncertainties. I contend that these uncertainties, at least partially, arose from the veil of secrecy that hung over CSG developments. This secrecy often "undermines trust in experts and hampers residents' ability to make sense of their own situation, thereby contributing to perceptions of disempowerment" (Willow 2014: 249; also AgForce 2017 & Chapter 8.3.). Secrecy thus constitutes not merely an absence of knowledge but the "the presence of an absence" (Raj 2000: 31). Through perceived secrecy, some actors can then became suspicious or aware of potential unknowns. With limited means to address those suspicions, uncertainties nonetheless remained in many instances.

The two overarching themes of organised irresponsibility and the veil of secrecy further illustrate the difficult sense-making processes associated with CSG developments. Within this context, actors may frequently find themselves in the uncertain 'middle region' in between partial knowledge and suspected, guessed or feared non-knowledge (see Chapter 2.1.2.). This status has sparked a large variety of responses from embracing to outright rejecting the CSG industry. Consequently, trust in administrative and regulatory processes cannot be taken for granted, but becomes itself a factor creating ambivalence in the process of coping with problems of knowing. As a female attendee at a company-organised gas facility tour emphasised in her response to a CSG company representative, *"[p]eople want answers and details. It's not going to help to say 'we comply'"* (July 2015). In this sense, 'discourses of compliance' (Stilgoe 2005) are problematic as they turn questions concerning unknowns and adequate scientific research into issues of measurement and compliance to set guidelines. Such guidelines represent what is known about particular hazards at a given moment in time. Discourses that stress compliance with these guidelines might then (re)create cognitive and social authority, but can potentially also obscure problematic uncertainties and demarcate unknowns from further consideration. They also allow regulatory agencies to manage contested issues solely in scientific terms, which can exclude non-scientific bodies from decision-making processes. Actors whose concerns remain unanswered, or are not even acknowledged, might consequently feel prompted to challenge regulatory processes. Discourses of compliance are thus fragile, especially when the underlying adequacy of guidelines is questioned (Stilgoe 2005; 2007; see Chapter 7.2.). Uncertainties can then remain when compliance is associated with irresponsibility and secrecy.

For some concerned local and outside actors, the perceived uncertainties and shortcomings of the regulatory processes have consequently become a source of deep-rooted distress (see, e.g., Albrecht (2005) on the notion of 'solastalgic distress'; also Chapter 4.1.). Not knowing can, in this regard, create profound discomfort and might lead to a loss of certainty about one's place in the world (Dilley 2010: 188–190). Rather than complete ignorance, though, these interlocutors' accounts demonstrate the connection of (partial) knowledge and suspected or feared unknowns. That is,

concerns arise not merely from a 'deficit' of knowledge but as the result of how these actors have come to make sense of CSG through a complex interplay of knowledge and ignorance; or, "precisely *because of* and not *in spite of* the knowledge" (Beck 2005: 588, original emphasis) these actors have of CSG developments:

> Leaking high-point vents, gas wells that are leaking … . We're not even saying 'oh, we're not sure about that', we know that now.
> [Concerned female landholder, tour of property with CSG infrastructure April 2015]

> The more you look into it, the more questions you ask, the further down the rabbit hole you go. … And it cannot possibly be as bad as that nutter over there is saying. … That is just a question I can't get an answer to and it bothers me, keeps me awake at night, wakes me early in the morning. … The alternative to the blissful ignorance is nightmares and terrors and fears. … I just want to leave, I want to be blissfully ignorant.
> [Female landholder with nearby CSG infrastructure, interview May 2015]

These accounts indicate how the awareness of impacts and uncertainties has had profound impacts on a number of residents and landholders. Some therefore chose to resist CSG developments, while others have decided to leave the Western Downs altogether due to unanswered concerns:

> I personally experienced that distress and sense of lack of control in the communities that were interviewed and of course about the environment change and change being experienced in the Surat Basin, we saw examples of tears and quite an emotional time, people expressing that in their own personal way.
> [Male state politician, interview April 2015]

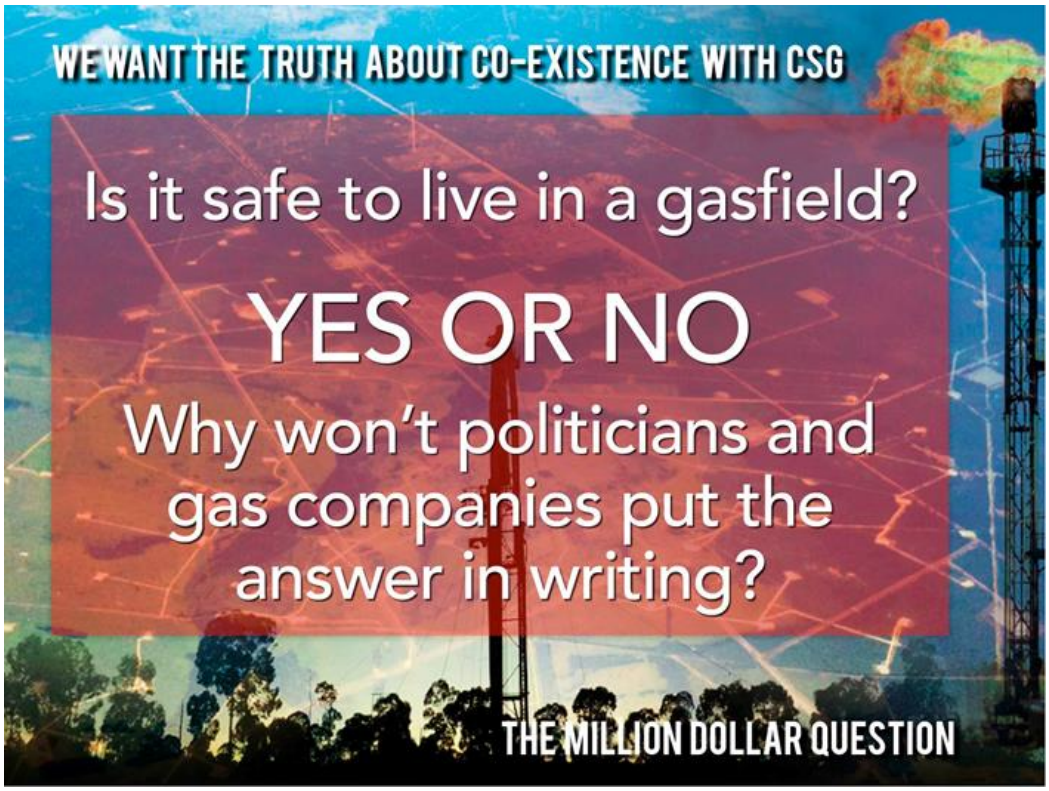


Figure 15 'The Million Dollar Question': no straight answer regarding the safety of CSG (source: interlocutor's facebook account, 2015)

> At the end of the day, if your kids are here getting sick all the time and you can't pinpoint where it's coming from and they won't give you a straight answer, you got to do the best by your kids and you got to say '[expletive], I'm going to pack up, get my kids, and get out of here'. … That's exactly what we've done. We can't get a straight answer.
> [Male landholder with nearby CSG infrastructure, community meeting April 2015]

The uncertainties around CSG developments have thus had profound impacts on some actors' sense of place and the ontological security of a reliable and meaningful environment (Huth *et al.* 2017; also Auyero & Swistun 2008).

Willow (2014: 249) argues in the context of US shale gas extraction that "the psychological trauma resulting from ontological insecurity can be even more detrimental than the physical hazards under scrutiny" (also Dwyer & Minnegal 2006: 12; Chapter 2.2.2.). CSG developments can, in this sense, contribute to landholders' levels of stress and mental health issues (Morgan *et al.* 2016). It is therefore important to acknowledge that:

> You can't argue with the fact that people are impacted. … That's a straight forward impact, regardless of health, regardless of chemicals, water, people are impacted. There's absolutely no confidence that the place is safe … . If that's not an impact.
> [Female landholder with nearby CSG infrastructure, interview June 2015]

Over the course of this research project I then personally encountered or heard of close to a dozen families that moved within or outside of the Western Downs due to CSG-related concerns (cf. Willow 2014: 253; see Chapter 4.1.). Some of these families may still own their properties or have been bought out by gas companies. While those anecdotal numbers are low compared to the thousands of families across the Western Downs, they highlight what many others may have also experienced to lesser degrees. In any way, these families' 'silent' departures have frequently not received much publicity and may have gone largely unnoticed.

These insights highlight that it is crucial to consider the actual experiences of CSG developments. As such, uncertainties resulting from not being able to 'get a straight answer' to the problems of knowing associated with CSG developments have had significant impacts on some actors. Yet, other residents and landholders appear to not necessarily share those concerns to the same degree or any longer. Their accounts will be the focus in the next section.

6.3. Can't Dwell on It: Rural Pragmatism and A Fair Bit of Trust

The problems of knowing I have attended to above were certainly also encountered by actors who support or have come to ambivalent arrangements with CSG developments. However, unlike the experiences considered in the last section, a number of those who found ways to exist with the

new industry appear to have reacted to (scientific) uncertainties somewhat differently. I particularly encountered a wide range of pragmatic responses and perspectives that had frequently changed over time. For instance, an irrigation farmer and later also representative of a CSG-specific statutory body was an early vocal opponent to the CSG industry. On multiple occasions, he emphasised how *'at the early stages, it was all wrong'*, but that you *'can't dwell on the past'*. In our interview in May 2015, he elaborated on his views:

> It's got its challenges, but if you spend your whole life whinging and dwelling on them and say 'this is going to ruin my health, this is going to ruin my family', then it will do. But if you get to accept it - … we've learned a lot, there's a lot more understanding about the impacts. We get a few bucks out of it, it's only going to be here another 12 or 15 years, already had it for five, not that big a deal. But we make the most out of the compensation we're getting, we'll be able to fence a few paddocks or buy another farm, send the kids to school or, you know, all those things.

Some actors may thus regard CSG's potential impacts and associated uncertainties as problematic but also considered prospective (financial) benefits for individual landholders and local communities (see Chapter 3.2.2.).

Likewise, a number of actors and groups viewed CSG developments as a *'once-in-a-lifetime opportunity'* that nonetheless should not proceed *'at any cost'*. CSG projects thus required *'more certainty and transparency'* and for scientific studies to precede any developments (BSA 2011b). In order for individual landholders to benefit from the industry, the BSA similarly advised to 'be pro-active' early on and that they 'need to educate themselves'. Much of this education is related to technical, economic and legal facets:

> It is critical that in order to make the best/right decisions for your business you become informed and seek professional advice. … Be prepared. … You must understand what is happening if you are to make good decisions. … Seek independent professional advice on Land Valuations, Agronomy, Hydrology and Engineering to help you develop your negotiating position with the CSG Company.
> [BSA Factsheet, February 2011, original emphasis]

The account of a farmer who irrigates with treated produced CSG water and subsequently tripled his crop production illustrates the ability to benefit from CSG developments due to pro-active engagement. This involvement also gave him confidence:

> I started doing a fair bit more research about what my rights actually were and discovered that … they [CSG companies] didn't have it all their way. … Because I was heavily involved initially, I made the effort to actually read a lot of the EISs that the companies submitted, which are pretty lengthy and not always the most easy to read. [Interviewer: 25kg.] Absolutely. And for that reason very few people in the public [read them] … . But that did give me an understanding of what the companies had actually projected to the government. [Publicly available interview, Youtube World101x May 2015]

The ability to pragmatically approach and cope with the challenges of an emerging CSG industry thus depended in large parts on early, active engagement. Landholders and residents were and are, however, not equally able to do so.

Malin (2014) has therefore critiqued such pragmatism in the context of Pennsylvania's shale gas developments as a form of neo-liberal individualisation and logic imposed onto farmers. While I am cautious with references to neoliberalism, a comparable theme emerged during my fieldwork. The interlocutors who appeared to cope best were often also those who can afford to consult expert, scientific and legal advice; have the ability and time to work through significant amounts of information; and can refer to representational bodies or interest groups. Hence, these landholders and residents were, for instance, able to negotiate better compensation agreements, have a stronger say in where infrastructure is located on their property, or could avoid certain impacts (cf. Measham *et al.* 2016: 107–108). I interpret this finding as the result of an interplay between multiple, unequally distributed capitals — in a Bourdieuan sense (Bourdieu 1986; cf. Stehr 2001: 48–53). The ability to mobilise such capitals influences experiences of uncertainties associated with CSG developments by allowing some actors to develop a sense of agency and beneficial engagements with the industry (cf. Chapter 8.3.).[84] Put differently, I often noticed that some actors and actor groups with more financial, social, or political capitals pre-CSG tend to have benefitted to a higher degree. Everingham *et al.* (2014, 2015) already employed such a Bourdieuan understanding to investigate shifting capitals in the context of CSG developments in the Western Downs, and I consider the (re)production of social inequalities *inter alia* through this lens in Chapter 8. Important to note here is how some interlocutors opted, broadly speaking, to critically engage with rather than outright reject the new industry. In these cases, the importance of knowledge as a capacity to action and agency is crucial (see Chapter 2.1.1.).

To be sure, critical engagements occurred across a wide spectrum and with a multitude of interests. However, I frequently noticed pragmatic approaches that are particularly common among farmers and graziers who are used to adapting to erratic weather patterns or fluctuating commodity prices. The account of a farmer who operates a profitable irrigation property on the Western Downs' highly fertile alluvial floodplains exemplifies this finding. He told me during out interview in May 2015:

> We've survived because we've had the ability to adapt and to change to the circumstances that have been forced on us. And the biggest …was a reduction in water access. Like we've lost 50 percent of what we had, and that is like losing 50 percent of your salary. … So those things drive the need for change, most of us feel uncomfortable about it when it happens but … we survived and adapted. That works well when you have the freedom to do that. But you

[84] On the importance of community agency in unconventional gas conflicts see Leonard *et al.* (2016).

> put a gas field over us in the form that we were seeing out here, takes away all that ability and freedom.

Drawing on such rural pragmatism, the farmer went on to recall how his local community decided to deal with the challenges emerging from proposed CSG developments in the area by 'working within the system'. In doing so, he highlights the significant changes that occurred between 2010 and May 2015:

> In 2010 … it was extreme hostility … . But it has taken us a while to, I suppose, reach an understanding, and that has taken a bit of movement on both sides. … If you went and asked every flood plain landholder 'Do you want CSG on your farm?', the answer is 'No'. But some of us are denialists and some of us are realists. … The real issue is that they have the right under the law. … At the end of the day you have to deal with what is possible and what is not possible. Some of us who try to do that set about working within the system as it was. We've managed to get some changes to that system, in the Regional Interest Planning Act.

Of particular importance to him, as for many irrigation farmers and bore owners in the Western Downs, are potential impacts to the availability of groundwater. Together with another irrigation farmer further west, he therefore agreed to host a drill site for an interconnectivity study that investigates the potential for an (undesired) connection between different aquifers. The initial outcomes and ongoing research for this study have given him greater confidence in the manageability of CSG-related groundwater impacts:

> What has been quite a comfort to us guys who are concerned about the impact to groundwater is that the company has come to the table with us, with the groundwater users and OGIA in conducting some quite serious research … . The research is happening to back-up what they thought. So we have got some science and some facts around that as time progresses. … So, I think most of us feel comfortable with the science and the efforts. … When the approval was given to actually have an impact on the groundwater we all knew nothing and nobody knew anything about it. … When you asked questions the government would trot out the nonsense line provided by the gas company. Even amateurs like myself could shoot holes in their logic. But now, there is some people with some serious credibility looking at this space.

For this cotton farmer and others, initial concerns about potential impact appear to have been resolved or are at least being addressed. Crucial, in this regard, was those farmers' existing economic, social and political capitals that enabled them to resist and negotiate with CSG companies and government actors.

These accounts resonate with the responses from a number of involved scientists and public actors who frequently emphasised that the quality and quantity of scientific research(ers) and understandings of CSG-related impacts had, in some areas, improved over the last five to ten years. Consequently, these interlocutors often described increasing degrees of confidence in, for example, the narrowing range of different groundwater drawdown predictions. For some, this led to a

declining priority of CSG development. A male policy manager for a primary industries peak body, for instance, told me:

> Here in Queensland, it [CSG] was probably in my top two issues for the first three years. Now it's probably more like a five, six or seven. … I've seen nothing that would have me really concerned.
> [Interview May 2015]

However, (perceived) improvements in scientific research are not the only source of comfort in dealing with problems of knowing resulting from CSG developments. Likewise, a felt lack of scientific understanding and certainty does not necessarily prompt actors to reject or oppose the CSG industry. Different kinds of (un)certainties can therefore overlap. For instance, uncertainties about appropriate scientific understandings may be remedied for some actors by certainties derived from a trust in the adequacy of regulatory processes or, contrary to the previous section, in responsible industry practices. In this context, one may understand what was variously described as trust, hope or faith as coping mechanisms for problems of knowing. The account of a male regional town resident and business representative illustrates this finding:

> With any industry that is invasive by nature, there is always going to be that risk and nobody in that community is naive enough to think that risk doesn't exist. … I guess those of us who are supportive about the economic stimulus the industry has had in [town] and the benefits, we live in hope. Which is a bit like being a Catholic. You know, the science isn't there, but we do hope we'll go to heaven when we die. … We just have to have faith that they are using best practice, … that science will improve. … We do feel a little bit powerless about that, because I'm no scientist or hydrologist, I don't know. … It implies a fair bit of trust. No, I can't be sure of that because the very draconian legislation that permits the exploration and production was very rushed. … And we don't know, we only know what each of the companies tells us … and so far it sounds so good and so far we have not had an environmental issue yet. … But we do need better controls and checks on the technologies and science. … So I never got into the nay-sayers. I took a fatalist view of it: it's already here, … let's make hay while the sun is shining. Let's hope they are being good citizens.
> [Interview May 2015]

These accounts demonstrate that local and outside actors perceived and reacted differently to the problems of knowing arising from the emerging CSG industry. Furthermore, perspectives have also changed over time.

For some actors, CSG developments have therefore become somewhat normalised (cf. Malin 2014). Their initial concerns about unknowns and uncertainties have consequently shifted towards more calculable — and possible acceptable — risks, especially with an improvement of scientific research. In this sense, risks must indeed be regarded as a form of knowledge that is distinct from uncertainty or non-knowledge (Wehling 2006a: 109–115; Wynne 1992; see Chapter 2.1.2.). Dwyer and Minnegal (2006: 3) thus rightly emphasise that:

> an increase in knowledge - a change of perceptual scale - may reposition a potential event from the domain of the uncertain to that of risk. And this means, of course, that from the perspective of different actors the same situation may be experiences as uncertain or as risky according to their current understanding of potential impacts. To the extent that actors will make different sorts of decisions in contexts of risk and uncertainty this distinction is crucially important.

It is important to bear these distinctions in mind and position actors' concerns over CSG developments accordingly. These insight further also suggest that, more generally, knowledge is best understood as a social interactional process. This implies that some actors' positions in risk debates, where uncertainties are primary concerns, can change over time despite potential unknowns remaining (see Chapters 8.3.–4.). It is thus important to situate particular observations within a given context and timeframe.

The findings outlined in this section indicate that, for some of my interlocutors, uncertainties about impacts from CSG developments have either reduced or that problems of knowing have been dealt with by placing faith in the regulatory system or conduct of industry. Their views appear to stand in stark contrast to the responses considered in the previous section. The question remains how these accounts relate to the wider context of the Western Downs. I will therefore conclude this chapter by contextualising these responses to CSG-related problems of knowing.

6.4. Conclusion: Contextualising Responses to the Challenge

This chapter attended to a number of interconnected aspects of problems of knowing and considered the range of responses to CSG-specific unknowns. While some actors may contend that a lack of adequate scientific research still exists or that current studies already prove environmental and health impacts, others have gained confidence that improving scientific understandings indicate only minimal impacts in areas of concern to them. The next chapter focuses on this ambivalent status of the sciences. Before moving on, though, I conclude by contextualising the evolving responses to CSG developments.

In general, most interlocutors described mixed feelings when asked whether the emerging CSG industry was positive or negative for them and the Western Downs. They usually noted some individual or collective benefits but also challenging impacts and concerns. A theme I thus frequently encountered was that interlocutors heard good and bad stories or had some good and bad experiences, but that the situation was somewhat settling after the initial boom (also Everingham *et al.* 2014; Measham *et al.* 2016):

> They all go through that real community angst and anger until they start to get some realities in. … Yes, the information does become better. The initial reactions, we hear the people that

> want to be heard. As it moves through, you then hear the people that are quieter and comfortable. You also have the gas companies in their first excursions into community consultation stuff it up big time. … There are some good news stories out of the gas industry for farmers as well as the real angst. When you hear of a farmer who has got 83 wells on his property and they are getting paid between $10,000 and $12,000 per year [per well] it is a lot of money.
> [Male agricultural sciences consultant and farmer, interview March 2015]

Such different stories have taken place on a communal level as much as in between landholders. Experiences of benefits and impacts can thus be markedly dissimilar even among neighbours. The exchange between three female landholders at a community afternoon tea gathering in May 2015 illustrates this finding:

> Attendee 1: Depends how long you've owned the property, how emotionally tied to the property you are, whether your husband and wife are still together, you got children at home.
>
> Attendee 2: Whether you were hoping to pass it on to them or not.
>
> Attendee 1: That's right. Whether you get your sole income off your property or whether you got an outside income.
>
> Attendee 3: Or whether you're just trying to retire to the coast somewhere and own a yacht. … Some of the people couldn't sign quick enough because they wanted to leave and retire to the coast. Or start a fight, or go to land court or whatever. We had the full range.

I came to interpret such differences as examples that illustrate how, based on conflicting values and priorities, CSG can split existing rural communities and increase individualisation.

Other researchers have described similar findings in the context of CSG and mining developments in the Western Downs and elsewhere (Askland *et al.* 2016; Everingham *et al.* 2014; Grubert & Skinner 2017). An important implication of these findings concerns the responses to the problems of knowing at hand, especially in relation to knowledge and ignorance as social phenomena. In this sense, CSG developments can increase processes of individualisation, which, in some instance, has negatively impacted social cohesion, led to community conflict, and left some residents feeling isolated. Three examples illustrate this insight:

> You'll probably find it's different stories even within the same communities. Even neighbours have different stories. … And you see those that are able to take advantage more likely to be telling that positive story. I guess that's human nature.
> [Male regional council representative, interview May 2015]

> They [CSG companies] split the community, because they get into one bloke who might be doing it a bit hard, short on dollars. … And then they go to the neighbours and say 'Bill's took it and accepted what we offered'. So they gradually get a hold in places and it makes it very awkward.
> [Male grazier with nearby CSG and coal mining infrastructure, interview May 2015]

> They [CSG company] love for us to stay isolated: 'Don't talk to your neighbours'.
> [Male sheep grazier with significant CSG infrastructure, interview April 2015]

These responses highlight the need to differentiate and contextualise perspectives on CSG developments and associated problems of knowing.

Consequently, a manager of a primary industries peak body emphasised that he did not *"like the idea of industry co-existence [with agriculturalists] because I don't think I can dictate as to whether or not an individual farmer could co-exist. But I do think it is possible for … some individual farmers to co-exist with CSG companies"* (interview May 2015). One aspect of this individualisation are, for instance, discernible differences in the outcomes of Conduct and Compensation Agreement negotiations. As the representative of a regional NGO found, there "*is evidence of large variation in the amount of compensation that various landholders are receiving*" and that "*some landholders have not been able to negotiate as effectively as others*" (Senate hearing transcript, Brisbane 27th July 2015: 16). This resulted in compensation amounts ranging from AUD 250 a year per well to over AUD 10,000. With government departments and representative bodies unable to support landholders in some instances (*ibid*.: 48), and thus following on from the organised irresponsibility theme, one can observe a privatisation of risk management (cf. Malin 2014; also Jasanoff 2002: 375; Rose 2006: 158). An individual's knowledge — or the ability to mobilise others' knowledge through the capitals discussed above —is thus crucial in coping with CSG developments. In the context of contested risks from CSG extraction, such shifting responsibilities towards individual landholders have also created a 'personalisation of risk' that causes varying levels of felt ontological insecurities (Jasanoff 2002: 375; also Beck 1992 on risk positions). The experiences of the epistemic challenges of CSG, perceived risks and overall attitudes towards the industry can therefore vary significantly between communities and individuals, which makes contextualising responses essential and generalisations problematic.

Nonetheless, it is helpful to draw out some overarching themes by combining qualitative and quantitative data. A first finding from my own ethnographic data is that many local interlocutors regarded those outright rejecting or actively resisting CSG developments as a vocal minority that often also included engaged 'outsiders' to the Western Downs. Reference was frequently made to 'five percent' of actors at either end of the rejection-embrace spectrum who will likely oppose or suppose the industry in any case. Two examples help to illustrate this theme:

> The industry will say it's safe, the departments are saying it's safe. We have a very passionate and evidence-based small demographic claiming it is anything but safe and appropriate. And I think all sides have a valid argument right now … . It appears that no one government is clearly in a position to take the bull by the horns and to run with an agenda.
> [Male state politician, interview April 2015]

> Some of the people who committed one way or another are really withdrawing to their lines. As usual, the vast majority of people are spread across the middle and a lot of the heat has gone out of the conversation. But the reality is that there is a lot of vested interest … and you can't just talk, this is not a conversation that can be held at a very simplistic level about whether someone thinks something's good or bad. … Like most big issues, it has many good attributes and many attributes that aren't necessarily good and are fraught with danger. … But there is still a lot of uncertainty. And the uncertainty is caused by the fact that everybody is subject to different sources of information that are quite often either totally conflicting or at least in part conflicting. … Again, it gets down to a trust factor.
> [Regional natural resource manager, interview April 2015]

Some interlocutors subsequently argued that these vocal 'naysayers' do not represent the general attitudes across the Western Downs' various communities (see Chapter 8.1.).

However, it is important to remember, firstly, that marked difference exist within the region itself between regional town residents and those out 'on country'. That is, impacts and benefits can vary significantly with CSG extraction primarily occurring on out-of-town properties but direct and associated economic benefits often flowing into regional towns.[85] Despite being the comparably smaller actor group, out-of-town residents may then be those most directly impacted and at risk. This can affect attitudes towards the industry. Second, I encountered references made to a 'don't-rock-the-boat' mentality that is common in rural areas. Some actors may not articulate concerns and anxieties openly in public. Third and most relevant, in light of the veil of secrecy surrounding CSG developments, particularly contractual confidentiality clauses, a number of concerned actors may remain silent due to potential legal or social consequences of speaking out or not feel knowledgeable enough due to persisting problems of knowing. Likewise, others may have close family members who are employed by or benefit from the industry, which can lead to self-restraint. Critical attention must therefore be paid to the issue of vocality as much as the quantity of opposing actors.

A second overarching theme is that while CSG-specific challenges have evolved and somewhat settled over the last few years, interlocutors often noted that local attitudes continued to be somewhat negative and that concerns remained, especially about long-term impacts to groundwater. A male representative from the CSG Compliance Unit noted how *"the protesters have pretty much given up"* and that complaints and enquiries were now largely related to specific cases of operational (mis)conduct or impacts to landholders' bores (interview April 2015). Whether this indicates an increasing normalisation and co-existence between the agricultural and CSG industry, as frequently proclaimed by proponents, or rather a rationalisation of what one critical grazier

[85] To compare the benefits and impacts on different regional towns and effects on local employment see UQ's Boomtown Indicators website.

described as a *'shotgun wedding'* is certainly open to debate (cf. Askland *et al.* 2016: 57–75; Everingham *et al.* 2016; Huth *et al.* 2017):

> There are ways where they can co-exist and there are ways that they can be mutually beneficial. … There are certainly concerns. And those environmental concerns are large and they loom large. That is the elephant in the room.
> [Male local council representative, interview May 2015]

> There's no such thing as 'co-existence'. We're trying to think up a new expression, like 'legislative enforced existence'. … To be fair, if the compensation is good enough, then you can 'co-exist'. But we're really worried about the water. I don't know, the science is not there to say whether in ten, twenty or thirty years' time it will be sustainable or not. … The co-existence on just the physical stuff is, you can live with it. Ninety per cent of people in the area are really concerned about the water. No one knows, no one can tell you.
> [Male grazier with CSG infrastructure and CSG-specific NGO representative, gas field group tour April 2015]

However, I hardly ever encountered landholders referring to 'co-existence' particularly in light of persisting uncertainties about long-term groundwater impacts.

These two overarching themes correspond to the findings of Walton *et al.*'s (2016) quantitative research on community wellbeing and survey data from 400 participants across the Western Downs. In their latest report, they note that "community attitudes vary across a wide spectrum but most people have moderate or 'luke-warm' views towards CSG development" and that the "there is a tendency towards more negative views than in 2014" (*ibid.*: 17). This trend is possibly a result of the industry's rapid downturn due to the transition into operation and challengingly low global oil price; as one regional town resident told me, this caused a *'second wave of uncertainty'* and brought back doubts (interview March 2015). Regarding the wide range of responses, Walton *et al.* (2016: 17) also remark that, similarly to my qualitative findings, there:

> was no single community view towards CSG development; rather there was a spread of attitudes that ranged from 'reject' CSG to 'embrace' CSG. … These differences may be attributed to people's previous experiences and current situations, individual needs and wants, and personal world views and beliefs around gas development. These include perceptions of community functioning, environmental management, trust, and fairness. … For all stakeholders this requires an understanding that different perspectives exist within communities and between communities. The research findings suggest that companies engage with communities in an individualised and nuanced way, as it cannot be assumed that people's views are similar.

The following two tables succinctly summarise these key findings and further contextualise responses to CSG-specific problems of knowing and uncertainties:

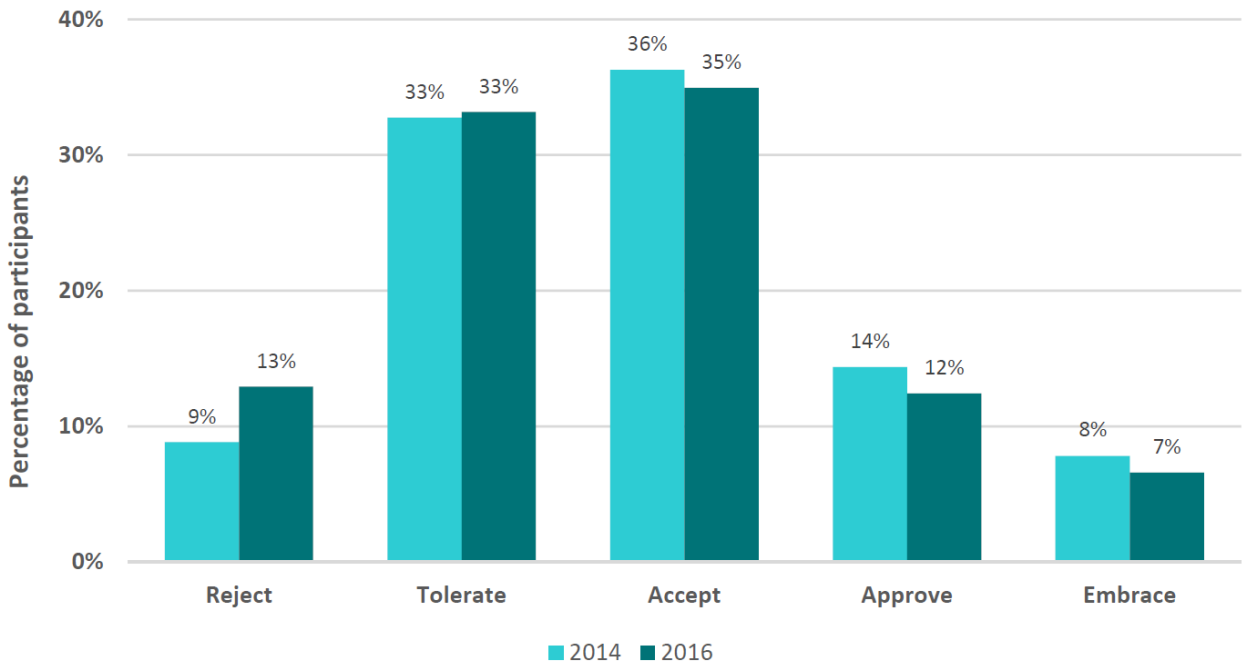


Figure 16 Attitude towards CSG development in the Western Downs region 2014 & 2016 (source: Walton *et al*. 2016: 17)

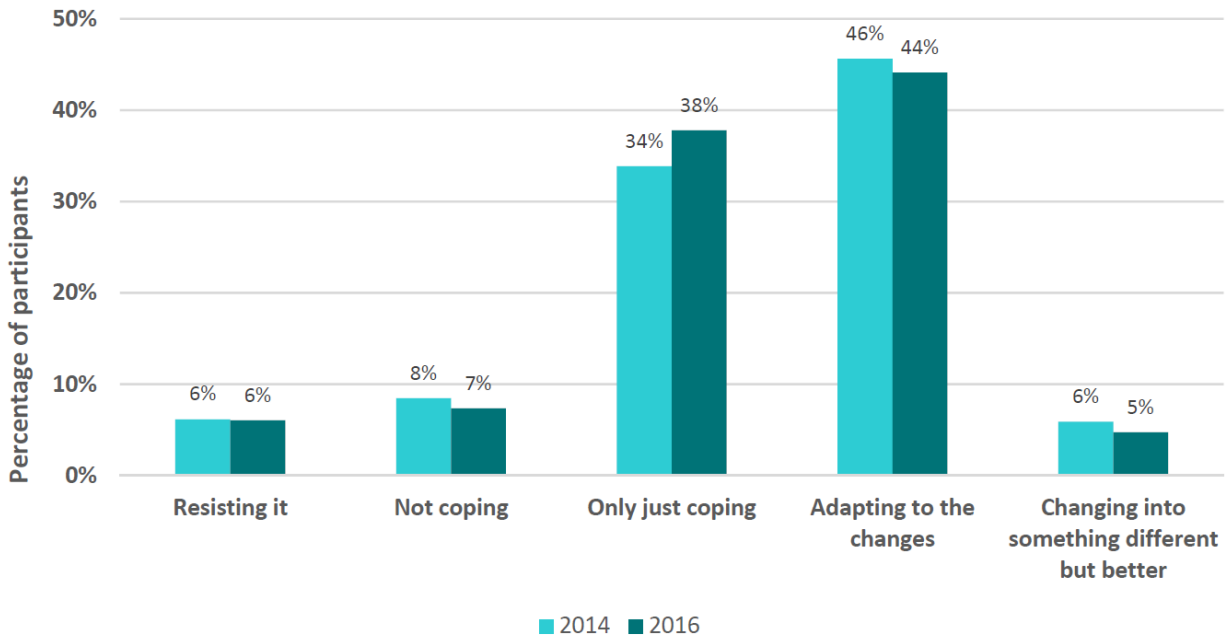


Figure 17 Community perceptions of adapting to CSG development 2014 & 2016 (source: Walton *et al*. 2016: 42)

Walton *et al.*'s (2016) overall findings indicate that indeed the majority of Western Downs residents' attitudes and perceptions are 'spread across the middle' with smaller percentages at either end of the spectrum — at least among those who responded to their survey.

However, they also point out that "[p]eople's views differed between towns" and "on where they lived. Those who lived 'out-of-town' felt negative on average … . Those who lives 'in town' felt neutral on average towards CSG developments" (*ibid.*: 18). Further differences can be observed in how company employees, external actors and landholders perceive the CSG industry (Gillespie *et*

al. 2016). While general tendencies exist, it is therefore important to contextualise and differentiate individual responses to CSG developments. These quantitative insights correspond to the accounts considered in this section.

Through the qualitative and quantitative findings presented in this chapter, one can appreciate the wide range of responses to CSG developments generally and associated problems of knowing in particular. While attitudes are diverse, multilayered and evolving, it became apparent that uncertainties and concerns remain even with those actors who embrace the industry. Environmental concerns, especially long-term cumulative groundwater impacts, and also health-related risks are important in this regard (cf. AgForce 2017). It is possible to link the insights of this and the last two chapters by noting the important role of natural scientific knowledges for many actors' dealing with these concerns. Some actors see scientific research as improving and feel their concerns to be addressed, at least partially. For others, however, scientific uncertainties and the "potential for unknown, unintended and irreversible consequences" (Everingham *et al.* 2014: 125) are an ongoing issue of concern. This indicates an ambivalent status of the sciences and that research outcomes themselves have become a crucial aspect of the debate. In the next chapter, I will therefore critically analyse responses regarding scientific research in the context of CSG extraction.

7. Right and Wrong Science: Exploring the Substructures of Ambivalence

The 'pure' universe of even the 'purest' science is a social field like any other, with its distribution of power and its monopolies, its struggles and strategies, interests and profits … . In the struggle in which every agent must engage in order to force recognition of the value of his products and his own authority as a legitimate producer, what is at stake is in fact the power to impose the definition of science.

(Bourdieu 1975: 19 & 23)

The science of this industry is dodgy.

(Queensland Greens Senator Larissa Waters, Rally for the Future, Brisbane May 2015)

The last three chapters attended to numerous aspects associated with CSG-related problems of knowing and discussed the indispensable, yet often ambiguous, status of scientific knowledge claims. In the preceding chapter, I demonstrated that actors' perceptions of the (in)sufficiency of scientific understandings are closely connected to their attitudes towards the detectability and manageability of risks from CSG extraction. However, not merely the 'outputs' of scientific research, or lack thereof, are debated but often the adequacy of research practices themselves (see Chapter 5.2.). This chapter specifically focuses on this aspect of the controversy and, building on the conceptual outlines developed in Chapter 2.3., critically consider interlocutors' varying responses regarding the 'right' production of scientific research. In doing so, I will follow Bourdieu's (1975) spatial metaphor of science as a social field by discussing these responses through the abovementioned lens of the technological zone.

This argumentation begins from the insight that most actors do not contest the value of science or its social authority *per se*. Rather, they debate what 'proper' scientific research ought to involve. I therefore, firstly, outline what interlocutors regarded as 'wrong' science. Following these accounts, the second section considers perceived obstacles in the way of adequate science, and whether those constraints are thought to be intentionally created. I subsequently focus on what interlocutors may regard as 'right' science and who ought to conduct this research. The concluding section brings these findings together in an understanding of scientific research as a body of situated practices that are subject to political debates regarding their adequacy. To conceptualise these debates, I propose the notion of a politics of (im)purity in an attempt to highlight the political dimensions of the contest between various actors to define adequate science according to the scientific root metaphor of objectivity, or 'purity' from subjectivities (see Chapter 2.3.1.).

7.1. When the Wind is Right: Wrong Science and Dressed up Guesswork

Chapter 5 and 6 considered the ambiguous, contested and evolving status of CSG-specific scientific knowledge claims. In doing so, I critically examined overly simplistic expert–lay perspectives that are invoked by some actors. Their accounts suggest that those with concerns or opposing the industry are, intentionally or not, merely ignorant of scientific knowledge. However, uncertainties and varying views are also expressed by scientists and relevant professionals — albeit often in different form and focus. To advance this insight, I argue that the ambiguous status of scientific knowledge claims is not simply the consequence of debates between those rejecting and accepting them as though these claims were static externalities brought into the debate. Instead, one key finding from my research is that even those most affected by or opposed to potential impacts from CSG extraction generally do not reject but embrace science or demanded more scientific research:

> It takes a lot of testing and a lot of pokey, pokey to get anything done. You have to collect the evidence. Everything is science-based. You can't just go and make claims. You have to have evidence.
> [Opposing female town resident, CSG-specific community meeting April 2015]

> We do not oppose the development of those industries in a responsible way, provided they are subject to a rigorous science-based assessment framework.
> [Male National Farmers Federation representative, Senate hearing transcript, Canberra 28th July 2015: 22]

It is therefore unsurprising that for many actors it is ultimately "the underpinning science that will determine the legitimacy of this industry" (Manning 2012: 171), particularly since scientific representations are indispensable for knowing and managing CSG (see Chapter 4). However, these accounts also indicate that the ambiguous status of scientific knowledge claims is not merely the result of some actors rejecting science. Rather, such ambiguity is the outcome of ongoing multifaceted negotiations between a large variety of actors over the configurations of proper scientific research.

These negotiations do usually not follow simple understandings of right and wrong science though, but involve uncertainties and the balancing of desired scientific research against restrictions to what can be investigated. I therefore found that, broadly speaking, many interlocutors were ambivalent about what CSG-specific scientific research should and, realistically, could involve. In this sense, the arrangements of scientific knowledge production themselves become a subject of debate wherein existing arrangements are often neither fully supported nor outright rejected. This makes the question of 'getting the science right' indeed complex. I thus agree with anthropologist Satterfield (2002: 82) who argues that "pro-science/anti-science polarizations conceal both the

diversity of perspectives and the 'substructures of ambivalence'" (cf. Durant 2017; Lamberts 2017a). This chapter attends to these substructures of ambivalence. I utilise the notion of substructures to explore the underlying facets and dimensions of negotiations over CSG-specific proper science. For some actors, such negotiations lead to ambivalent views about the status of scientific knowledge claims. Let me begin by considering what various actors regarded as wrong science.

Throughout my fieldwork, I encountered interlocutors from diverse backgrounds who were critical of the arrangements or specific conduct of ongoing CSG-specific research. However, even those most opposed actors appeared to be 'pro-science'. For instance, one former female landholder who had CSG infrastructure on her property and now advocates against the industry stressed that *"to evolve into the 21st century, we will need a Minister of Science. We need funding in education not mining"*. Similar to other interlocutors, she regarded the science and technology of CSG extraction as outdated, yet insufficiently studied. A central concern for her and others is therefore inadequate testing regimes and lacking research of potential impacts. This, she stated, has decreased her confidence and trust in the regulating institutions:

> Nobody knows what this is actually doing. It's all hearsay. And yet, you go to a doctor, here is the medication, you take it. But you take it on the knowing that the government has tested the medication for the last 10 years. That scientists have broken it open, done the research … . So why does the government approve something here that has no scientific baseline studies? It doesn't make sense. … Well you don't know, you are asking questions and nobody is giving you answers. And yet we're told it's safe. Well, show me that it's safe.
> [Interview April 2015]

A number of other interlocutors raised similar concerns about scientific research that, in their views, remains yet to be conducted:

> The big problem is the fact that it has not been tested - … that government departments took very conscious decisions not to do testing. … Their own report recommended that testing should be done in order to determine the total gas field emissions and the exposure of the residents to those emissions. But … a very specific decision has been taken by someone not to do that testing.
> [Opposing urban-based medical practitioner, Senate hearing transcript, Dalby 17th February 2016: 34]

> I'm not attacking him [public servant]. I'm attacking the whole system; that we the landholders and taxpayers got to put up with these harebrained ideas. … You talk about the science has got to be right. Well [expletive], the science was never right in the first place.
> [Concerned grazier, AGM CSG-specific NGO October 2016]

As these accounts illustrate, for some actors who voiced concerns about unknowns and uncertain impacts, the issue of inadequate science fundamentally begins with scientific research that has not been conducted or commenced too late.

This is especially apparent in regard to risks that may emerge beyond physically observable phenomenological cues and essentially require scientific research to be detected, such as air pollution or exposure to chemicals. For instance, I already considered the critical exchange between two Environmental Defenders Office solicitors and the Chair at a public Senate hearing about chemicals used in hydraulic fracturing (see Chapter 6.2.). It is possible to argue that the perceived 'knowledge and regulatory gaps' described in this exchange arise from a suspicion of incomplete scientific research, *inter alia* by the federal government's National Industrial Chemicals Notification and Assessment Scheme (NICNAS):

> Ms Walmsley: Out of 23 chemicals known to be used in fracking fluids in Australia only two have been assessed by NICNAS.
>
> Chair: Why is that? … One could, perhaps, extrapolate that with the additional chemicals - the 21 out of the 23 - there is no need for them to be tested because they are completely benign.
>
> Dr Carmody: That is putting an extraordinary level of faith in the regulator. … Given the level of public concern, it would be advisable to actually test them and make that data publicly known. The second point is: they are the 23 chemicals which are known to be used. There are others which we do not know of.
>
> [Senate hearing transcript, Brisbane 27th July 2015: 7]

Such concerns about incomplete chemical assessments are not new, though. Already in late 2011, another Senate committee considered conflicting submissions about the safety of fracking chemicals and concluded in its *Interim report: the impact of mining coal seam gas on the management of the Murray Darling Basin* that:

> It is beyond the resources of this committee to settle the claims and counter claims with regard to the safety of the chemicals used in the fraccing process. … The committee heard from NICNAS and formed the impression that it is drastically underfunded for the responsibilities it has. NICNAS has considered only four of the "50 to 60" chemicals used in fraccing fluids. The wide discrepancy between the figures given for the number of chemicals used reinforces the need for a public listing of all chemicals used by the industry. … In addition, many of the chemicals used by the gas industry have been in common use in this country for many years and were 'grandfathered' on to NICNAS registers and may never have been subject to assessment in the way that new chemicals are.
> [Senate Standing Committees on Rural and Regional Affairs and Transport, Interim Report, November 2011: 34 & 35]

Despite the committee's recommendation, it is questionable that merely disclosing these chemicals will settle debates if government institutions like NICNAS are perceived as possibly underfunded.

Additionally, they are subject to companies' commercial-in-confidence claims about exact chemical compositions and might be faced with research agendas beyond their capacity (also Manning 2012: 57–63). There are, consequently, constraints associated with the assessment of disclosed information about these chemicals. Even more limited are non-specialised actors or groups who likely lack the means and abilities to conduct substantial assessments.

For a number of interlocutors, such inadequacies of testing regimes can contribute further to the abovementioned problems of knowing and instances of organised irresponsibility. In these contexts, substantial epistemic and legal challenges can arise from potentially insufficient testing regimes or even 'undone science'; that is, incomplete or absent research "that is systematically produced through the unequal distribution of power in society" (Hess 2015: 142). I will attend to these power dimensions below and in Chapter 8, but it is here important to emphasise that undone science and associated uncertainties about unforeseen consequences particularly affect those actors in immediate proximity to CSG developments (cf. Stilgoe 2005: 61; see Chapter 6.4. on unequal risk positions). For example, multiple graziers pointed out that they are responsible for completing so-called National Vendor Declarations. Grazier might thus be liable for any chemicals found in their livestock without fully knowing if the bore water that their cattle drink may become impacted by CSG extraction.

This is also the case for missing baseline assessments of environmental or health indicators prior to any developments — an omission that cannot be rectified *ex post*. As a male state politician remarked at a gas field tour I attended, "*the baseline stuff has been really consistent … . You need somewhere to make a mark from*". Another attendee quickly replied, "*[i]t is too late, you can't make a baseline now*" (April 2015). While it is difficult in hindsight to determine the intentionality of this undone science and resulting unknowns, some critical actors have spoken of 'omission corruption' that, combined with the rapid pace of development, established *a fait accompli* for local actors (e.g., Senate hearing transcript, Brisbane 27th July 2015: 56–62; Manning 2012: 69–70). In this sense, Beck and Wehling (2012: 40, original emphasis) note:

> the notion of intentional non-knowing is not confined to the *explicit* intention of certain actors to refrain from knowing something, but includes as well those cases in which non-knowing, though not deliberately manufactured, may be causally attributed to the actions and omissions of persons or groups. Yet, it is obviously always contestable whether actors could in fact have known more in certain situations if they had only been more interested.

Instances of incomplete scientific research can thus become regarded as cases of inadequate science with varying ascriptions of culpability and responsibility.

For other actors, inadequacies of existing scientific arrangements further emerge from the actual manner of research. A recurring theme was perceptions of wrong testing practices and the use of

arbitrary guidelines to interpret results (cf. Checker 2007; Stilgoe 2005, 2007). For example, some interlocutors were suspicious or convinced that industry and also government professionals deliberately took air or water samples during favourable conditions — *'when the wind is right'* — or at less affected locations to receive lower readings:

> They wait until everything is shut down, turned off. Then they come and do their testing. … Once they've done their testing and are gone, they turn it all back up again.
> [Concerned male landholder with nearby infrastructure, community meeting April 2015]

> They did all this testing, and they tested the water in the weir. And the places where they tested the water were as far away from the outlet of the RO [reverse osmosis, i.e. CSG water treatment] plant as you could possibly get. Why didn't they do one there at the RO plant? I don't know why. Just fails to be transparent. … Tell me the science behind that.
> [Opposing female landholder with nearby development, interview May 2015]

In addition to perceptions of wrong scientific testing procedures, others interlocutors further criticised the interpretation of test results:

> In children the risks of exposure to even low-level toxins is not well understood. Occupational health standards cannot be applied to children. So, what can be considered acceptable for an 80 kilogram worker exposed to a single toxin over an eight-hour day cannot be extrapolated to an unborn infant or a child exposed 24 hours a day to a mixture of toxins, many of which are unidentified.
> [Opposing female urban-based medical practitioner, Senate hearing transcript, Brisbane 27th July 2015: 57]

> The guidelines of their [government department] basis of what's OK to be in the atmosphere is just — they've taken the best of whatever guideline they could find that made the result OK. And I've got results that show the results they've got are not OK and their guideline is the incorrect guideline.
> [Concerned female landholder with nearby infrastructure, privately-organised gas field tour April 2015]

I thus came across a number of responses that questioned the appropriateness and arbitrariness of threshold guidelines regarding, for instance, risks from chemical exposure or air pollution.

For these interlocutors, the underlying scientific basis of regulatory guidelines itself rather than the industry's compliance with them is at stake (see Chapter 6.2.). Stilgoe (2007) made similar observations in the context of the mobile phone risk controversy in the UK. As he notes (*ibid.*: 50–51):

> concerned public were not looking for reassurance that mobile phones and base stations complied with guidelines. They were asking questions about the continued adequacy of these guidelines … . And these uncertainties were given no representation in the numerical standards that emerged from the process of review, meta-analysis and risk assessment.

This finding generally relates to the potential problems arising from a predominance of ontologies of detachment and the ontological insecurities experienced by some actors (see Chapters 4.4. & 6.2.). Important for this sections, however, is that the adequacy of scientific research itself was an issue of concern for some interlocutors.

These usually overlapping perceptions of both wrong testing procedures and arbitrary interpretations of their results were certainly most apparent with critical and opposing interlocutors who voice mistrust of the conduct of company and government officials. While it is difficult to determine whether their apparent suspicions were a result of their attitudes towards the industry or *vice versa*, I found that such views of wrong science were often diverse, ranging from reinforced mistrust early on to shifting initial trust following perceived misconduct. However, other actors gained increasing confidence in improving scientific research (see Chapter 6.3.). One can thus observe a multitude of attitudes towards the appropriateness of scientific research across the wider public of the Western Downs and that views can change significantly over time. Public concerns are then indeed "multidimensional, subject to change and difficult to nail down" (Stilgoe 2007: 55). Nonetheless, much of these aspects around CSG-specific uncertainties related to concerns over inadequate or insufficient scientific research. While these different aspects need to be addressed in detail, I propose that such concerns can generally be interpreted through the lens of wrong science.

Such concerns were not exclusively an issue for local residents and members of the wider public. Albeit usually in different form and focus, I also encountered responses regarding inadequate scientific procedures from 'within' the scientific community, particularly with reference to groundwater-related impacts (see Chapter 5.2.). One ramification of these debates worth highlighting is that some professionals in hydrogeology and other relevant disciplines have consequently noted the contingent and potentially problematic nature of groundwater impact assessments. In their views, research outcomes that are based on insufficient data or flawed assumptions can, broadly speaking, result in wrong science:

> Assessments of this nature … often include lengthy 'desktop' studies of the hydrogeology of a region, but the scale may be inappropriate (too large or too small) and they typically do not include adequate resources and time to install new groundwater monitoring wells and other infrastructure, so that baseline conditions can be comprehensively documented. This is vital so that any modelling predictions … can be conducted with a high level of confidence. Numerous examples of problems in predicting impacts due to inadequate monitoring data can be seen in cases referred to the Independent Expert Scientific Committee.
> [University-based male environmental engineer, Senate report, 30th September 2015: 37]

> We will test whether we think the proponent's assumptions they have made, for example, are valid and robust. … Whether we think the data that they have used is sufficient or adequate.

> … In many cases, the answer to that question has been no, that the data is inadequate, the assumptions the proponent has used are inadequate and the conceptualisation is wrong.
> [Chair IESC, Senate hearing transcript, Brisbane 27th July 2015: 37]

> [So] 'too much of what has been dressed up as research is actually little more than guess work. Claims are made that things are safe or that things are very low risk but often that is based on assumption. That is not based on good field data and long-term monitoring of existing coal seam gas projects.'
> [Male Chair of Senate Enquiry, Senate hearing transcript, Dalby 17th February 2016: 45–46]

In these accounts, perceptions of wrong science do concern the very process of scientific research and its institutional arrangements. Whether justified or not, such challenges are often also brought forward from within the scientific community itself — criticism of the sciences "formulated as science" (Stehr & Grundmann 2012: 39), with most non-specialised actors unable to fully assess conflicting claims.

To be sure, I would suggest that such disagreements are a fundamental part of the scientific project and are also a result of the 'disunity of science'. The key insight, however, is that debates over scientific knowledge claims in the context of CSG developments cannot simply be understood as parts of a lay public advocating 'anti-science' counter-claims as opposed to experts' 'pro-science' claims (cf. Wynne 1995). Rather, what is at stake is a "problematization of science itself" (*ibid.*: 387) that involves negotiations over what is considered proper science. These negotiations include debates on whether resulting uncertainties or unknowns could and should be avoided. In this regard, the intentionality of not knowing becomes important if some actors feel that potentially 'uncomfortable' scientific research remains undone (see Chapter 2.1.2).

I will address the wider implications of these findings in section 7.4., but must here note that merely conducting more studies does not guarantee a resolution to the problems of knowing caused by CSG developments if these are regarded as inadequate. This further substantiates the argument that '(just) more won't do' (see Chapter 5.4.) and highlights that scientific knowledge claims must become accepted as the outcome of right science if they are to potentially settle risk controversies. We will attend to the issue of right science below, but first consider potential reasons why some interlocutors regarded particular scientific research as inadequate.

7.2. No Data, No Problem: Guardians of the Technological Zone

Having reflected on what may constitute CSG-specific wrong science, I can focus on the actual arrangements that enable and restrict scientific research and that thereby lay the ground for the 'substructures of ambivalence'. My analysis involves three interconnected questions: who can and does conduct research around CSG developments; what is (not) tested and to what extent; and who

has access to the results of this research? To do so, it is helpful to revisit the spatial metaphor and conceptual lens of CSG emerging within access restricted scientific knowledge spaces (see Chapter 4.3.). To reiterate, in a wider reading of Barry's (2001, 2006) notion of technological zones, I considered how these are epistemic spaces "to which only certain people have access and in which space and time are marked differently" and that thus create a "distinction from the surrounding landscape" (Willow & Wylie 2014: 228). In this sense, the sciences created "a space with restricted access", which explains how a "form of knowledge that is the most open in principle has become the most closed in practice" (Shapin & Schaffer 2011: 336 & 343). This section follows these perspectives and examines who has access to these spaces, can determine its internal arrangements and controls its outputs.

To address the first of these questions, it is worth recalling the elusive ontological status of CSG and the resulting epistemic challenges concerning the detectability of potential impacts. This status makes scientific research and representations indispensable for knowing CSG. At this stage, it is important to further ask who is able to conduct such research; that is, has access to these restricted knowledge spaces. One key finding from my research is that CSG's minimal materiality, its underground remoteness, and the complexity of environmental processes around CSG extraction significantly limit the number of actors who are able to conduct comprehensive CSG-specific research. In regards to complex environmental risks, such as groundwater-related impacts, this actor group is usually limited to a small number of specialised scientists in industry, government and universities. This has led to concerns even from within the scientific groundwater studies community that *"there's just not enough people to do this job properly for all of these sites"* (former industry-based senior male hydrologist, interview April 2015; cf. Chapter 6.1.). One dilemma is consequently that access into the technological zone is restricted due to its dependency on technical expertise and associated capitals. At the same time, the capacity of the small number of specialised actors who have such access is, of course, limited. Put simply, research is crucial but can only be conducted by a group with limited capacity, which makes is necessary to ask who these actors are and what they research.

Following this insight, I encountered a number of responses that scrutinised who is conducting CSG-specific scientific research. Some interlocutors were especially critical of an imbalance between experts employed by the industry and government departments, respectively (see Chapter 6.1.). In their views, this imbalance frequently forces public servants to pass on any concerns and complaints to the tenement-holding company, which is then required to conduct or commission relevant testing and research. Unsurprisingly, the issue of unequal capacities for investigation and research has also caused uncomfortable power inequalities and suspicion for some actors:

> When is our government going to stop asking the perpetrator to investigate their own incident which they wouldn't have heard of if we didn't complain? And they actually investigate the incident themselves.
> [Concerned female landholder with proposed nearby development, Interview May 2015]

> It's not just a blind mistrust. The mistrust is because we've seen it over and over again where: here's my complaint … and I'm giving it to [names government departments]. They take it and … go to bloody [company name] and say 'Here's this complaint'. So, they hand it over and [company name] write their report, hand it back to them and then they take it back to the landowner saying 'There's the report, everything is fine'. This is why landholders do not trust the government departments or companies … . Self-regulation, self-reporting - it doesn't work.
> [Opposing female town resident, interview 2015]

These accounts illustrate how not merely the presence or absence of scientific research but their adequacy can be at stake in CSG risk debates. One crucial aspect, is the question of who has access to restricted scientific knowledge spaces and who conducts and reviews this research. In other words, knowledge claims — as interested activities — are situated and assessed against the identity of those bringing them forward (cf. Chapter 2.1.1.).

At the same time, it is also important to consider not just who conducts research but what is researched. I already discussed undone science in the preceding section. Even if research is conducted, however, decisions still need to be made about what is tested or monitored. A university-based hydrogeologist and petroleum engineer, for example, stressed that asking a natural scientist to determine whether CSG extraction as a whole is safe is a red herring because potential risks are always context-dependent and, crucially, that it is impossible to just 'monitor everything'. Consequently, he contended that every study or monitoring regime requires exact locations, concrete variables and measurements to consider (informal conversation, June 2015). Setting these parameters is, of course, an active decision-making process and it is important to consider the negotiated and contested character of these agenda setting practices. Two facets to this question emerged from my research.

The first aspect is a recurring theme concerning what is tested or researched. For instance, a number of local interlocutors cited uncertainties or suspicions that existing testing and monitoring regimes may be inadequate since they focus on specific variables while potentially neglecting others. Such uncertainties and suspicions were often based on knowledge of previous instances of unanticipated side effects. This finding is illustrated by two examples. The first excerpt is a discussion between a local grazier and two visiting female landholders from the Darling Downs during a CSG-specific group tour I attended. They discuss whether a nearby feedlot owner utilising untreated produced CSG water to rear cattle is safe. The second examples concerns possible exposure to air pollution:

Attendee 1: What about the heavy metals?

Local Grazier: Well … there's not a lot of testing done on heavy metals. When the DDT [a potentially carcinogenic pesticide; cf. Carson 1962] thing happened they gave a recommendation that you put it into your cattle feed and put it through your cattle to get the DDT out of the system. But what actually happened, the cattle stored the DDT in the fat, so we ate it. We don't know what's going to happen with the heavy metals.

Attendee 1: Are there any studies being done on that?

Local Grazier: No, I don't think so. …

Attendee 2: Is it a case of they don't really want any studies to be done, that they're scared? I'd be scared.

Local Grazier: Well, the gas companies are not going to volunteer for that.
[Privately-organised gas field tour, April 2015]

We need to know where and what they are testing, because no one knows. It comes down to the same thing: they need to prove to me that it's safe. And until they do that testing, they can't.
[Female landholder with nearby infrastructure, interview June 2015]

These accounts demonstrate how CSG is generally made sense of through the entanglements of existing knowledge, awareness of previous unanticipated consequences and suspected unknowns. This similarly applies to understandings of its risks (Auyero & Swistun 2008).

Such experiences do, of course, often predate CSG developments and also differ between farmers, graziers, or town residents. The point to highlight, though, is that in light of the impossibility to test all known variables, let alone those unknown, what becomes the focus of research agendas is one aspect of CSG risk debates. This is important since technology and risk regulation, such as for hydraulic fracturing, is based on the maxim of 'what gets measured, gets managed' (Liroff *et al*. 2016: 3). In this sense, monitoring data and testing results are actively constructed and negotiated, which makes some scholars argue that the idea of 'raw data' is an oxymoron (Gitelman 2013; Walford 2017).

These findings can, once again, not merely be attributed to a lay–expert divide or anti- and pro-science attitudes. Instead, I also encountered similar debates throughout the work with scientists and industry professionals. While their concerns tended to be focused on specific aspects of CSG developments, they likewise highlight that, even if an increasing amount of research is conducted, what variables and facets are considered is by no means unanimously accepted (cf. Yearley 2005: xiv). In this regard, one can find perspectives similar to those critical of the restrictive assumptions and possible confirmation biases in groundwater modelling (see Chapter 5.2.):

Most of the impacts are around water levels, in some respects that is a bit easier to deal with. … Water quality on the other hand is a lot more complex. … Because decreasing water level

> is in a sense a direct measurement. … Chemistry may actually be a warning indicator. … It's really the water chemistry where it starts getting odd. … It's not too complicated, I think it's more … arrogance in a way. The companies say: 'Why are you bothering us again with that? We told you that doesn't matter. … We know that doesn't matter'. And then you go: 'Where is the evidence?'. 'Oh no, that is commercial-in-confidence, we just know'. So that is stupid, I'm going to keep asking the question.
> [University-based female hydrologist, interview May 2015]

While such biases and potentially ignored research are often not deliberate and the consequence of excusable 'unknown unknowns', a number of interlocutors were more critical about the level of intentionality in some instances. A male environmental management consultant recalled:

> I actually took it up with the industry, [name of industry body], and prepared an issues paper to try and get a bit more science around that. It got to the point where it got shut down effectively from the wider industry group, saying we'd rather not know effectively, that was it.
> [Interview April 2015]

These accounts illustrate that what is tested and researched is an essential element of the negotiations over right and wrong science.

A second facet of this aspect of the debate is how much or where testing and research occurs. Fitting examples are arguments over the appropriate extent of groundwater monitoring. As fundamentally the case for most scientific research, "*[i]f you're into groundwater, there can never be enough monitoring*" (government-based male hydrogeologist, CSG-specific community workshop June 2015). However, the actual level of monitoring is often contingent on questions of technical and economic feasibility and, crucially, negotiations over 'when is enough enough'. As already noted, some actors are increasingly satisfied with the amounts of monitoring and research while others still consider these to be insufficient. The adequacy of the extent of monitoring efforts is then yet another layer within the substructures of ambivalence surrounding CSG-specific sciences. As a male OGIA-based senior hydrogeologist noted:

> The submissions that we received last time [for the updated UWIR] were largely around companies saying 'there is too much monitoring … . It's more than you need, it's going to cost us an arm and a leg'. And people in the bush saying 'it's all about monitoring, they need more monitoring' … . So, somewhere in there is a balance. But even people in the bush … didn't really know whether you need more monitoring. It's just more monitoring is going to make us feel safer than if there is less monitoring.
> [Interview April 2015]

In addressing the second facet around the focus and extent of scientific research, it is important to appreciate that the arrangements and conduct of scientific practices — that is, the internal operation

of the technological zone — are also subject to ongoing negotiation and potential contestation by a variety of actors.

The third element concerns the output of CSG-specific scientific research. I argued that without this research some impacts may remain undetected and unknown; or 'no data, no impact' (see Chapter 5.3.). Especially those suspicious or critical of the industry questioned who controls the release of monitoring results and testing data. Similar to the veil of secrecy theme, a number of interlocutors therefore repeatedly referred to cynical phrases such as '*no data, no problem*' to explain why perceived impacts were not investigated or acknowledged. To be sure, local actors generally did not demand actual raw data, which would certainly be of little use to the majority. However, many interlocutors appeared to be aware of the importance of access to this data for the conduct of scientific research. Furthermore, for some actors — even outside government, industry or universities — these results and data can be useful, as these actors might be qualified or able to consult and mobilise relevant expertise (see Chapter 6.3.). Control over monitoring data and testing results was therefore a recurring theme during my fieldwork. The opinion of a local grazier and CSG-specific NGO representative about proposed changes to the Queensland Water Act illustrates this insight:

> Those [monitoring] bores will become the ownership of the gas company … and they will own the data. It's supposed to be public data. … They were put down by [company name] as water monitoring bores as required under the Act. But under the amendments, they will own those bores, and they will own the data.
> [Grazier and CSG-specific NGO representative, gas field tour April 2015]

Restricted access to data, for instance related to companies' groundwater monitoring, has thus been an ongoing concern for a number of actors.

These restrictions may have hindered a more transparent and constructive engagement with the rapidly emerging industry, especially early on. A male regional natural resource manager told me:

> I'm not sure we did a great job early on at getting all of that stuff on the table like we're doing now. … The companies held all that data and they were supposed to provide it to state government and they weren't … . So, I don't think we did a great job at using what we had for whatever reason, whether it was no time, no competence, not intended or not. And we still suffer from that.
> [NGO group meeting to discuss my project, May 2015]

Such constraints were even more criticised by scientists and professionals outside government or the industry who often do have the expertise and means to process and scrutinise raw data and monitoring results. A recurring response during my research with actors from these backgrounds was therefore a sense of frustration and reliance on industry and also government gatekeepers who control or, to maintain the spatial metaphor, guard crucial data and results:

> One of the key problems … is that getting hold of a lot of the really detailed groundwater data and information that exists both within companies and within government is very, very difficult. … It seems to be, according to locals, that the groundwater levels are declining faster than was predicted. But, again, to validate that statement would require a lot more science, and the data is just not public … . So, I am left trusting the people that tell me that information.
> [University-based male environmental engineer, Senate hearing transcript, Dalby 17th February 2016: 41]

> The companies hold an enormous amount of data that is not publicly available at all. A bunch of it they don't even give to the government. … By law they have to give a certain amount of data to OGIA, to use in revising the models and estimates … . And the companies are taking water quality samples, levels, doing all sorts of tests for their own commodity and also trying to understand their risks and nobody has that data. Well, the companies hold that data and keep that data and they will not release it. We have got a [research] project now … . So, we had one meeting and everybody is like … 'great' - including companies, government, university. Everybody is 'let's go'. Then a bit of time passed and they go … 'we think it's a good idea but we're not giving you the data'. So we had to negotiate. … Some of it was commercial-in-confidence, which in my view was rubbish.
> [University-based female hydrologist, interview May 2015]

These responses illustrate how restricted access to data constituted a significant obstacle for a number of interlocutors and may cause some scientific research to remain limited or even undone (Lafleur & Sandiford 2017: 3). This similarly applies to the social sciences (Espig & de Rijke 2016b).

These findings once again raise the question about the level of intentionality of those restrictions. While some opposing interlocutors were suspicious or even convinced that companies deliberately withheld data that might indicate environmental or health impacts, others noted companies' general risk aversion as well as meticulous quality assurance and quality control procedures. I also encountered references to the CSG industry's challenging rapid development or companies' internal compartmentalisations as explanations for such shortcomings. Similar to the organised irresponsibility theme (see Chapter 6.2.), assigning culpability for a potential institutional failure of dealing with data and 'information overload' (Weinberger 2011: 5–13) may thus be difficult:

> Part of the reason it's not organised within the companies is it's such a massive amount of data. They can't keep control of it. They could have been really smart from the beginning, gone 'we'll give you our data', they could have completely swamped the government. The government would still be trying to figure out what to do with the data. … Even within a company, different groups have different data sets. … I'm not convinced anyone knows all the data they have somewhere. … It's extremely messy. … It's sort of funny: the scientists just sit there and go 'we don't have enough data' and in effect they have got too much.
> [University-based female hydrologist, interview May 2015]

A senior public servant with 20 years of industry experience likewise noted the problems related to data (mis) management, a potential lack of government coordination, and real-time data sharing. Following his perspective, the perceived guarding of data and monitoring results might also be the consequence of more fundamental systematic issues that affect industry and government professionals just as much as external researchers and the wider public:

> Queensland [Government] has several terabytes of geoscientific data acquired over the last 50 years with a replacement value of around 40 billion dollars … . It's very clear that there are significant issues around data availability, data quality and then the ease with which companies can integrate that data … . Under the current management and regulation of geoscientific data … each proponent, in order to progress their project, will have to go out and drill their own wells, test them, build ponds and produce for several months in order to characterise gas performance and production. So, reforms that are being considered are to streamline that … . The industry is, by my experience, wonderful at acquiring data, but pretty poor at keeping and maintaining it.
> [Conference presentation, November 2015]

To what degree particular research arrangements and their limitations are deliberately created is therefore no simple question. Restricted access to data and resulting limited or undone science can, in this sense, certainly be the outcome of intentional gatekeeping by either individual professionals or as a result of company policies and government departments' procedures. Alternatively, restrictions might also systematically emerge from unintentional institutional shortcomings that, albeit in different ways, affect most actor groups.

By bringing all three interrelated elements considered in this section together, it is possible to grasp how access to data or testing results may influence who conducts CSG-specific research and what might be the focus and extent of this research. To be sure, this applies to all scientific research to some extent and I do not intend to dismiss the value of CSG-specific research. Instead, through the conceptual metaphor of access-restricted technological zones, I aim to demonstrate how scientific knowledge claims are not merely given epistemic objects but emerge within actively arranged and maintained epistemic spaces (see Chapter 2.3.2.). In this sense, scientific practices are simultaneously made possible and become constrained within these spaces.

Crucial for my analysis is the insight that the constructed character of scientific practices makes them malleable and opens the possibility of alternative arrangements. As a result, notions of acceptable scientific knowledge production and adequate research can be subject to ongoing negotiation. In other words, those arrangements are changeable and may require justification. Wynne (1996b: 44) therefore emphasises that "the quality of its [science's] institutional forms - the organisation, control, and social relations - is not just an optional embellishment of science in public life, but an essential subject of critical social and cultural evaluation". This is particularly apparent in instances where some actors — non-experts and scientific specialists alike — begin to question

the arrangements of the scientific status quo. For those actors and others, this can created further ambivalence towards the status of scientific knowledge in the context of complex problems of knowing, such as those emerging from CSG developments. Investigating the underlying dimensions of this ambivalence — its substructures — provides important insights for the overall analysis of what 'getting the science right' entails. I discuss what, correspondingly, may be perceived as right science in the next section.

7.3. Asking the Right Question: Research Politics and the Quest for Independence

This chapter so far attended to interlocutors' perceptions of wrong science and explored the substructures of the ambivalent status of scientific knowledge claims. I discussed why '(just) more won't do' if research practices are considered inadequate (cf. Chapter 5.4.). In this section, I examine what may be regarded as CSG-specific right science, how it can be put into practice, and who might be considered suitable to conduct scientific research. To do so, it is necessary to move beyond the existing arrangements of technological zones and discuss wider research politics and the quest for scientific independence.

Resonating with the three questions addressed in the previous section, a recurring theme during my research has been the importance of the right questions being asked by the appropriate person at the right time. For instance, a critical female landholder remarked during our discussion about the safety of specific chemicals that may be present in treated CSG water:

> And that is the other thing, getting the science right. … How come these questions are never dealt with?
> [Interview May 2015]

Without the right questions being asked in advance or as CSG projects progress, some interlocutors thus feared that scientific research will be constantly behind and impacts may not be detected in time:

> It won't be discovery, it'll be reaction. That's really worrying. Why did that happen?
> [Male agricultural sciences consultant and farmer, interview March 2015]

> Non-compliance won't occur because one of their monitoring stations lights up, it will be because fish are dying, or the cattle won't drink the water out of the river.
> [Male grazier and CSG-specific regional NGO representative, gas field tour April 2015]

One concern for a number of actors is therefore not necessarily the quantity of scientific research(ers) or a lack of suitable equipment and procedures but an inability or unwillingness to ask necessary, critical questions.

Surely, CSG developments have created a large impetus and investment for research and some areas of scientific research have consequently expanded significantly. This also brought onto the scene professionals and researchers who may have otherwise not engaged with CSG and related environmental aspects. In this regard, CSG projects were a catalyst for some undone science to be addressed and for improving research practices. For instance, a government-based senior hydrogeologist repeatedly stressed at a CSG-specific community groundwater workshop I attended how the CSG industry's procedures are "*better than any government has ever taken water samples and monitored. … That is stuff [testing] we've never done in the past, but that's best practice; so they're doing it*". These standards are not just found in company staff's practices but also the equipment and financial means at their disposal. Referring to a number of projected photos, he thus also explained: *"that's a [company] sampling truck, which is better than anything we've ever seen in our lives. … This bore [company's stainless steel monitoring bore] is better than anything the department has ever produced"* (June 2015). The emerging industry has then clearly sparked a significant growth in scientific research and standards.[86]

However, such growth in research activities has not necessarily settled risk debates. On the one hand, this is possibly due to diverging interpretations and the subsequent policy recommendations drawn from research. A retired farmers and long-standing conservation NGO representative explained this to me during a group meeting. He stated:

> They have done some absolutely fantastic environmental research. … Now, our beef is not the EIS, it's the decision that makes it the finish of the EIS. But you look at what some of these scientists have done … . It's all there in the EIS if you want to read it. And, it's all cost us nothing, the community nothing. But that doesn't mean to say we like the EIS. Some of them are brilliantly written but, 'due to all the above circumstances we think it would be quite all right if gas [developments progressed]'. One sentence at the end — No [disagreement with interpretation of EIS and its recommendations].
> [Privately-organised gas field tour, April 2015]

In this sense, it might be not the research itself but the interpretation of its outcomes that is contested. This is unsurprising as, for example, Sarewitz (2004: 389) notes in relation to climate modelling, "[f]acts can be assembled to support entirely different interpretations of what is going on, and … how to address what is going on". Any interpretation and assessment of risks are thus inevitably biased (Douglas & Wildavsky 1982: 67–82).

On the other hand, the controversy remains for some actors due to research not addressing crucial aspects associated with CSG developments. A number of interlocutors therefore stressed the need to focus on the right research questions in the first place. Of course, in cases of unknown unknowns or closed ignorance, potential impacts might be inconceivable and can, consequently, not

[86] This also applies to social scientific research, with this thesis a case in point.

become the focus of scientific research. Those interlocutors' concerns, however, emerged from a suspicion, awareness, or partial knowledge of potential unknowns; that is, from what I conceptually described as the 'middle ground' of suspected, guessed or feared non-knowledge (see Chapter 2.1.2.). During our interview in May 2015, a university-based female hydrologist implies such concerns by referring to hydrogeological complexities that are not sufficiently studied:

> The companies have the people in place for the monitoring, they do a pretty good job with that. … They sample the way I would, so 'Ok you guys are good'. The straight data analysis, there is enough people. What there is not is people who have that broader overview and start looking at some of the complexities. That would be, to me, the role of the universities rather than straight government or the companies.

In attending to this middle ground between knowledge and ignorance, one can see that some actors within CSG debates remain sceptical about the focus and scope of scientific research. This might affect whether scientific findings are considered robust and credible. In this sense, Stilgoe (2005: 61) emphasises that the "credibility of public science is tested by the questions that are asked of it, often by non-experts". Hence, in cases where some actors doubt that right questions are being addressed, it is unlikely that more scientific research will be convincing, even if they regard it as properly conducted.

Addressing complex scientific questions, especially when there are recognised vested interests involved, does then not merely depend on aware or willing scientists but becomes an issue of wider research agendas 'allowing' particular inquiries. After all, critical research could indeed uncover unanticipated consequences or prompt the questioning of held certainties. Conversely, it may just as well validate existing studies. Similar to the discussion on complexity reduction in groundwater modelling (see Chapter 5.2.), crucial underlying, often tacitly answered, questions therefore need to be considered. On a micro-level, these questions concern, for example, appropriate levels of complexity and the inclusion or neglect of particular parameters. More fundamentally, thought, scientists need to also negotiate the level of 'blue sky research' in their investigations. Difference can emerge between what Jasanoff (1998) calls 'regulatory science', which follows stricter research foci and is intended to be immediately applicable, and more fundamental 'research science' (Epstein 1996: 35–38). Such clear-cut distinctions between 'applied' and 'basic' research are, of course, problematic and scientists can occupy diverse roles in relation to political decision-making processes (Pielke Jr. 2007).[87] Important for my analysis is that these aspects influence research agendas and determine to what extent research is open to unexpected findings and surprises (cf. Chapter 2.1.2).

[87] Cf. debates over the status of supposedly 'pure' academic and 'profane' applied anthropological research in Australia (Trigger 2011; Responses to David Trigger 2012).

As such, scientific research does not follow a linear progression over time, nor is it independent from the broader social conditions of its production (Jasanoff 2011; Pielke Jr. 2007). Rather, such practices are fluid, precarious and context-dependent. One crucial element of asking the right questions is thus the political dimension of scientific research:

> Often the research gets caught up in a political process … . That's the only research going because the political agenda [is:] get another report that says the same thing and once they get to a certain height on the desk, people will be convinced. So, you have to keep asking the same question and keep doing the same research. … The problem with the current research is that they aren't asking any new questions. … People are realistic and pragmatic. They are probably not doing the research they want to do, they are just doing the research that research decision makers are open to. … Being able to ask questions in a constructive way in a highly politicised environment is a very challenging thing to do. … Certainly, research is part of it, there is always going to be questions that need to be answered. … But I do think that the quality of the questions needs to get better. … The assessment about the quality of the question can be very subjective depending on who you are.
> [Male regional natural resource manager, interview April 2015]

> If you had the time for the science to dictate the rate the world developed, you would do it differently, grow it more slowly. … But it's just not the way the world works.
> [Male government-based senior hydrogeologist, interview April 2015]

By focusing on the social conditions of scientific knowledge production, it is possible to observe the entanglements of scientific and political processes.

For scientific researchers and professionals, these entanglements can constitute significant obstacles. For instance, a group of NGO and government-based regional natural resource management professionals highlighted during our meeting in May 2015 the continuity and time required for adequate groundwater research and monitoring. Yet, they stressed the vulnerability of such projects to shifting political and social contexts, which often requires navigating changing governmental research agendas. In regard to their CSG-specific groundwater monitoring work and an important community engagement project (see Chapter 8.3.), they noted:

Male 1: The big risk is that in two years' time, a change of government. … You lose a whole lot when you lose momentum with the community and you lose continuity of data. …

Male 2: The last thing you want is some clever [expletive] coming along with a new methodology to gather data halfway through this sort of thing and go 'let's do something else'. And then you do that for a couple of years and go 'so what's happened over ten years?' Well, we actually can't compare this data to that data, so we don't know. …

Male 3: One thing we're doing to try and make sure this keeps going is building infrastructure that the government has to then maintain.

Addressing the issue of appropriate questions is thus again complex and involves various interrelated factors. Those actors at the fore of CSG-related science appear to be aware of the resulting ambiguous and contingent character of their research and that it is not merely about 'asking the right questions'. Instead, research must also navigate existing research agendas in attempts to conduct the best possible research that is permitted within the given social and political contexts, time constraints and funding limitations.[88] It is therefore important to examine in detail who gets to set the parameters around particular research projects, how they do so and why. This must be done for every individual context and field of research, which is beyond the present scope.

Important for this analysis is that a number of critical 'public' actors are aware of these possible restrictions. Some interlocutors subsequently wondered whether existing research agendas and political circumstances allow for difficult questions to be asked. In doing so, they questioned what I described as the intentionality of non-knowledge. One male grazier, for instance, sarcastically stated that government and industry scientists avoid dealing with difficult issue by simply putting them in the *"too hard basket"* (interview May 2015). His and other interlocutors' accounts further demonstrate how unknowns and ignorance can become a 'present absence' within debates over CSG developments (see Chapter 2.1.2.):

> Might be poisoning a few people along the way, but, hey, we're getting our money. There is not the political will to ask the difficult questions. … So there is massive problems if we keep on going the way we are and there are massive problems if we actually ask the difficult questions. Because if we ask the difficult questions and get some answers that aren't very good … . Can they afford that?
> [Regional male town resident and church minister, interview May 2015]

> How do you get the [expletive] science right? ... What science? There is clearly no science involved in this. Because if there were, that wouldn't be happening. … [Interviewer: Is it a lack of political will?] Oh yeah. What would they do if they looked into it? What could possibly be their response?
> [Opposing female landholder with proposed nearby CSG developments, interview May 2015]

As found in Chapter 6.2., for some interlocutors this awareness has created a dilemma wherein suspicions or partial knowledge of unknowns exists without the (scientific) means to address them; indeed a "hapless position of realising that one's knowledge is limited, but of having no way of knowing just how limited it is" (Ingold 2000: 212). Based on these uncertainties, it is unsurprising that critical actors are often unsure what might be the 'right questions':

> I wrote and asked what standard did they test the water to … . I didn't know what to ask but I was trying. … I got back a reply that said it was all fine.
> [Regional male town resident and church minister, interview May 2015]

[88] Shackley and Wynne (1996: 287) therefore emphasise that "strengthening the authority of science … in turn reinforces a particular policy order". In this sense, Jasanoff (2012: 15–17) rightly asserts that the production of knowledge is the reproduction of politics.

> They didn't disclose any of those risks to him [a neighbouring farmer]; so he didn't even know to ask for those risks.
> [Opposing female landholder with proposed nearby CSG developments, interview May 2015]

These accounts illustrate that some interlocutors in non-scientific roles questioned whether CSG-specific scientific research was adequate and addressed crucial aspects of CSG developments. Within the epistemic middle ground of suspicions and uncertainties, however, their perspectives frequently remain ambivalent about how exactly scientific research could or should be improved.

Following these insights, it is important to note that the issue of right science relates to a large number of interrelated aspects once research practices are considered within the wider context within which they emerge. A central aspect of the ambivalence surrounding scientific knowledge claims is therefore the underlying politics of research and agenda setting. Addressing debates over right and wrong science may consequently begin with consensus building, or at least the creation of discursive spaces for the constructive expression of disagreement. In this respect, a male state politician remarked:

> We don't have a clear agenda about how we manage this stuff. … I don't know who sets that, under what framework, and we would probably never agree. But … somewhere some mature, robust debate should identify what this does. … If there is a consequence we need to test what that consequence is. … We need to start with a scope, the body of the testing needs to be done, we need to challenge that testing, we need to be objective and we need to end up with a summary review. … I wouldn't care who funded it, as long as we agree, all sides of the divide, and of the social spectrum, agree on the framework. … That's the problem: if you don't set the framework and methodology on what we are looking for. I can go on Google and find two reports to say two different things in a heartbeat.
> [Interview April 2015]

The view that questions of adequate scientific research need to be collectively negotiated was also shared among a number of scientific researchers and professional. For instance, a former industry-based senior male hydrologist recalled:

> So there was a groundwater managers group - … all the groundwater managers from the five CSG companies and from some of the major coal companies. … They were all involved in discussions about the science: what those parameters should be and what made sense and what didn't make sense. That was the sanity check on it. … There are people who would distrust that, because they were all industry people. But I know most of them, and they were all committed scientists; they weren't industry people. They were looking at it from a groundwater perspective not from an industry perspective.
> [Interview April 2015]

Both accounts illustrate how some interlocutors regarded a critical process of consultation and, if possible, consensus building as a central element of addressing CSG-specific environmental

concerns. This, of course, raises further questions of who is and should be included into consultation processes (see Chapter 8.3.).

Related to this is another crucial element of 'getting the science right': the perception of scientific research not being subject to vested interests. A recurring theme throughout my research therefore revolved around the demand and search for uncompromised science. I encountered this 'quest for independence' across a large variety of actors. Many critical interlocutors, for instance, disapproved of the perceived proximity between government and industry actors. They thought that this compromised adequate assessments and emphasised the need for independent representation (also Chapter 7.1.):

> There's no government or independent person that you can go to.
> [Female former landholder with CSG infrastructure, interview March 2015]

> I'll be honest, everything these days depends on funding. … People aren't trusting and I don't blame them.
> [University-based female hydrologist, interview May 2015]

> An ombudsmen, yeah. You should be able to get someone who is away from it.
> [Concerned female landholder, privately-organised gas field tour April 2015]

Other interlocutors believed that some independence exists, for example, through the work of 'outside' consultants or designated government units that arbitrate in debates over CSG-related groundwater impacts:

> That is my role, I'm independent, I facilitate. You talk with rather than to [landholders], it takes the power out of the situation.
> [Male agricultural sciences consultant and cotton farmer, interview March 2015]

> We're independent. We have nothing vested in choosing a particular course of action or results. We just want to call what we see, because there is no ramifications or implications for us.
> [Male public servant in CSG-specific unit, interview April 2015]

These accounts highlight the identity politics between scientific researchers, actors who communicate scientific knowledge claims in industry or governmental roles, and members of the 'public' are a crucial element of the CSG controversy.

This important link between social identities and the public engagement with science has, of course, been stressed by Science and Technology Studies scholar for more than two decades, perhaps most notably in Wynne's work (e.g., 1995, 1996a, 1996b; Irwin & Wynne 1996). Particularly insightful is Rifkin's (1994; Rifkin & Martin 1997) analysis of the social identity of experts and the ongoing negotiation of their participation status. Makki (2015) also applied a social identity perspective more generally to investigate the CSG controversy in the Western Downs. He

argues that conflicting identities are a root cause of different community responses to CSG developments.

The insight my analysis can add to this existing scholarship concerns the role of perceived independence in how some actors determine what constitutes 'proper' science. I already considered, for example, the role of OGIA and how some interlocutors have become increasingly confident with the levels of research and improving accuracy of modelled drawdown predictions (see Chapter 6.3.). At the same time, I cited an OGIA senior hydrologist who noted that they *"don't give pathways into the [groundwater] model"* and *"don't anticipate that people and local community will run the model"* (interview 2015; see Chapter 4.3.). Throughout my research, I therefore came to appreciate that much of those interlocutors' growing confidence is not primarily based on them having directly scrutinised groundwater models or other scientific research in great detail; after all, access to the CSG-specific technological zones is restricted. Rather, their views of improving 'right science' are often intertwined with a growing trust in the integrity and perceived independence of key scientific actors or organisations (cf. Buys *et al.* 2014; on trust see Chapter 8.3.–4.).

Unsurprisingly, other organisations and groups, too, attempted to create this sense of independence. For example, the Australian Government set up the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) in 2012, with the aim to assess groundwater-related impacts *"through an independent and transparent process that builds confidence in the science used in decision making"* (IESC 2017b). Similarly, the Gas Industry Social and Environmental Research Alliance (GISERA) was formed in 2011 as a collaboration between the CSIRO, the Australian Government and state governments, and a number of CSG companies. On their website, GISERA stresses its *"independence, integrity and transparency"* in a designated Research Independence section (GISERA 2017). However, the role of GISERA has been problematised by some interlocutors and other observers due to its reliance on industry funding (Grudnoff 2016). University-based researchers have also reflexively questioned their role within Queensland's CSG developments, particularly concerning university-industry partnerships (Hardie *et al.* 2016). The issue of scientific research bodies' independence therefore remains ambiguous.

As a result, a number of interlocutors were critical of some research organisations while being more confident with others. Particularly OGIA's ongoing research was noted positively at numerous occasions. It appears that direct interpersonal contact established during, for instance, groundwater workshops and seminars OGIA held or at least attended in the region are an important factor in this regard (see Chapter 8.3.):

> Whatever you think about OGIA … . Yes, they are technically under the government umbrella, but I do trust the integrity of some of the people that are involved in OGIA. … I

> have confidence in their independence and their professional integrity. The other condition that we insisted on, that there would be an expert of our choosing involved. So, we had confidence in [name] independence. … It is hard to find a hydrologist or hydro-analyst who is not compromised by other work for resource companies. It's almost impossible to find somebody that is totally objective and independent in this space.
> [Male cotton farmer and regional irrigation NGO representative, interview May 2015]

> If I was to rate someone as the most trustworthy, I think OGIA is doing a pretty good job of being as independent as possible. … And then their work is coming up with the same sort of conclusions as what the CSG companies are coming up with. And as long as you've got confidence in OGIA, well, then you can have increasing confidence.
> [Male policy manager of agricultural industries peak body, interview May 2015]

The perceived independence and trustworthiness of research organisations and researchers are thus central aspects of complex environmental controversies within which a variety of actors can often remain ambivalent towards the status and appropriateness of scientific research.

These findings indicate that notions of appropriate, trustworthy science are, at least partly, based on perceptions of 'right' scientific research. I elaborated on some, yet certainly not all, factors that influence actors' perspectives in this regard. First, I discussed that, for some interlocutors, not merely more scientific research it needed, but that research must address the right questions. However, what is regarded as the appropriate focus areas of scientific enquiries differs. Some interlocutors' concerns also remained vague as they emerge from uncertainties or suspicions rather than clearly defined unknowns. Second, I demonstrated that the perceived independence of experts and researchers is another essential aspect of the negotiation of right and wrong science. Yet again, who or what institutions are considered independent varied between interlocutors and over time.

In concluding this and the above sections, it is important to emphasise that actors' perceptions of the status of scientific knowledge can differ and frequently remain ambivalent, depending on whether research is regarded as appropriate (cf. Stilgoe 2007: 54–55). I therefore agree with what Wynne (1995: 375) describes as a "commitment to avoiding a priori assumptions about what 'proper' science is". Instead, it is crucial to investigate what practices involved actors perceive, contest, and promote as appropriate. I propose that these insights can be summarised through the conceptual lens of a politics of (im)purity.

7.4. Conclusion: Science as Situated Practices and the Politics of (Im)Purity

This chapter began from the finding that the ambivalent status of CSG-specific scientific knowledge claims is not merely the consequence of conflicting pro- and anti-science sentiments. Instead, these result from more complex negotiations over the adequacy of scientific research. With

this in mind, I outlined the resulting substructures of ambivalence and addressed a number of aspects that may determine what is regarded as wrong and right science. *Prima facie*, this analysis arrived at a contradiction. On the one hand, it has become apparent that many actors are aware of the conditions of scientific research. Their accounts indicate that the sciences are indeed best understood "in terms of their situated material and discursive *practices*" (Wehling 2006b: 81, original emphasis). As knowing generally, scientific knowledge claims are then indeed a practical performative act by epistemic agents who are positioned in social contexts, materials places and particular times. These claims are thus situated, interested activities that are influenced by values, agendas, and limitations (see Chapter 2.1.1.). It is therefore crucial to follow a 'relational focus' (Irwin & Wynne 1996: 7; cf. Ingold 2016: 8; Marks 2009: 279) and view scientific practices within the social contexts of their production and also subsequent uptake in society.

On the other hand, much of the sciences' authority rests on the boundary-work around the root metaphor of the modern settlement. Particularly important is the enforced separation of nature and society, and knowing from being, through practices of translation and purification (see Chapter 2.3.1.). This root metaphor is based on what Charlesworth *et al.* (1989) describe as the myths of 'objectivity', 'the impersonal scientist' and 'pure science'. Within these myths (*ibid.*: 98–101):

> there is a sharp distinction between the domain of science, which is morally and politically neutral or 'value free', and the domain of moral and social values. In itself science is neither good nor bad, save insofar as knowing the truth about the world is good. … The myth of 'pure science' is closely linked with another myth about the 'objectivity' and 'disinterestedness' of science. … 'Pure science' is uncontaminated by the personal and subjective. … Scientific knowledge is then separated off from the person who knows. Knowledge is, as it were, disembodied or depersonalized.

In appealing to right and independent science, many actors certainly advocate — whether consciously or not — such a disinterested perspective where the 'facts speak for themselves'. These are attempts to keep politics out of science that are based on "the old myth that we can separate science from politics, and then ensure that the science is somehow untainted by the 'impurities' of the rest of society" (Pielke Jr. 2007: 149; also Ingold 2016; Jasanoff 2012; cf. Chapter 8.1.).

Rather than regarding these findings as a contradiction though, one may interpret them as the result of political negotiations over 'pure' and right science as opposed to 'polluted' and wrong science (Espig & de Rijke 2016a: 87–89). Inspired by the work of anthropologist Douglas (2002 [1966]), I employ the ideal type notions of purity and pollution somewhat differently with reference to the myths of the scientific root metaphor. My aim is to contrast interpretations of apolitical, acontextual, and objective science with science that is, allegedly, somehow tainted by vested interests and agendas, emotions, or subjective opinions (cf. Trigger 2011; Responses to David Trigger 2012). In this sense, Epstein (1996) demonstrates in the context of the politics of purity

around AIDS research that scientific 'cleanliness' is a powerful political device for the determination of legitimate science. That is, "[g]ood science, like God, patriotism, and the flag, are rhetorical devices designed to be impossible to argue against - devices often used in the absence of a good case on the merits" (James in Epstein 1996: 256). As found in sections 7.1.–2., within CSG debates the legitimacy of scientific research and testing can indeed become tainted by highlighting the social conditions of its production, or lack thereof. This is even more apparent when some actors — who often have their own strong interests — perceive conflicts of interest or the proximity between industry, government and university-based actors:

> We had [company] and [government department] turn up in the same vehicle to go and inspect that [leaking] vent.
> [Concerned female landholder with proposed nearby CSG developments, group meeting April 2015]

> You have to have the water results done at a lab that isn't compromised.
> [Concerned female town resident, community meeting on property near CSG infrastructure April 2015]

> They [government] are taking advice from the fox that wants into the henhouse.
> [Female Darling Downs landholder visiting the Western Downs, privately-organised gas field tour April 2015]

Perceptions of improper research and critiques of scientific conduct are thus certainly linked to ideas of apolitical, impersonal, and objective science.

However, by understanding science as situated practices, such claims to impurity can essentially be made for all scientific research. Instead, I propose that various actors frequently employ strategies of 'partial impurifications' (see Chapter 8.1.). While working with opposing interlocutors, for instance, I found that tainting proponents' science functioned as a strategy to delegitimise these scientific knowledge claims. However, this does not appear to affect perceptions of the root metaphor of scientific objectivity. Following the quest for independence, pure and right science can still be achieved by disinterested scientific research:

> They [industry] bought off scientists and all kinds of people so they could go ahead and say 'there's nothing wrong with it', but more and more independent scientists are coming out and calling them out.
> [Opposing activist and former Australian Greens politician, *Frackman* film screening July 2015]

> They [local water testing company] make their livings from these guys [industry]. You got to get somebody who's away from here. That's why all the blood tests that were done … were send to a lab in [neighbouring state]. They raced down there within the timeframe so that it was completely independent.
> [Female Southern Queensland landholder visiting the Western Downs, privately-organised gas field tour April 2015]

Conversely, proponents sometimes similarly delegitimise ascriptions of wrong science as tainted by emotion and activist interests; while, of course, likewise stressing their adherence to objective science (see Chapter 5.1.):

> But if they [professional activists] are serious about the country's future, they need to listen to the country's leading scientists and not the increasingly hysterical chatter on social media that tries to pass itself off as informed debate.
> [Male QRC Chief Executive, industry conference opening speech November 2015]

> When is science best ignored? When it doesn't fit with your dogma, it would seem. Activist groups have steered well clear of a visit by a group of highly regarded international experts on unconventional gas.
> [Energy Resource Information Centre, newsletter 9 October 2015]

I elaborate on these findings in the next chapter. Important here is that such partial impurifications of scientific knowledge claims are an important aspect of the politics emerging from CSG risk debates. Some actors might strategically critique particular scientific practices or findings while promoting others as 'proper' to support particular agendas or values. This implies that "science and technology are not only epistemic and material but also normative processes" (Jasanoff 2012: 16). In debating the production and utilisation of science, actors therefore "necessarily also reflect on and reaffirm particular conceptions of political order" (*ibid.*).[89] This entanglement of science and politics can further contribute to perceptions of an uncertain and ambivalent status of science. Wynne (1996b: 45) cautions that such ambivalence is not intellectual feebleness that is antithetical to (scientific) rationality, but "it may be a necessary corollary of a social commitment to disavowing control of others". Actors' partial impurification of the entanglements between science and politics might then be regular rather than exceptional social phenomena.

Unsurprisingly, such entanglements can constitute challenges for scientific researchers and also public policy makers. Many of my interlocutors from these actor groups seemed to be aware of the various factors that create the substructures of ambivalence and frequently emphasised a need for a nuanced understanding of the merits and limits of scientific research. Yet, I also encountered resistance to the pressures of political contestations over appropriate science through attempts to remain detached from particular vested interests:

> The committee does not take a position. Our role is to provide advice to the regulators on the basis of the best scientific information we have available.
> [Male chair IESC, Senate hearing transcript, Brisbane 27th July 2015: 31]

[89] Ingold (2014b) argues that the different ways of knowing environments we discussed in Chapter 4 are epistemologically not of a fundamentally different kind and can be brought together. The reasons this often does not happen are "not philosophical, they are political and they lie in the overwhelmingly greater power of the neoliberal state and corporate industry to enlist institutionalised science in the pursuit of global interests" (*ibid.*).

> We are agenda-free. We have an agenda around good science for whatever issue we're talking about. … I guess the other thing, too, is that we live in a society where we keep thinking about ultimate truth. This concept is flawed.
> [Male regional natural resource manager, interview April 2015]

As these accounts illustrate, regulatory agencies and research bodies are often "eager not to be construed as doing 'politics'" (Silgoe 2007: 55). However, scientific researchers are increasingly caught up between rising demands for 'evidence-based' policies and simultaneously growing challenges to justify the adequacy of their research (Reddy & Syme 2014). Rather than being independent bystanders, environmental scientists and regulators are instead frequently in the very midst of risk controversies. Particularly in research areas that are increasingly complex and uncertain, such as hydrogeology (*ibid.*; Loch *et al.* 2014; see Chapter 5), questions of scientific adequacy, independence and legitimate authority become central elements of environmental controversies.

Following these insights, there is thus a strong incentive to defend or challenge the ability to determine what can be demarcated as right science. Much of this appropriation rests on the ability to maintain the 'myth of objectivity' and also to taint, and thereby delegitimising, conflicting knowledge claims or suspicions. Within such political conflicts over the (im)purity of scientific knowledge, "what is at stake is in fact the power to impose the definition of science" (Bourdieu 1975: 23). In this sense, attempting to demarcate certain areas of debate as apolitical questions of science can, instead, create new arenas of political debates (Barry 2001: 197–215; Stilgoe 2007). The question of right science therefore inevitably involves political dimensions that need to be considered.[90]

So while I have argued throughout this chapter that not science *per se* is contested, it is here necessary to somewhat qualify this argument. That is, if the primary element that makes science special is the power to impose and maintain the definition of science through successful boundary-work that demarcates science and non-science (see Chapter 2.3.1.), then indeed science itself is contested in debates over the adequacy of CSG-specific scientific research. Questions around the appropriateness of scientific, if not all, knowledge claims are thus also questions of social and political power. As Marks (2009: 279) notes, "knowledge is power, science is both". Especially within risk debates where scientific knowledge claims are frequently contested, it is thus crucial to attend to what Beck (2005: 593) termed the 'relations of definition'. These social relations are decidedly political. It is therefore important to consider the politics of (non)knowledge more generally when addressing the question of what 'getting the science right' might entail.

[90] Shortly before submitting this thesis, I discovered that Duschinsky (2013) similarly suggests the notion of 'politics of purity' in a somewhat comparable argument.

8. Getting it Right: The Politics of the (Un)Known and the Limits of Science

> *In risk conflicts, the central question of power is indeed a question of definition. … The question of determining who is responsible, and who has to bear the burden of paying for damages, has been transmuted into a battle over the rules of evidence and the laws of responsibility.*
>
> *(Beck in Yates 2001: 100)*

> *We don't find environmental people invited to the business dinners … . It's not a question of science, it's a question of power.*
>
> *(Male former senior public servant, Queensland State Government, Interview July 2015)*

The preceding chapter examined the sciences themselves as a site of contestation and I argued that CSG-specific epistemic debates over proper science cannot be understood as resulting from anti- and pro-science perspectives. My analysis considered the substructures of ambivalence that underlie such debates and concluded that these can be conceptually analysed as politics of (im)purity. By that, I indicated the importance of the politics involved in the, more or less tacit, negotiations over the definition of appropriate science. The concluding section foreshadowed the social 'relations of definition' involved in the boundary-work and demarcation of the sciences. This chapter addresses more thoroughly the underlying political dimensions involved in these definitional processes — or what Beck (2009: 24–46) coined 'relations of domination'. I particularly attend to the broader political context of knowledge and ignorance claims, and demonstrate that risk debates carried out, at least partially, through a contestation and defense of science are also a (re)negotiation of existing social relations. Debating the science of CSG can thus become a proxy for wider social and political negotiation. 'Getting right' problems of knowing therefore goes beyond mere scientific aspects but also requires social resolutions.

To develop this argument I, firstly, consider the utilisation of scientific knowledge claims to mask — deliberately or not — what essentially social and political questions are. The purpose of such cryptonormative practices is primarily to socially position and (de)legitimise actors as knowledgeable and ignorant. The debate about who gets to participate leads, secondly, to the interconnected question of the onus of proof within conflicting knowledge claims and the underlying politics of evidence. I investigate diverging interpretations of existing scientific research and the potential of leaving some science undone as a way to mask certain aspects of the debate. The third section consequently addresses (un)invited participation that may challenge the existing arrangements of scientific research and the relationship between engagement and trust. Employing the empirical example of a citizen science groundwater monitoring program, I highlight the

importance of transparency and involvement to create trust. The chapter concludes with a discussion of CSG risk debates as a form of social commentary. This prompts me to reflect on the limitations of scientific knowledge claims and their inseparability from moral and political thought.

8.1. But I'm not a Protester: Cryptonormative Claims and Social Positioning

One recurring finding from my research has been various interlocutors emphasising that they just respond to and advocate (scientific) facts. At the same time, they noted that conflicting knowledge claims are based on emotions or vested interests. Such claims are often explicitly articulated as 'science over emotion' narratives by, for instance, proponents and supporting advocacy groups (see Chapters 5.1. & 7.4.; Espig & de Rijke 2016a: 86–87). I encountered similar tendencies with some local interlocutors and certainly opposing actors. For them, uncomfortable scientific findings were intentionally ignored due to economic interests or untrustworthy and wrong science forming the basis of industry and government decisions. To be sure, such conflicting scientific knowledge claims are certainly part of most research areas. In Chapter 5.3., for instance, I discussed how good scientific practices often generate an 'excess of objectivity' that can lead to 'contradictory certainties' (Sarewitz 2004; cf. Everingham *et al.* 2014: 125–126). These contradictions can, however, be masked when actors, consciously or not, discredit conflicting claims as unscientific while simultaneously claiming to adhere to scientific facts themselves. I analyse this process through Habermas's (1987) notion of cryptonormative claims. In such contexts, one can observe the relations of definition and politics around the demarcation of science at play. Let me develop this argument in more detail.

Chapter 5.1. already noted some actors' perspectives that the 'science is in' and that the CSG controversy is largely due to a lack of public understanding of the proper science. Opposition or uncertainties about the industry's risks and impacts are then frequently critiqued as 'unscientific' and due to political interests or irrational emotions:

> My experience generally is that it [hydraulic fracturing bans and moratoria in some Australian states] is more about the politics than it is about the science.[91]
> [Male APPEA representative, Senate hearing transcript, Canberra 28th July 2015: 53]

> It's sad to see that with any health or environmental implications there's always going to be some people who will deny the evidence of research. … As a person of science and evidence … I find it frustrating, but I have to accept it, especially in our role as politicians.
> [Male State politician, CSG science briefing November 2015]

[91] At the time of finishing this thesis, Western Australia became the fifth of Australia's eight mainland states and territories to impose a moratorium on onshore hydraulic fracturing. One state, Victoria, had banned 'fracking' altogether (Reuters 5th September 2017).

Interestingly, a similar counter-narrative can be found with some actors who oppose the industry or hold concerns about potential impacts. Throughout the work with those interlocutors, I often encountered responses that the appropriate science is ignored in decision-making processes. For them, valid claims are more or less deliberately disregarded as they may conflict with economic interests or political agendas:

> The science doesn't matter. That's the bottom line. The science doesn't matter, it's the greed and the pursuit of greed that is the problem.
> [Female landholder concerned about proposed nearby CSG developments, interview May 2015]

> If reason and science prevailed, we had a proper green industry.
> [Male former Greens politician and representative of anti-CSG NGO, Gas Field Free Community Declaration event May 2015]

> Despite the best attempts of the Queensland government to avoid any science based approach to the ongoing reports of ill health in Queensland's gas fields, the international science is now coming in, and it is my assertion that no longer can claimed ignorance of human health harms be a defence for legislators.
> [Opposing urban-based female medical practitioner, Senate hearing transcript, Brisbane 27th July 2015: 56]

These accounts contain narratives and counter-narratives that both portray existing scientific knowledge as being ignored due to, for example, a lack of public understanding or, conversely, vested economic interests.

In light of such contradictory assertions about the status of the sciences concerning impacts and risks of CSG developments, it is unsurprising that making particular knowledge claims is often accompanied by discrediting claims of actors with conflicting views. This often involves morally laden ascriptions of ignorance (see Chapter 2.1.2.). Opposing or concerned actors usually do so in two ways. Ignorance can, firstly, be ascribed on the level of scientific knowledge claims themselves:

> These [CSG] companies have so little understanding of the science. They ask these [subcontracting] companies for what they were looking for. They asked the company to tell them.
> [Opposing female Darling Downs landholder, CSG-specific community meeting April 2015]

Such ascriptions are somewhat problematic and limited though, since any "claim that charges ignorance must have access to the alternative … and thus make a claim of improved reference and reliability" (Alcoff 2007: 54). Bringing forward defendable ascriptions of scientific ignorance thus also entails (tacit) claims to having 'better' scientific knowledge. However, access to the means and outputs of scientific research is often restricted and only partially or not at all available to many

non-scientific actors (see Chapter 7). I therefore found that especially local actors ascribed ignorance not only 'through science'.

Some local interlocutors, secondly, noted how proponents and government staffers disregard the values of local knowledge and violate a locally taken-for-granted common sense.[92] Closely tied to the importance of 'being there' and experiencing CSG (see Chapter 4.2.), interlocutors thus frequently highlighted a 'city–bush divide' wherein urban-based CSG company employees, departmental officers and also scientists are ignorant of the idiosyncrasies of the local landscape or land uses (cf. Askland *et al.*: 93–105). I recorded numerous instances where interlocutors used sarcasm or humour in reference to avoidable and all too obvious cases of company employees' illogical and unfathomable behaviour. Much of this local knowledge and common sense rationality is based on the everyday interactions with country and the embodied skills and knowledge that spring from the long resource histories of the Western Downs (see Chapter 3). A few examples illustrate this theme:

> And these people that come out … they haven't got a bloody clue. … They're supposed to have done environmental impact studies. And they don't know that. So, you think: 'Well, we're getting it wrong from the top, so what hope is there when they're not understanding simple geography?' … They got too much formal education and not enough common sense, and not enough experience out on the ground.
> [Opposing female town resident, interview May 2015]

> We've got some pretty smart cookies in our team that have been 5th, 6th and even up to 7th generation land holders in Australia. They knew what they were talking about. They knew how to manage country. … You can't manage country on ideology. … You've got to have practicality.
> [Male farmer and conservation NGO representative, CSG-specific community meeting April 2015]

> To say with a high level of confidence that they're not having any impact on the aquifer, it just defies belief. … Everyone knows it's not true. …. So, we were already over-utilising the supply of water as it was. … And they say: 'Well, it won't have an impact'. It defies logic.
> [Male farmer and former CSG-specific NGO representative, interview April 2015]

> They know nothing about stock. And they come and want a - what do they call it - workable relationship. … You can't work the land from a book - you can't learn from a book how to do it. It's bred in you, it's brought up in you.
> [Concerned male grazier with nearby coal mining CSG infrastructure, interview May 2015]

These accounts illustrate the importance of local knowledge and its underlying common sense rationality. Unsurprisingly, non-local industry staff and government employees do often not

[92] I here refer to Geertz's (1983) notion of common sense of a cultural system. Following this perspective, "the really important facts of life lie scattered openly along its surface, not cunningly secreted in its depths. … Some of the crucial properties of the world are not regarded as concealed beneath a mask of deceptive appearances, things inferred from pale suggestions or riddled out of equivocal signs. … Indeed, its tone is even anti-expert, if not anti-intellectual" (*ibid.*: 89 & 91).

communicate their knowledge claims in such local terms. This can have implications for the status of their knowledge claims. Cohen's (1993: 33, original emphasis) argument is insightful (also de Rijke 2012 & Chapter 4.4.):

> Expert outsiders are almost bound to be wrong, not because they are technically deficient, but because extraneous expertise is insensitive to the modalities of local knowledge. … For locals, the disputation with experts may not call into question the *substance* of their knowledge, but its appropriateness. The sense of a discrete local knowledge does not deny that outsiders could know '*what* we know' but, rather, that they could know '*as* we know'.

In addition to what is (claimed to be) known, it is therefore also important to consider how something is known. Outside actors can, in this sense, always be regarded as ignorant and their knowledge claims can get dismissed as inappropriate.

At the same time, scientific ways of knowing and scientific expertise are already part of the 'local' knowledge of many residents within the intensively managed, manufactured landscapes of the Western Downs (see Chapter 3.1.2.). Locals' knowledge is therefore not necessarily distinct from those of outsider experts, with especially farmers and graziers often holding specialised knowledges and considerable expertise in, for example, soil or agricultural sciences. Notions of a 'city–bush divide' or the importance of 'being there' are thus not merely a dichotomy between outsider experts' scientific knowledge and local knowledge, which is frequently synonymised with 'lay' understandings. Instead, those notions refer to the appropriateness of specific scientific knowledge claims for the given circumstances within particular localities.

With these insights in mind, one may ask why particularly scientific knowledge claims and ascriptions of ignorance have gained a central role in the CSG controversy. Somewhat unsurprisingly, I found that especially those with comparably easier access to and control of the outputs of scientific research employed narratives of scientific ignorance to discredit and delegitimise conflicting views. Within those views, resistance to CSG developments, for instance, can get framed by supporters as unscientific and associated with politically motivated minority groups that are usually described as activists, protesters, or greenies. Allegedly, these actors are either misinformed or deliberately disinformed. Decision-making thus ought to follow instead the *'inconvenient truth of scientific consensus'* (see Chapter 5.1.). This illustrates another aspect of the entanglements of science and politics.

These insights highlight how the CSG controversy has become somewhat 'scientised'. Sarewitz (2004: 385) proposes this notion to describe a narrowing of societal debates into questions of science, which is based on the "old-fashioned idea that scientific facts build the appropriate foundation for knowing how to act in the world". This is certainly inevitable to some degree due to the indispensability of the sciences for knowing CSG. However, this underlying tendency has been

subsequently increased, especially by supporters but also opponents mobilising scientific expertise to simultaneously justify their own and invalidate contradictory claims. Consequently, I found that many actors who claimed to adhere to scientific knowledge frequently also situated others' claims as (un)intentionally unscientific and thereby ignorant. They often did so without acknowledging the ambivalent and inconclusive status of the sciences. Following the discussion on pure science (see Chapter 7.4.), I argue that this 'scientisation' can insightfully be analysed as attempts to establish a polarisation between science and politics. In this sense, one's own claims are discursively depoliticised and naturalised while conflicting claims are portrayed as politically motivated to appear less valid. To conceptualise this argument, I propose the notion of a cryptonormative (de)politicisation of knowledge claims. These practices *inter alia* function to socially position epistemic agents in the CSG risk debate.

I develop this argument through Habermas's critique of Foucault's cryptonormativism (1987: 265–293; cf. Kolodny 1996) to grasp the processes by which actors mask normative motives as claims to merely be following the scientific facts. Such cryptonormative masking implicitly rests on the root metaphor of the purity of science. As Nelkin (1995: 453) notes, the "authority of scientific expertise has rested on assumptions about scientific neutrality. The interpretations and predictions of scientists are judged to be rational and immune from political manipulation … . Thus scientists are enlisted by all sides of disputes".[93] The value of masking and thereby depoliticising one's own motives lies in the appropriation of this authority and subsequent decision-making power. Conversely, the simultaneous politicisation of conflicting views as being those of *'politically and fundraiser-motivated activists'* denies such authority to others. This conceptualisation allows us to understand how "technical expertise becomes a resource, exploited by all parties to justify competing moral and political claims" (Nelkin 1995: 453). These processes are crucial for understanding important aspects of the CSG risk controversy.

However, the findings presented over the last chapters demonstrate that notions of risk and science are not an independently given criterion but the result of relational processes of definition, especially in complex environmental controversies. Adding to this insight now the political dimensions of scientific authority, one can appreciate why Beck (2009: 24–46) consequently regards "relations of definition as relations of domination". Szerszynski (1999: 240) elaborates on Beck's conceptualisation (cf. Chapter 4):

[93] Pielke Jr. (2007: 144–145) develops a similar argument: "The advocate looks to science to provide a compelling justification for why his or her preferred policy position ought to be adopted rather than an opponent's position. … [S]cience provides a vast pool of knowledge from which information and data can be carefully cherry-picked to support a predetermined view. The advocate's opponent thinks along the exact same lines, and also looks to invoke science in support of his or her preferred policy position. Why science? The linear model of science brings with it an air of impartiality and of being 'above the fray.' Ironically, the use of science in such advocacy works to undercut any claims of impartiality. Like the politician, the advocates each look to science to resolve debate; so long as the resolution is in line with the answers they already have in hand".

> Because of their relatively inaccessibility to the senses, late modern risks are also highly mediated risks, extremely open to social definition and interpretation. This generates a politics of knowledge in which different social groups continually compete over risk definitions.

Nelkin (1995: 452–454) suggests that such processes are 'tactical considerations', which implies a high degree of intentionality. However, I doubt that actors are always fully aware of the cryptonormative (de)politicisation they attempt when claiming scientific knowledge and ascribing ignorance. Actors might indeed be convinced that 'their science' is right or at least better than others'. In any case, the important point is that within CSG risk debates — albeit in varying forms and degrees — such (de)legitimating claims were made by various interlocutors along the supporting to opposing spectrum. The frequent reference to conflicting views as, for example, unscientific *'myths'* illustrates this finding (e.g., Lloyd-Smith 2012 & ERIC 2014). Debating in this context the situated character and ambiguity of CSG-specific scientific knowledge claims might adversely affect the appeal and authority of 'objective science' (cf. Sarewitz 2004: 398). Instead, many actors attempted to gain the upper hand in defining proper science in order to defend moral standpoints or political agendas.

Drawing out the underlying processes of these relations of definition prompts further enquiry into the potential purposes of such cryptonormative claims. I argue that appealing to the authority of scientific knowledge *inter alia* allows for the social positioning of epistemic agents and the determination of legitimate actors within contentious issues. This argumentation rests on the relationality of knowledge and ignorance wherein "constructions of knowledge may be agentive, in that they indicate who is qualified to know and act, and who is not" (Hobart 1993: 11; see Chapter 2.1.3.). Questions of accepted knowledge and legitimate action are therefore intrinsically connected. Stehr (1999: 54 & 56) elaborates on this link and analyses "knowledge as a stratifying principle … or the extent to which knowledge may be employed as a capacity to acquire social standing". He thus argues that being regarded as knowledgeable "yields social advantages and disadvantages in the form of power and authority … , for example, in the sense of a particular agent's socially recognized capacity to speak and act legitimately" (*ibid.*: 57, original emphasis). I propose that the ability to appropriate scientific knowledge is particularly important within such processes of legitimisation since it allows actors to "cloak normative statements with science as a way of justifying their positions" (Evensen 2015: 515). Put differently, some actors might suggest that they are merely responding to the scientific facts when they advocate certain actions.

Ascribing ignorance can function in a similar way. Dilley (2010: 177) notes that "the character and conditions of ignorance are intimately linked to claims to knowledge: 'ignorance guarantees potential knowledge'". A small number of scholars have thus specifically focused on the 'social function of ignorance' (Moore & Tumin 1949; Uekötter & Lübken 2014: 1–11). For instance,

Moore and Tumin (1949: 788) argue in an early, functionalist account that the "function of ignorance that is most obvious … is its role in preserving social differentials". In another way, ascriptions of ignorance can also serve to uphold traditional normative structures and differential access to knowledge (*ibid*.: 791–792). Taking these aspects of ignorance — however problematic their functionalist undertone, it is possible to read statements such as 'but a few protesters who do not know better' as ascriptions of delegitimising ignorance. Here, ignorance might be regarded as a "function of social positioning" (Dilley 2010: 182) within the negotiation of expertise. Ascriptions of ignorance then constitute one facet of ongoing identity politics. Related to questions of legitimate participation, these identity politics involve negotiations over who has the privilege to speak and to be heard (Rifkin 1994; Rifkin & Martin 1997; cf. Checker 2007: 121; Satterfield 2002). Ascribing ignorance to some actors in the CSG controversy is therefore possibly aimed at decreasing the role of these groups within decision-making processes.

In this sense, opponents to CSG developments are facing similar discreditations as those associated with the 'not in my backyard' (NIMBY) label, which depreciates concerned local people as irrational, ignorant of scientific facts and selfish (Cotton & Devine-Wright 2010: 118; also Askland *et al.* 2016: 62–66).[94] Such social positioning is linked to the abovementioned processes of cryptonormative (de)scientisation. That is, "practices of depoliticization that bound science off as an apolitical space often go hand in hand with the construction of lay publics as scientifically illiterate, and hence unfit to participate fully in governing societies in which scientific knowledge matters" (Jasanoff 2012: 26). Opposition to CSG developments may thus be framed as a public deficit of scientific understandings or politicised as protest groups' *'scaremongering tactics'*. The claims of those actor groups are often portrayed as antiscientific or ignorant by those supporting CSG developments (cf. Wynne 1995: 387–388). However, one must ask critically whether ascribing ignorance in this context "is knowledge denied or denigrated, and its apparent 'growth' is really a growth in the knowing party's power to denigrate other knowledges and to refuse to engage in dialogue with their knowers" (Vitebsky 1993: 114). Let us consider this question with reference to my data.

In response to such discursive associations of protest with ignorance, I frequently encountered a refusal by opposing or critical interlocutors to being classified as protesters or activists. For example, in April 2015 I was invited to attend a community meeting in the Tara Estates[95] for which the flyer stated:

[94] A survey conducted across the Surat Basin indicates that landholder concerns are not limited to impacts on their immediate surroundings. Instead, landholders are also worried about CSG's wider regional impact. NIMBY labels are therefore misleading (AgForce 2017; also Everigham *et al.* 2014: 126).

[95] The Tara Estates consist of small, often non-farming and relatively cheap 'lifestyle blocks' situated on agriculturally poor country. The area has a reputation for attracting lower income groups. I often noted negative comments when discussing the issues arising

> Family Friendly
> This meeting is for anyone and everyone. Everybody's story is different.
> This is not a protest group, just individuals who want answers to what is happening in the area and the impacts this is having on normal people, with ordinary lives.

During the meeting, the organiser emphasised not 'just being a protester' and repeatedly re-affirmed the legitimacy of her concerns about the impacts of nearby CSG extraction. The views of the nearby landholder and mother of two clearly resonated with most of the approximately 30 attendees:

> People are alone out there. They don't know what it is. Because of the stigma, as soon as you say 'I don't like CSG'. I got told I'm a crazy protester. I refused to be a protester. I'm just a mum and a landholder. I'm not a protester, and I don't think anyone here is. … I refuse to protest and I refuse to create protest. Why should I have to? … There's a difference between protesting and protecting.

This group's situation must certainly be put into the context of the Estates. However, I encountered further situations where interlocutors refused activist or protester classifications.

At two separate public Senate hearings, for instance, committee members of the Basin Sustainability Alliance (BSA) gave evidence in support of their submission to a proposed bill. The BSA is an agricultural community group that was formed in early 2010 in response to the emerging CSG industry. It represents some 100 paying members throughout the Western Downs. Those members' accounts also demonstrate a rejection of politicising protester labels and thereby, as we can now infer, delegitimising ascriptions of ignorance:

> Members of the BSA do not see themselves as political activists. We are a not-for-profit group consisting mainly of farmers and graziers who volunteer their time trying to get governments to see what impact their decision making is having on the livelihood, health and wellbeing of rural Queenslanders and to focus debate on the sustainability of the Great Artesian Basin.
> [Male BSA Committee member, Senate hearing transcript, Brisbane 27th July 2015: 15]

> Unfortunately, this whole issue keeps getting political. It is a social issue and it needs to be dealt with on a conscience basis. … It deeply concerns me that this gets so party political, because if you are seen to align anywhere in particular you can be dismissed, or your concerns can be dismissed as belonging to a particular persuasion. I have voted for all parties … . I cannot see that these sorts of issues are not fundamental to everybody.
> [Male BSA Committee member, Senate hearing transcript, Toowoomba 19th August 2014: 9 & 11]

These BSA committee members clearly refuse being classified as protesters. Similarly, another grazier emphasised that his and neighbouring landholders' initial resistance to proposed CSG and also coal projects nearby was legal and legitimate. He noted that:

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there outside the Estates. Also, the main Australia-wide anti-CSG group, the Lock the Gate Alliance, initially formed here. Makki (2015) explores this issue of conflicting social identities and the stigmatisation of the Estates' population in detail.

> We were the watchdogs, we went to the land court, we operated within the law and the mining companies didn't. … We operated within the [Water] Act the whole time, with integrity and honesty. And anyone who calls us anything but responsible citizens, can go … . [Interview April 2015]

Unsurprisingly, many interlocutors thus refused such classifications. Their experiences are not dissimilar to other cases of resistance to resource developments. In an opinion piece, a central Queensland grazier, for instance, described being labelled a "green extremist" following his legal challenges to two proposed coal mines. However, he refused this label and emphasised that "[t]he arguments we made in court were based on scientific evidence and the 'precautionary principle'" (The Courier-Mail 28th October 2016; cf. Chapter 8.2.). Actors who were or still are critical of CSG and other resource developments can thus face discursive challenges to the legitimacy of their concerns by being classified as protesters or activists.

The data from these groups with different social backgrounds indicates that at least parts of the community members who critically responded to CSG around the time of my fieldwork refused to be classified as protesters or as holding particular political agendas. Instead of active protest and civil disobedience, my observation is that much of the critical engagement occurred through 'conforming resistance'; that is, by focusing on (scientific) evidence-making as a means of producing legitimate claims that can influence the decision-making around CSG (see Chapter 8.3.). Being framed as protesters or politically motivated appears to render this approach less legitimate. At the same time, many opposing actors do question the *'dodgy science'* of parties whom they regard as economically motivated. Ascriptions of ignorance can, in this sense, become a "moral weapon for those caught up in conflict" (Dilley 2010: 188).

Important for my analysis is that situating actors through such ascriptions challenges cryptonormative claims to facts and objectivity that may allow for the appropriation of scientific and thus decision-making authority. It is within such dynamic societal negotiations where the "tacit cultural politics of the legitimation of science" (Wynne 1995: 388) can be observed. These negotiations are inseparably linked to the wider identity politics of social positioning and legitimate knowledge claims. In this sense, appeals to scientific knowledge and ascriptions of ignorance are intrinsic aspects of the negotiations over legitimate participation in decision-making processes in the context of CSG developments. However, the ability to mobilise scientific knowledge as the basis of cryptonormative claims is, of course, not equally distributed (see Chapter 7). These unequal relations become apparent around the making and negotiation of legitimate evidence.

8.2. It's Gotta Be Gospel: The Onus of Proof and Politics of Evidence

Following these insights, processes of legitimate evidence-making can be explored as one empirically relevant arena in which underlying political dimensions play out. As shown in Chapter 4, scientific research and representations are indispensable for knowing CSG and its potential risks. It is thus unsurprising that controversies over CSG and the underground are pervaded by scientific knowledge claims and lend themselves to becoming scientised. I therefore already highlighted findings concerning the importance of making (perceived) impacts *'into something tangible'* and having them realised within the standardised procedures of administrative and legal institutions (see Chapter 4.3.). On the other hand, Chapter 7 highlighted that the ability to mobilise scientific research and knowledge claims is not equally distributed. In interviews and ethnographic work with local and other 'public' actors I consequently often encountered a more or less explicitly discussed disparity between the need and ability to bring forward legitimate evidence.

A recurring theme within my research, especially with interlocutors who were critical of CSG developments, was therefore the question of who has the onus of proof and also what counts as permissible proof:

> The onus is on us. … Shouldn't the onus be on the government to providing that [evidence] and proving that it is [safe]?"
> [Concerned female landholder with nearby CSG developments, interview June 2015]

> [Department name] doesn't care, they got a report on it and that's gospel. … Yeah, whatever they write down, it's got to be gospel. But whatever we say, you got to prove.
> [Male grazier with nearby coal mining and CSG infrastructure, interview April 2015]

Similar to landholders' ability to prove impacts to groundwater over time, these accounts point towards the challenges that some interlocutors face when they attempt to have impacts acknowledged. Often these are impacts that they suspect or believe they already know through direct experience and by proxy. However, the perceived onus of proof is one of scientific proof.

Science in this context, as Satterfield (2002: 87) argues, "becomes the cognitive equivalent of 'putting on a suit' to present one's case to persons in positions of power". My research indicates that this cryptonormative mobilisation of scientific knowledge claims is not always a deliberately chosen strategy, though. Instead, some interlocutors appeared to feel forced to engage with science within a (partially) scientised CSG controversy. A rather desperate open letter by a landholder and mother of two, who became a key interlocutor during my fieldwork, illustrates this finding:

> Prove to me that you think it [is] fine for your own flesh and blood.
> Until this is done I will not believe there is no risk, well I know there is a risk, and scientific reports continue to say this, it is only our officials who seemed to have blinkers on the subject. …

> To get the appropriate response … , I am forced to attempt to put together a complex series of information and prove to the highest authorities, the danger of coal seam gas and the total disregard for basic human rights … .
> I have no idea how to write a report, or how to reference information … .
> I am not sure if this is the acceptable way to present this information, but as the onus is being put on me, as an individual to get the appropriate response, I will do the best I can.
> [March 2015]

Despite both experience and projection being important in the sense-making of CSG, these landholders' accounts exemplify how the bureaucratic realisation of perceived impacts appears to be dependent on particular forms of (scientific) knowledge claims that can be articulated within "the global environment of technoscience" (Ingold 2014a: 242; see Chapter 4.4.). More specifically, they emphasise how struggles over who has to prove what are a crucial aspects of CSG-specific risk debates.

Such negotiations provide an insight into the potential political dispositions and social relations that underlie the controversy. A number of interlocutors linked the onus of proof that they felt is placed on landholders and residents to pro-development discourses and forms of technological optimism within various levels of government and industry.[96] The following accounts illustrate this finding:

> There is an attitude of 'technological optimism' among 'can-do' people who populate the industry, a confidence that the engineers and geologists (and markets) will solve whatever disposal or environmental problems arise. It is this, rather than ethical carelessness, that explains why the industry is powering ahead … . However, this optimism is potentially misplaced as it is quite likely that for many fields no solutions that are both financially viable and environmentally benign exist.
> [Former Queensland State public servant, CSG-specific issue paper, Edwards 2006: 67]

> The fact is, they had the law, the government, on their side to do just that, which was offensive. … Now, those days are gone, I will readily admit that … . But in rural communities, people are naturally conservative and defensive when it comes to their core assets [e.g., their property and access to (ground)water] because it makes us who we are and what we do. … You break a trust that isn't easily repaired.
> [Male cotton farmer and CSG-specific NGO representative, interview May 2015]

> Citizens ought not to be expected to summon up the resources to argue against the mining companies because we employ the government to do it. So the government has ceased being an umpire. … The legislation is both a driver of the culture but also an outcome of the culture. … Again, it's becoming pro-market to the exclusion of others.
> [Former Queensland public servant, interview July 2015]

[96] Some interlocutors explained such pro-development attitudes with the rotation of staff from government into industry and *vice versa*. This so-called 'revolving door' phenomenon has received much public criticism regarding conflicts of interest and a 'brain drain' into industry (e.g., Buckingham 2015a & 2015b). On resource extraction and 'the culture of development ideology in Australia' more generally see Trigger (1997).

A number of interlocutors who were critical of the CSG industry thus suggested that there was, at least initially, a tendency among proponents and regulators to tacitly presuppose the appropriateness of the emerging CSG industry, which needed to be disproven.

To be sure, governments are certainly also mandated to provide economical security. CSG developments have, in this regard, likely created direct and associated economic growth and financial benefits for some actors (GasFields Commission Queensland 2017; see Chapter 3.2.2.). However, some local actors and observing researchers have raised concerns about 'growth-first' political economies wherein, for example, environmental issues become delegitimised (Mercer *et al.* 2014). This insight is relevant as such economic rationales and a technological optimism might form the basis of an underlying default positions that needs to be disproven.[97] In turn, this can determine who has the onus of proof. In this sense, Wehling (2006a: 319) argues that in contemporary societies the burden of proof often lies with those actors who question that uncertainties and perceived unknowns are not merely temporal; that is, that more research is going to close knowledge gaps in due course (also Checker 2007: 119–120).

Within these particular political and economic settings, interlocutors from various backgrounds stressed the potentially limited role of scientific research as well as the ambivalence around notions of risk and uncertainty. For example, a public servant in charge of the assessment of one proponent's development application noted how 'green tape reduction legislation' was introduced to speed up the approval process. However, she criticised rushed assessment outcomes. In her opinion, the large number of remaining unknowns, doubts and assumptions should, instead, lead to certain risks being automatically classified in the highest category (informal conversation February 2016). Many interlocutors were then ambivalent about the question of what needed to be (dis)proven and by whom.

Diverging interpretations of existing evidence and prescriptive views of what further scientific research is necessary thus constitute central aspects of the CSG controversy. These elements are empirically manifested in, for instance, debates over adequate levels of precaution as opposed to the subsequent management of potentially unexpected impacts (cf. Beck & Wehling 2012: 46):

> What do you say, 'Well, we shouldn't have started because we didn't have the data'? State government was never going to do that because they want the royalties. ... Saying 'we need the precautionary principle, we need to see impacts avoided or plans to have them minimised'. ... Most of it not fell on deaf ears but a lot of it was: the Queen Mary at sail — it's moving, it's steamed off.
> [Male regional national resource manager, CSG-specific group meeting May 2015]

[97] Insightful here is a dispute between Australia's federal Commonwealth government and some Australian State governments that emerges at the time of writing. In a rather explicit 'pro-development' move, federal ministers warned States who banned or have moratoria on hydraulic fracturing that their share of the goods and service tax (GST) might be reduced unless hydraulic fracturing is allowed (e.g., The Guardian 29th June 2017).

> We [in Queensland] do not actually have the precautionary principles set out in relation to these activities in law. … The decision maker is perfectly entitled to take into account ESD [ecologically sustainable development], but that has to be weighed up against … , for example, economic factors. … The fact that ESD is not implemented under that legislation is the most keenly felt in relation to mining and CSG development.
> The precautionary principle should be applied in state legislation relating to mining … and … actions should not be proceeding if there is uncertainty as to their scientific impacts.
> [Environmental lawyers, Senate hearing transcript, Brisbane 27th July 2015: 6 & 7]

These accounts illustrate some actors' concerns over an erroneous interpretation of available evidence and insufficient precaution taken regarding risks from CSG projects.

Reference to the precautionary principle being (un)intentionally ignored or not fully satisfied was a frequent theme, particularly with those critical or uncertain about CSG developments. Conversely, I already considered the accounts of those regarding the science as 'in' and the precautionary principle thus satisfied (see Chapter 5.1.). Merely demanding more precaution does therefore not provide an indication of exactly when sufficient understandings are gained or 'enough' research has been conducted. As a female university-based hydrologist emphasised, determining these levels is not only subject to scientific but also political and economic considerations:

> We could be researching 50 years from now and then go: 'Oh wait a minute, there will be an impact'. … And it will be nothing like what we expected'. But holding an industry up for that long, … it's a different decision. For me, that's not an environmental decision, that's an economic decision.
> [Interview May2015]

Debates concerning the precautionary principle in the context of unconventional gas developments is consequently one arena wherein the wider politics of evidence and (scientific) knowledge and ignorance play out discursively (Fleming & Reins 2016; Stephan 2017). In this sense, precaution is a political rather than merely scientific principle. Evensen (2015: 518 & 519) therefore notes in a study of unconventional shale gas developments in the U.S. that (also Douglas & Wildavsky 1982: 21–28):

> Unless a principled and non-arbitrary threshold is established for the level of knowledge needed to promulgate regulation, calls for additional data collection are weakly justified. … [A]ppeals to the precautionary principle … represent a common cryptonormative claim in scientific research … . These appeals are problematic due to being offered as scientific rather than normative conclusions.

Following this insight, it can be problematic to 'scientise' and thereby mask what are essentially political and moral disputes over appropriate evidence and acceptable degrees of remaining uncertainties.

Yet, I found that the politics of evidence within the CSG controversy are often negotiated 'covertly' and cryptonormatively. This finding becomes obvious within the debate over whether existing scientific research is interpreted as evidence for the absence of environmental and health impacts or as insufficient; that is, an absence of evidence (cf. Stilgoe 2005: 61–63). In the context of potential health risks related to CSG extraction, for instance, Werner *et al.* (2015: 1127) remark that while a clear link cannot be drawn, "there is also no evidence to rule out such health impacts". This is particularly so since "no epidemiological studies have been conducted on the impacts of CSG on human health, in Australia or elsewhere" (Werner *et al.* 2016: 2). They therefore caution that "absence of evidence does not mean evidence of absence" (Werner *et al.* 2015: 1138; also Claudio *et al.* 2017; Krupnick & Echarte 2017; McCarron & King 2014). This disparity can also be observed during two Senate committee hearings for a proposed bill allowing landholders to refuse CSG developments and banning hydraulic fracturing. At a hearing I attended in Brisbane, two actively opposing members of the public stated:

> We are often accused of making wild … or unsubstantiated claims about the industry. That is very frustrating to us because the amount of information which quite often accompanies, for example, an application from one of these projects is minimal. … There is virtually no substantial evidence to back their claims about water. … A lack of information often gets turned on its head by these companies, so that they say there is no evidence to justify these groups or these communities saying that, for example, there are health impacts. … Whereas … these companies and the governments are not doing sufficient scientific studies to say whether or not these impacts are occurring.
> [Male president of opposing Lock the Gate Alliance, Senate hearing transcript, Brisbane 27th July 2015: 9]

> [Department name] are overriding the health concerns of the people out there. There is no science. The reason that you cannot find data is because the collection of data has been deliberately blocked. … It goes round in circles. They did not find that there was no problem; they found that they needed more studies to define, not whether the companies are compliant or not.
> [Opposing urban-based, female medical practitioner, Senate hearing transcript, Brisbane 27th July 2015: 60]

The views of these two members of the public are clearly that insufficient evidence exist to prove the safety of the CSG industry.

Interestingly, another hearing for the same proposed bill was held in Canberra, Australia's capital, the next day. At the Brisbane hearing it was primarily critical Western Downs landholders and members of other sections of the public who testified and attended. Conversely, the Canberra hearing mainly heard testimonies of federal public servants and representatives of extractive industries peak bodies, including the Policy Manager of the Queensland Resource Council (QRC) who did not attend the Brisbane hearing. The hearings' different social compositions and their

underlying spatial politics are certainly noteworthy in themselves. Important for my analysis, though, is the markedly divergent interpretations and discursive utilisations of notions of proof, which exemplify the CSG-specific politics of evidence. These difference become apparent if the Brisbane and Canberra hearings are counterposed.

During the former, attendees focused on uncertainties, the perceived absence of conclusive scientific evidence, and local experiences proving or suggesting existing impacts. At the latter, those advocating for the industry questioned the representativeness of such 'anecdotal' stories and brought forward contrary evidence:[98]

> The QRC feels there is little evidence to support the need for further landholder legal protection. … There are more than 5,000 agreements in place and only a small handful have required a dispute resolution process.
> [Female QRC representative, Senate hearing transcript, Canberra 28th July 2015: 44]

> We can talk about individual cases that have come forward in - there are not actually very many of them in the submissions. … But I still do not think there is evidence of this as a systemic problem.
> [Female Minerals Council of Australia representative, Senate hearing transcript, Canberra 28th July 2015: 48–49]

> There is ample evidence showing that regional businesses, agriculture and the gas industry can and do co-exist … . Is everybody happy? No. There are individuals who feel aggrieved and will make it known. … But that in and of itself is not evidence that there is a systemic problem across the board.
> [Male APPEA representative, Senate hearing transcript, Canberra 28th July 2015: 50 & 54]

The framing of submissions as individual cases and reference to their accounts as anecdotal stories in these testimonies is insightful. I propose that such rhetoric is aimed to delegitimise concerns and issues raised by opposing actors — whether consciously employed of not. Referring to 'anecdotal evidence' does, in this sense, demarcate the boundary between these knowledge claims and more legitimate, scientific ones. Ascriptions of anecdotal evidence thus affect the epistemic status of conflicting claims. In doing so, such ascriptions have epistemic and political dimensions, including (tacit) contestations of some actors' legitimate participation in debates over risks and uncertainties (Moore & Stilgoe 2009; Stilgoe 2007). It is therefore important to examine how conflicting evidence and scientific uncertainties are interpreted, and what actions these interpretations subsequently justify. Furthermore, different perspectives can affect who is regarded to have the onus of proof and might prompt dissimilar responses to CSG specific problems of knowing.

The final committee report that concluded these particular Senate hearings serves as an example. The committee recommended that the Senate should not pass the proposed bill *inter alia* because it

[98] I can here only consider indicative examples. The interested reader may find the two testimonies of extractive industries representatives at the Canberra hearing insightful (Senate hearing transcript, 28th July 2015: 42–56).

did not *"consider that it was provided with sufficient credible scientific evidence during the inquiry to justify a ban on hydraulic fracturing"* (Final report, September 2015: 52). This interpretation prompted the Australian Greens, whose committee member had proposed the bill, to submit a dissenting report. They argued that *"the scientific work to assess the risks of those projects has not been done"* and the evidence presented during hearings *"ought to ring warning bells"*. In their opinion, the committee consequently *"adopted a deeply flawed interpretation of the precautionary principle"* (*ibid.*: 56 & 57). This Senate report thus provides on explicit example of the politics of evidence, wherein particular interpretations of existing evidence can be utilised to justify specific action.

Such diverging interpretations do usually not acknowledge the ambivalent, precarious and often limited character of scientific findings. Instead, debates over what evidence or 'facts' exist and what arguments they support are often one particular arena for the cryptonormative struggles over CSG developments. In these instances, attempts to appropriate scientific authority constitute attempts to (de)politicise various claims. However, Parkhurst (2017: 6, original emphasis) notes that:

> rather than being *apolitical*, the appeal to evidence, or to particular forms of evidence, can be *decidedly political* by promoting a de facto choice amongst competing values. The politics comes in 'through the back door' by giving political priority to those things which have been measured or those things which are conducive to measuring.

Notions of fact and evidence must therefore be situated within the social contexts of their discursive utilisation. As such, these notions have epistemic and political dimensions (Moore & Stilgoe 2009; Parkhurst 2017). The presented findings support this contention.

However, one must not only consider the interpretation but also the historically and socially situated production of facts and evidence (Poovey 1998; Shapin 1994; Sismondo 2017). In this sense, many critical interlocutors stressed what they felt to be an intentional or systematically created absence of evidence, or ignorance, due to the undone science of CSG (see Chapters 2.1.2. & 7.1.). That such concerns can have substance is shown in a closely related case of uninvestigated instances of 'black lung' disease identified in a small number of Queensland coal miners. A designated parliamentary committee found in March 2017 that research on coal workers' pneumoconiosis has been deliberately underfunded for decades and suggested *"a massive systemic failure across the entirety of the regulatory and health systems intended to protect coal industry workers"* (Interim Report, March 2017: 6). One is here reminded of Beck's (2009: 193) argument about risks being as big as they appear and that, as such, "silence detoxifies". Revealing this ignored exposure and institutional exclusion of uncomfortable knowledge illustrates the political and potentially problematic nature of scientific research and evidence in contemporary risk debates. To be sure, this does not imply that similar circumstances apply to CSG developments. I merely

aim to demonstrate the need to critically examine how notions of fact and evidence are constructed and to what end.

As for scientific research, this means that questions around the interpretation and production of evidence are epistemic as well as political. I thus agree with Parkhurst (2017: 9, original emphasis) that claims to "[e]vidence cannot tell us which is the *right* choice between different arrangements of benefits or which social outcomes should be pursued over others. Such decisions must be made on the basis of some formal consideration of social values". The sciences are undoubtedly important and invaluable in this context, but are themselves constructed to particular ends. In this sense, scientific research surely 'makes visible' certain aspects of CSG and associated risks. However, undone science or underfunded research can conversely also create "situations of invisibilization and accommodation" (Boudia & Jas 2014: 23–24). This means that uncomfortable research might remain limited and that the onus of (scientific) proof is passed onto those with limited means to bring forward legitimate evidence. In doing so, particular social value can be promoted over others, often cryptonormatively, and existing distributions of risks and responsibilities may become legitimised through science. A number of interlocutors therefore felt that *"there is a transfer of risk, or a transfer of responsibility, back to the residents away from the sector"* (male State politician, interview April 2015). Unsurprisingly, some of those actors have responded to the political dimensions of evidence-making by challenging CSG-specific scientific knowledge claims and seeking an active role in the production and interpretation of research and evidence.

8.3. It's Not About the Data: (Un)Invited Participation, Engagement and Trust

The insights from the preceding section show how questioning scientific research and evidence around CSG's risks constitutes an epistemological as well as political challenge. In this sense, one frequent point of contestation among a number of different interlocutors was the insufficient involvement of local actors into the processes of determining risks to groundwater or human health. In attempts to force involvement and recognition, some actors and grassroots groups therefore invested significant funds and work into monitoring potential and existing impacts themselves. In doing so, these interlocutors have challenged not merely the science behind CSG but also the trustworthiness of the institutions and procedures through which certain scientific research is and, maybe more so, is not produced. My conversation with a landholder who opposed nearby CSG developments illustrates this finding. We discussed her private testing of certain air quality parameters and whether it should be up to individual citizens to conduct scientific research. She remarked:

> And that says it all, doesn't it? Why would I, the mother of two, invest $5,000 in a unit to test [this], if the science was right? To find the truth. … The people who are not funded … are doing scientific research that they can't afford to do, answering the questions that these people who are funding it can't, or won't. … Obviously there is something wrong. … And here we are, still blindly pushing forward with this. We've got evidence to the contrary. There is the science. Why is that not being applied here?
> [Interview May 2015]

In responding to these perceived systematic shortcomings around wrong or undone science, a number of interlocutors therefore bought their own testing devices, commissioned third-party testing or consulted specialists who they perceived as independent. For instance, a landholder group with a dozen or so members sent out an email to local, state and federal politicians in July 2015. In this email, the group's most active member complained about what she regarded as inadequate government responses to testing they had conducted. An excerpt from this email is insightful:

> The attached FLIR [Forward Looking Infrared] footage further outrages our community with regard to the deliberate misinformation/lies perpetrated by the government and the industry … . I refer you further to my 7 page letter … requesting specific attention to the problems of exposure and health in our community. Your generic and vague responses are further exposed as wholly inadequate given the attached footage. We have personally enhanced the information in these images by understanding atmospheric testing of wells and infrastructure in the same area. We have measured 109 ppm of Volatile Organic Compounds (VOCs) coming from one HPU [hydraulic power unit] on one Well. This indicates that what is being vented from High Point Vents (HPV) is more than 'just methane'.

This except is followed by specific complaints and detailed technical explanations of, for example, their FLIR footage. While this account demonstrates the close connections of the themes discussed in Chapters 4 to 7, it also specifically highlights how some interlocutors challenged the adequacy of the regulation and management of potential impacts associated with CSG developments. In doing so, these actors are not just passive 'recipients' of uncertainties but seek active participation in the risk debate by having their knowledge claims recognised (cf. Checker 2007; Satterfield 2002: 63–77).

However, such 'uninvited participation' (Wehling 2012; Wynne 2007) in the production of scientific research and risk assessment remained restricted in scope for most interlocutors due to limited access to necessary capitals (see Chapter 6.3.).[99] Many of those interlocutors resisting CSG developments furthermore also felt that even if, what they regarded as legitimate, scientific claims are made, these are ignored by industry and government actors. As a result, one opposing landholder described her feelings of *"disempowerment — to use a fresh new word — it's*

[99] In this sense, the mere access to measuring devices is insufficient for participation without the specific knowledge and skill to operate them and interpret results. An opposing female town resident highlighted this during a CSG-specific community meeting in April 2015: *"You got to have evidence. I don't know how many of you got gas meters or Geiger counters … . You need to have your meters calibrated properly and ticketed people who know how to use these things"*.

disempowerment. Because, what do I do? They [government departments] are not going to listen" (interview, June 2015; cf. Willow 2014). Her account indicates how some actors not just mistrust CSG-specific scientific research but also distrust the institutions that regulate and manage CSG developments (AgForce 2017; Gillespie *et al.* 2016).[100] This distrust cannot simply be resolved through more research:

> There is a real lack of confidence on the information being provided. And I believe concerns could easily be addressed with better and more objective engagement and communication. … Because even if I send out 50 articles in their letterboxes telling them that everything is rosy and everything is great, unless they believe it, it's a waste of time.
> [Male State politician, interview April 2015]

> People obviously have concerns and you need to have those concerns allayed. But … as most people aren't experts in that area, you'd have to be able to trust what you are being told. And you don't know if you are being told a furfy.
> [Male policy manager of agricultural peak body, Interview May 2015]

It is thus important to note that while some actors — particularly non-experts in a given field — might mistrust regulatory and scientific institutions, they are also often unable to fully evaluate, contest or presented scientific research themselves. This is especially so within complex environmental controversies that usually spark a plethora of conflicting claims, which all advocate supposedly valid scientific evidence.

As a result, actors' understanding of risks are often not merely evaluations of available evidence but also influenced by the perceived trustworthiness of those social institutions that produce and enact scientific knowledge claims (cf. Chapter 7.3.). Wynne (1996a: 57, original emphasis) thus argues that "public perceptions of responses to risks are rationally based in judgements of the behaviour and trustworthiness of expert institutions … . That is, the most germane risks are (social) *relational*". Put differently, a critical stance towards the institutions, scientists or procedures bringing forward particular knowledge claims makes sense for critical actors. Public mistrust in these institutions can then be magnified when some actors feel that their claims are denied (Checker 2007: 118). At the same time, an absence of vocal criticism of scientific and expert knowledge claims does not necessarily equate to public trust (Wynne 1996a: 52; Centemeri 2014: 142–145). Getting the science right is therefore not merely a scientific issue where 'just more' solves risk disputes but requires certain levels of trust in scientific and regulatory processes. So how might trust be established under these circumstances?

[100] Perhaps unsurprisingly, then, AgForce (2017) found in their Queensland landholder surveys that trust in the information provided by government and CSG companies remains low. In 2017, landholders generally distrusted (54%) rather than trusted (7%) government information. This similarly applies to CSG companies (35% vs. 15%). Therefore, the main source of trusted information for landholders are other landholders (61.5%), AgForce (54.4%), and legal advisors (41.4%). These survey responses correspond to my own ethnographic findings.

My research indicates that, in the context of complex environmental controversies, perceptions of adequate and right scientific research remain important (see Chapter 7). However, trust in scientific results is ultimately also dependent on other social and political aspects. One of those is the involvement and respectful engagement between the various actor groups within the CSG controversy. During interviews with a large variety of interlocutors, frequent reference was, for instance, made about the importance of talking with, rather than to, local residents and landholders. This includes having 'real' conversations:

> There has got to be that ongoing communication. … You can put a lot of information on a website but that doesn't necessarily mean people will be informed. You can do all the groundwater testing you like, publish the results and make it transparent, but it doesn't mean people are any more informed about the risks to their groundwater, which is what they are worried about.
> [Male regional Natural Resource Management professional, interview April 2015]

> I said, 'If you want to get along in the community, have a BBQ on every weekend or once a month, invite all the locals and tell us what's going on. You may or may not be accepted, depending on what you tell us. If you tell us lies and we find out, you'll be gone'.
> [Male grazier with nearby coal mining and CSG developments, interview May 2015]

Central elements of such ongoing conversations are then, first, direct interpersonal relationships between those industry and government actors who bring forward CSG-specific (scientific) knowledge claims and other members of the public. Interlocutors therefore often noted the importance of companies' land liaison staff and government department officers' personal engagement 'on the ground'. One government hydrogeologist remarked, *'It's not rocket science. Building trust takes time and good personal relationships'*. He was thus concerned about the pace of CSG projects and companies' frequent turnover among engagement staff (CSG research forum, April 2014; cf. Chapter 6.1.–2.). Likewise, even initially critical and opposing interlocutors acknowledged that once they started knowing, for instance, government hydrogeologists personally, they began to trust groundwater models and predicted drawdowns:

> It will be interesting to see if companies finish their community liaison role. I suspect they will. They were really important. Grossly undervalued by the gas companies, but really important.
> [Male former farmer and agricultural sciences consultant, interview March 2015]

> People that criticise it [OGIA] don't know the people involved. He [general manager] is painted with the brush that he is on the government side, so what he says you couldn't trust. I was in that camp at the start … , but until you actually work with these guys you don't know. … I have confidence in their independence and professional integrity.
> [Male cotton farmer and groundwater-specific NGO representative, interview May 2015]

> Because they [local community] don't know where you are coming from. And that gets in the way of the trust thing.
> [Male regional Natural Resource Management professional, interview April 2015]

These accounts show that interpersonal relationships can be a crucial aspect of trust-building and *vice versa*. As Babidge (2013: 286) notes in the context of a Chilean mining conflict, "[a]n injunction to 'tell the truth' is a means of moral and political positioning" within community–corporate partnerships. Furthermore, those relationships are important within the underlying identity politics that are involved in the "localization of knowledge"; that is, the accommodation of what frequently are outsiders' expert claims into "the ways in which things are known locally" (Cohen 1993: 35 & 37; also Wynne 1996a). A topic of further enquiry is certainly what kinds or levels of engagement are regarded as sufficiently personal.

A second decisive element is the perceived transparency of the information and research underlying epistemic claims. Interlocutors frequently emphasised that honesty about uncertainties and potential unknowns is a prerequisite for meaningful communication. This stands in contrast to the veil of secrecy surrounding, at least initially, many CSG projects. In this regard, company employees often appeared to community members as non-transparent: *"They [company staff] think they should know everything, and are scared to open up because they think if they give an answer of 'I don't know' then it's going to tarnish them in some way"* (male environmental management consultant, interview April 2015; cf. AgForce 2017 & Chapter 6.2.). However, this approach has been largely unsuccessful. A number of interlocutors highlighted that honesty about limitations fared much better with concerned local community members:

> We've seen a vast shift. … It was cowboy culture when they first came in - 'Mate, you don't have to worry about us. … We're taking care of it'. But … there is a much more open philosophy now, and I think that should continue and improve. Again, it's about that transparency of information. That trust in what is going on. … And I think that is really important, that visible presence in regional communities is really important. To be there as part of the community.
> [Male regional town resident and local council representative, interview May 2015]

> I'll try and make it clear [to community members], 'We know this and this. … And here are the things we don't know. Here are the measurements we are doing. Here's the monitoring we're doing, that we think is the right thing to do to eventually close up those gaps'. … I certainly find people generally just want you to be straight with them. So it is transparency. It is important to acknowledge the uncertainties, but don't overstate the uncertainties. … And I want to understand what you would think would be good evidence. … Ask the people, 'Well, what would make you confident? Not that I necessarily have the power to change it, but what would make you confident?' … Science and communication is just absolutely critical, in any and everything.
> [University-based female senior hydrologist, interview May 2015]

Honesty and transparency are thus critical components within the politics of knowledge and unknowns. This finding relates to insights gained from other risk controversies. Following the UK's bovine spongiform encephalopathy (BSE) risk debate, for instance, Frewer *et al.* (2002: 371) found that public actors "are more accepting of uncertainty associated with the scientific process of risk management than a lack of action or lack of interest on the part of the government. … It is suggested that people want transparency in risk management and to be able to make informed choices about exposure to food risks" (also Buys *et al.* 2014). However, what particular actors or groups count as honest and transparent relationships is a topic for further research.

These insights into the importance of interpersonal relationship, honesty and transparency can be substantiated through a specific example. Around the time of my fieldwork in 2015, the Queensland Government updated its approach to groundwater monitoring and launched the CSG Online and CSG Net projects. CSG Online takes data from dozens of monitoring stations across the Western Downs and beyond and makes it available to the public 'live and online'. Through a *Google Globe* add-on, members of the public can then find the monitoring data for particular wells and areas. CSG Net is a citizen science programme that involves regional landholders into groundwater monitoring. I propose that CSG Net in particular has proven successful in generating trust in ongoing CSG-specific scientific groundwater research among some actors in the controversy due to the factors considered in this section.

CSG Net consists of approximately a dozen small community groups of about thirty bore-owning landholders each from the Western Downs and neighbouring regions. Groups are divided according to specific geographic areas. Through the project, landholders are supported in regularly measuring and reporting groundwater levels in their private bores. The respective State government department includes these readings into its own monitoring data set and annually reports back to landholders. During group meetings, findings are then discussed and landholders can engage directly with each other and the government's hydrogeologists. Figure 18 provides a schematic overview of the Queensland Government's transition to these CSG groundwater monitoring arrangements:

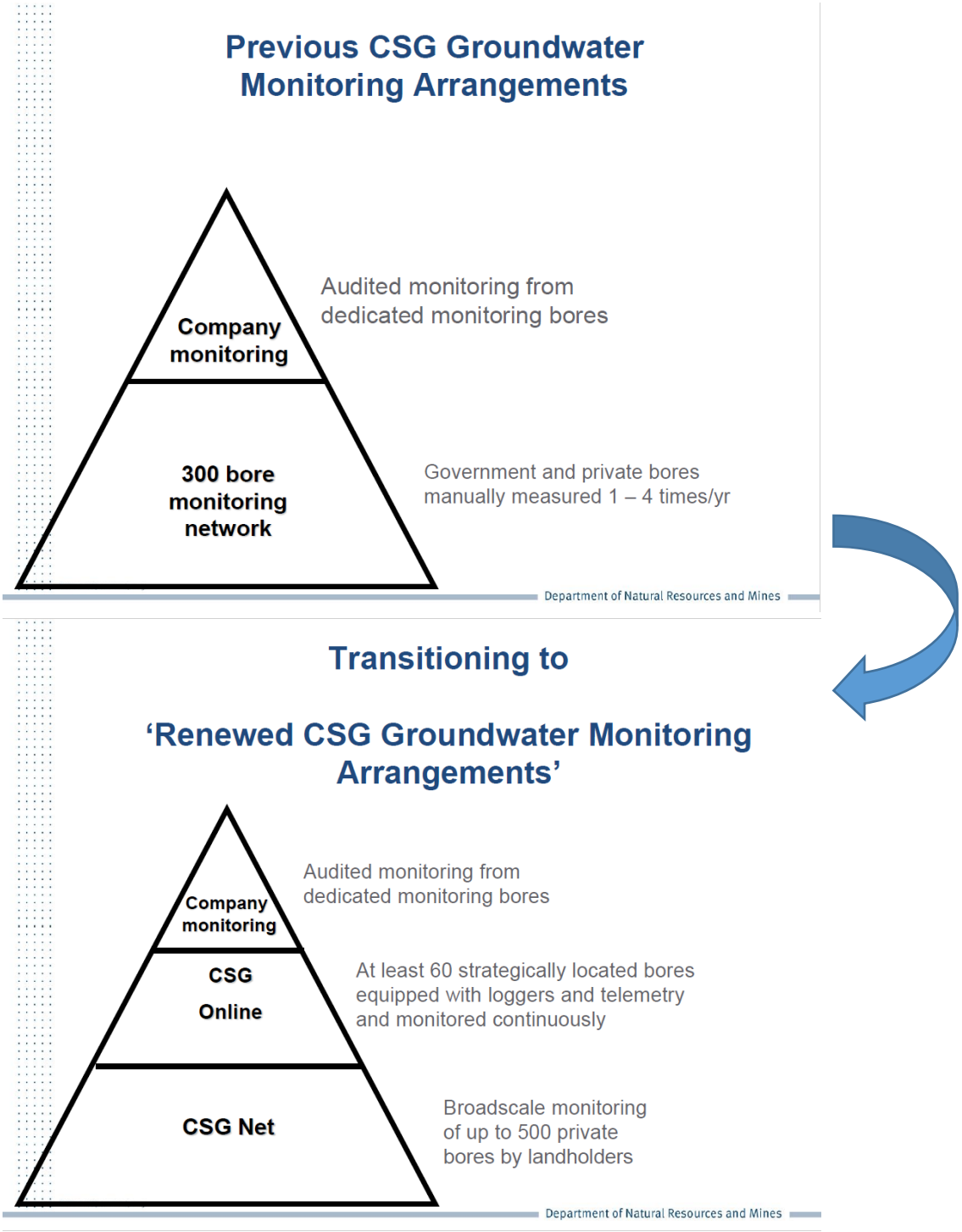

Figure 18 The Queensland Government's renewed CSG groundwater monitoring approach (Source: workshop presentation, June 2015)

Throughout 2015, one of the government's lead hydrogeologists within CSG Net presented on the initial success of the project. His slides stated that landholders now *"have 'ownership' of the data that will be used as the basis for conversion so the data is 'ours' rather than being 'their' (Government) data"*. Furthermore, *"[b]y involving landholders in monitoring, and providing transparent information on any groundwater impacts, there is the opportunity to build trust and relationships"* (e.g., here). On multiple occasions, he and another government hydrogeologists

therefore used the simple formula that *'transparency & involvement -> trust'* (*ibid.*). These findings correspond to the insights I considered earlier in this section.

During meetings with the government and NGO staff who administered the project, it became clear that the benefits of this 'invited participation' (Wehling 2012; Wynne 2007) are not primarily in improving the quality of groundwater research but are rather social and political (cf. Kinchy *et al.* 2016; Sovacool 2014: 13):

> In a way, this CSG Net project is an example of trying to engage the community … and saying, crudely, 'How about you put your effort and your money where your mouth is?'. … A lovely new term is 'citizen science', but really it's: 'Well, you guys could contribute to information if you're sceptical about company data and you don't trust the government'.
> [Senior male natural resource manager, CSG-specific group meeting May 2015]

> I don't think it's the monitoring outcome, it's the process that's important. The process of getting people together in a group, of providing them with information, real information, transparent information. … It's not the data that's the most important part, it's the process. Because in the end, with a pressure gauge … you can only record to a certain accuracy. … It will never be at a stage where you can say this is done to this ISO standard or whatever. … [It is] about giving power back to the landholders, because a lot of them feel like they've lost all their power. … [So] getting some power back and having the ability to actually contribute to the process that they haven't had before, and you can see the sort of light-flickering in their eyes.
> [Senior male government hydrogeologist, CSG-specific group meeting May 2015]

The engagement between various actor groups through the CSG Net project appears to have had significant positive outcomes concerning the debates over CSG-specific groundwater impacts, including improved mutual trust and the empowerment of participants (Carruthers 2015; generally also van der Vegt 2017; Wynne 2006).

Furthermore, face-to-face group meetings also provide a pathway for landholder concerns to be heard and responded to by government officials, which was highlighted as crucial. A participatory approach and invited engagement with often uncertain or opposing landholders has improved the relationship between government and public actors (cf. Checker 2007: 120). This project thus appears to have increased local community members' trust in the science behind CSG-specific groundwater risk management procedures. These findings correspond to Walton *et al.*'s (2016: 18) quantitative research in the Western Downs that shows that more positive attitudes and feelings towards CSG are associated with people who feel they are listened to, have higher levels of trust, and are getting access to information. The same research also demonstrates that these factors must be accompanied by a sense of agency if communities are to respond successfully to rapid change resulting from CSG developments (Leonard *et al.* 2016). Following these insights, I agree with Wynne's (1996b: 40–41) argument that "[w]hilst trust is a key dimension of 'public understanding'

and perceptions of risks, it should not be reified into an objective entity. It is a profoundly relational term, a function of the complex web of social relations and identities". I propose that these complex social relations emerge, among other factors, through constructive interpersonal relationships, a sense of honesty and transparency, and feelings of respectful engagement (Irwin & Wynne 1996: 13; Mercer-Mapstone *et al.* 2017).

Whereas these factors do not necessarily affect the uncertainties present within ongoing scientific research, they provide grounds for public trust into the social and political institutions that regulate and manage CSG developments. I therefore follow Jasanoff's (2012: 29) argument about the importance of continual interaction between the various actors involved in techno-scientific risk debates:

> Public understanding grows through myriad repeated encounters between people and those to whom they have entrusted responsibility … . That interactivity goes begging when public reason becomes artificially depoliticized, the preserve of insulated expertise. Skepticism and questioning, however uncomfortable or irritating in the short run, make better foundations for democracy than imperial opinions handed down in the expectations of acceptance. … '[E]ngagement' is not simply a matter of opening the doors wide to all comers. … Rather, it is about the dynamic character of trust-building, as well as knowledge-making, in democratic societies; it is about establishing, and reperforming, the rhythms of 'normal democracy' that make it possible to put one's trust in the wisdom of strangers while holding ignorance and denial at bay.

The notion of entrusted responsibility is important as it stands in contrast to some interlocutors' perceptions of an organised irresponsibility concerning the regulation and management of CSG developments (see Chapter 6.2.). Perceptions of irresponsibility or contradictory understandings of responsibility by State actors and citizens can subsequently lead to citizens mistrusting or feeling alienated from government structures (Gill 2011; Wynne 1996b: 42). In this sense, notions of trust and responsibility are closely connected.

Ottinger (2013) makes a similar observation in the risk controversy emerging around a Louisiana oil refinery's potential environmental and health impacts. She argues that disputes abated not necessarily due to the refinery's expert presenting infallible, certain science, but because they could convince opposing residents of their responsible operation and safe conduct. This study and my research demonstrate that debates over (un)knowns, risks and uncertainties of CSG developments not only concern scientific questions. They also involve the (re)negotiation of social relations regarding whether or not individuals and the public can entrust regulatory institutions with the responsibility to address and manage those uncertainties on their behalf. This often means that "[w]hen science and technology decisions are demonstrably responsive to the concerns of a wider range of citizens", then "the public is more likely to accept those decisions" (Sclove 2010: 8).

Conflict may thus arise not because concerns are not (yet) fully resolved, but because citizens do not consider them taken seriously and addressed responsibly.

This social relationality has implications not only for public and government actors but also for scientists, namely in the sense of a 'reciprocal validation'. That is, the validity of scientific knowledge is not based "in nature *per se*, but … in the identification by participants of new possibilities for 'carrying on' the existing culture, not without new elements of practice, relationships and identity emerging" (Wynne 1996a: 75; also Lamberts 2017b). Put differently, those making or advocating scientific knowledge claims can take seriously public concerns and fears through respectful communication and active engagement rather than dismissing opposition as (scientifically) ignorant. In turn, this may result in public actors being more inclined to constructively assess the usefulness and validity of such claims against their existing knowledge and experience (cf. Szerszynski 1999). Creating trust through respectful communication is thus not only beneficial to improving non-expert actors' understandings of an already validated scientific end product; this would be a mere extension of a deficit model of the public understanding of science (Irwin & Wynne 1996: 214; see Chapter 5.1.). Instead, involvement and trustful social relationships are a pivotal component in the establishment of the sciences' credibility, validation and usefulness in the first place. Some interlocutors therefore fittingly stressed that *'science without communication is useless'* (cf. Lloyd *et al.* 2013; Taylor 2010). In this sense, public participation might, as some scholars have argued, decrease the social and cognitive distance between the public and science that grows with the increasing speed of scientific knowledge production (Stehr 2001: 123–124).

My conclusion from this section is that invited, non-expert public participation is an important factor within the establishment of social relations between scientific experts and non-experts (Stilgoe 2007). This can generate a sense of responsibility and accountability, as well as empower non-expert citizens and scientific experts alike (Irwin *et al.* 1996). At the beginning of this section, however, I noted that limited, uninvited participation can also lead to perceptions of disempowerment among some actors (Willow 2014). A crucial question that then arises, but which I can here only foreshadow, is who gets granted and grants the status of participant and legitimate 'stakeholder'; this applies to public and also expert actors (Colvin *et al.* 2016; Rifkin 1994; Rifkin & Martin 1997; Wehling 2012; Wynne 2007). In other words, complex politics of representation and identity emerge. Addressing the CSG risk controversy is therefore as much a social and political as a scientific task.

8.4. Conclusion: CSG Risk Debates as Social Commentary Beyond Science

This chapter addressed certain aspects related to the politics of knowledge and science, which illustrate how "'science' as a category blurs into other areas of social practice and contestation" (Irwin & Wynne 1996: 13). In particular, I analysed how scientific knowledge claims can become utilised within processes of cryptonormative (de)politicisation and the wider politics of evidence. Mobilising science in these contexts becomes an important political strategy wherein appeals to scientific authority are based on the mythical root metaphor of disinterested, apolitical scientific research (Nelkin 1995; Sarewitz 2004). Yet, assessing the risks of CSG developments scientifically is an ambivalent and precarious process that, perhaps inevitably, delivers limited, incomplete or conflicting results. Such outcomes are subsequently open to multiple interpretations and political relations of definition concerning what counts as legitimate evidence. In this sense, I follow Bourdieu's (1975: 21) argument that "epistemological conflicts are always, inseparably, political conflicts". I therefore propose that debating the risks of CSG 'through science' not just addresses scientific questions but becomes what Claeson *et al.* (1996: 110) describe as "a commentary on the social world", however cryptonormatively this may occur.

Such commentary, firstly, involves responses to political power inequalities regarding the definition of particular risks and, crucially, who is and should be responsible for bearing those risks (see Beck 1992 on risk positions). In this sense, many opposing interlocutors with nearby infrastructure resisted being *'guinea pigs'* for CSG extraction technologies. Yet, other local actors were able to halt CSG projects or more successfully negotiated developments on their terms (cf. Chapters 6.2. –3.). This often not merely followed NIMBY rationales (AgForce 2017; Everingham *et al.* 2014: 126). For instance, an influential irrigation farmer on the Western Downs' agriculturally valuable floodplains explained the implications of legislative changes that they supported to protect their farming operations:

> What it actually means is they will go to all the places where it is a lot easier to develop before they come here. As it should be. … Why would you undertake any activity where there is even a potential that you might cause irreparable harm to the productive systems that support agriculture here when you could do it there [further west on less productive land] to your heart's content with very low risk? When you have done it there until there is nothing left - well, A: we will have learnt a lot. And B: we will be a lot of years down the track. With technology and science developing at a rapid pace, who knows how we will be extracting the energy from beneath this part of the world. So, go somewhere else and come here as a last resort.
> [Interview May 2015]

This farmer's account indicates the underlying local power relations involved in debates over the status of scientific knowledge and acceptability of uncertainties and risks.

Social commentaries within risk debates can, secondly, concern the relationship between local, government and industry actors. Particularly important are questions around actors' participation status. In such debates, actors from geographically and socially 'peripheral' rural regions might be disproportionally affected by infrastructure developments and find it harder to participate in decision-making processes in 'core' urban centres (Blowers & Leroy 1994; Willow 2014: 241). Challenging the adequacy of science in these context might in fact address political power inequalities.

> We don't find environmental people invited to the business dinners and the influence that senior business can exert on government is greatly disproportionate. So that blows out of the water any model you might put forward based on simple consensus or presentation of ideas … . It's not a question of science, it's a question of power.
> [Male former State public servant and policy expert, interview July 2015]

> It depends on your definition of politics, where it starts and ends. But … what the issue has done is raise the shortcomings of the way we currently communicate within regional communities and the broader Australian community. Again, the process becomes the victim of the agenda. … We are using outdated communication protocols. We are expecting to have conversations that require high levels of trust in the absence of any trust. We are having conversations that require a deep understanding of technical and scientific issues in the absence of most people having that understanding.
> [Regional NGO-based male natural resource manager, interview April 2015]

The acceptance and perceived appropriateness of the CSG industry is therefore not only dependent on its underlying science, but also on the quality of interpersonal relationships between proponents, government officials and various local actors. A former farmer and agricultural consultant summarised this insight by noting that the *'real issues of co-existence'* are *'understanding, communication and trust'* (CSG-specific research forum September 2014). Fair and high-quality community engagement that creates transparency and trust is therefore crucial (Gillespie *et al.* 2016; Lacey *et al.* 2017; Moffat & Zhang 2014; Zhang & Moffat 2015).

Debating the science behind CSG can, thirdly, also be a commentary on the arrangements, performance and legitimacy of certain social and political institutions (Wynne 1996a: 76; see Chapter 6.1.–2.). As such, trust and a mutual understanding are contingent upon the perceived adequacy of the institutional structures and procedures related to CSG-specific risk assessments. Good scientific research is crucial in this regard, but ultimately not the only determining factor:

> Dr Johnson: The evidence to date … suggests that, so long as the risks are understood and the proponents deploying that particular technology are cognisant of the risks and act in accordance with best practice and guidelines issued by the state jurisdictions, the risks, based on the current knowledge that we have, seem to be low.

Senator Waters: That is assuming the conditions are complied with, which is sadly an assumption we cannot make.

Dr Johnson: Yes. That is not a scientific matter. That is a matter for the regulators.
[Male Chair of the IESC, Senate hearing transcript, Brisbane 27th July 2015: 31]

I think getting the science right is getting the governance right too, and the policy. You can't see it on its own little silo, having those chains and interactions and commitment at all those levels.
[Female natural resource manager for regional NGO, CSG-specific group meeting April 2015]

A sole focus on scientific research and evidence might therefore fall short of addressing these social and political dimensions of CSG risk debates.

Some interlocutors, especially those in roles that deal with actors from various sides of the debate, therefore highlighted the importance of reliable and trustworthy frameworks for the assessment of CSG risks. This includes openly discussing broader concerns and envisioned directions of development. The feeling of having a voice and being listened to respectfully are just as crucial in these processes as a belief into the capabilities of government and industry actors to which members of the general public (have to) entrust the responsibility for assessing and regulating the CSG industry:

It would be desirable to ensure that all appropriate investigations are undertaken under a detailed risk assessment framework. … Something that we can all grab hold of, that is tangible, like a framework that people can trust. … I wouldn't care who funded it, as long as we - all sides of the divide, and of the social spectre - agree on the framework. … Somewhere down the line there has got to be a framework for that conversation. You have got to give people dignity and they don't have any dignity now.
[Male State politician, interview April 2015]

It is extremely dangerous to have trials by media. … If you can bring people back to the real discussion through genuine processes you become, you remain part of the solution. … Things take time. … It's very dangerous to make big decision very quickly without full consideration. … It takes time for a community to build their knowledge to participate better in those public conversations. … Like any extremes in a scenario, the main game is in the middle and it's about trying to work to people from where they are at. … How are we going to deal with it, and how is it going to influence them? How are we going to have that conversation, without asking them to join a club that they have already, by default, decided they don't want to join?
[Male regional natural resource manager, interview April 2015]

These accounts illustrate that it is important to "challenge the separation of risk into 'scientific' and 'social' domains (of which both scientists and social scientists are guilty). 'Risk' is neither 'scientific' nor 'social.' It is the (co-)production of representation of both nature and society"

(Stilgoe 2007: 57). Debating CSG risks does thus concern particular hazards in a narrow sense as much as what makes for a socially just and good society (Arnoldi 2009: 105; see Chapter 2.2.1.).

These three aspects of CSG debates as social commentary make apparent the limits of scientific knowledge claims. Everingham *et al.* (2013: 6) therefore rightly suggested that "differences in perception [of Queensland's CSG developments] indicate that co-existence of energy extraction and agriculture requires solutions that take into account social dimensions and subjective values rather than simply technical solutions" (also de Rijke 2017). Different values and emotions are thus important factors of the CSG controversy that must not be ignored. As a regional natural resource manager noted, *"[i]f you didn't have an emotional reaction to something, you're dead"* (Interview April 2015; also Everingham *et al.* 2013: 85). However, I agree with Evensen (2015: 512) that "discourse about major public policy decisions, particularly in relation to controversial environmental issues, oftentimes ignores the limits of science and/or the importance of moral thought in policy-making". Especially instances of cryptonormative scientisation can, in this sense, be detrimental to what are also social and political negotiations. Furthermore, scientising debates and thereby neglecting the limitations of the role scientific research can take within complex environmental controversies can backfire and significantly undermine the sciences' social value (Nelkin 1995; Pielke Jr. 2007).

Fully addressing the social and political dimensions of risk debates can therefore not occur through covert politics of scientific evidence or knowledge that can exclude a considerable proportion of the public as scientifically illiterate or ignorant. Instead, it appears more appropriate to not regard the sciences as "a quick, direct route to the 'truth'" (Bocking 2004: 226–228). Sarewitz (2004: 398–400, original emphasis) therefore cautions against scientising and foreclosing political negotiations:

> Political debate permits the mobilization of a broad range of weaponry, including scientific facts, … in defense of one's values and interests. But scientized debate must suppress the *open* discussion of value preferences; were it not to do so it would have no claim to distinction from politics. … Scientization of controversy also undermines the social value of science itself. … Bringing the value disputes concealed by - and embodied in - science into the foreground of political process is likely to be a crucial factor in turning such controversies into successful democratic action … . Moreover, the social value of science itself is likely to increase if scientific resources relevant to a particular controversy are allocated after these value disputes have been brought out into the open … . [P]rogress in addressing environmental controversies will need to come primarily from advances in political process, rather than scientific research. … The technical debate - and the implicit promise that 'more research' will tell us what to do - vitiates the will to act. Not only does the value dispute remain unresolved, but the underlying problem remains unaddressed.

As the positive glimpses of invited participation within the CSG Net programme indicated, a respectful and mutually validating engagement between scientific and non-scientific actors can be constructive. It has this potential primarily not because of the quality of citizen science — a specialised division of labour exists after all for a reason (cf. Kinchy *et al*. 2016), but as a means of dissolving, to some degree, the separation of scientific research and social life. With some scientific uncertainties inevitably remaining around CSG developments, creating social spaces for the open discussion of unknowns, instead of hiding them, is crucial. As such, uncertainties and ignorance should be regarded as regular social phenomena rather than deviant, necessarily detrimental and always eradicable epistemic obstacles (Gross & McGoey 2015a: 4; see Chapter 2.1.2.). Creating opportunities for the inputs from a diverse range of actors to direct ongoing research appears paramount for this task.

9. Conclusion

> *I do not mean that we should abandon science or that we should oppose the knowledge of inhabitants to scientific knowledge. Rather, we need to find ways in which they can work together.*
>
> *(Ingold 2014b)*

I begin this concluding chapter by briefly summarising the main thesis findings and restating my main arguments. The second section reflects on what my account can contribute towards CSG developments and their associated risk controversy. I also draw out some more general implications for environmental anthropology and the broader literature employed throughout this thesis. The conclusion provides an outlook on the status of the sciences within contemporary environmental risk debates and what role anthropological perspectives might play in these contexts.

9.1. Thesis Summary and Main Findings

In Chapter Two, I developed three conceptual propositions. First, I suggested that knowledge and ignorance are not externalisable possessions or their absence but rather a performative act by situated actors. As such, they are both part of the ongoing reconfiguration of reliable and meaningful environments for those actors. My second proposition was that risks are a special form of knowledge and part of humans' attempts to systematically assess and shape future circumstances. Third, I conceptualised the sciences as social practices and highlighted their 'special status' as the result of boundary-making practices. These outlines set the theoretical framework through which I commenced examining the CSG risk controversy.

The third chapter sketched out the study region's historical context within which CSG developments emerged. I particularly focused on the complex resource environment of the Western Downs and the subterranean entanglements of water and hydrocarbons. This allowed the reader to grasp the importance of scarce surface and groundwater sources that, by the time CSG projects commenced, were already contested resources. Understanding the historical trajectory of the Western Downs as an already intensively managed landscape made it possible to foreshadow some of the environmental risk debates emerging around CSG developments. I also addressed the economic impacts of large-scale CSG projects.

Structured around Ingold's typology of environmental awareness, the fourth chapter examined the role of scientific ways of knowing within the sense-making of CSG's environmental impacts. I suggested the notion of CSG as a transcendent quasi-matter with minimal materiality. As such, CSG becomes known through inseparable entanglements between phenomenological experiences

and projected, scientific ways of knowing. I proposed the notion of 'hybrid CSG' to capture these entanglements. However, it remains important to consider the possibility of a dominance of projected ways of knowing and of so-called public deficit models of scientific understanding.

Chapter Five addressed such deficit model perspectives within CSG risk debates. I scrutinised the assumptions underlying such perspectives, namely that 'the science is in' and that uncertainties remain due to some actors being misinformed or deliberately disinformed. Through the example of groundwater modelling, I demonstrated that uncertainties and problems of knowing persist also due to the nature of scientific research and critiques from scientists themselves. Nonetheless, local actors still need to make sense of potential impacts and environmental changes, which can create feelings of ambivalence. The case of gas seepages in the Condamine River anchored this argumentation. Following these insights, I suggested that more scientific research is necessary but that assumptions that 'just more' will resolve the controversy are possibly misleading. I proposed to move away from linear models of science and to employ a relational focus on the social and political contexts within which the sciences are situated.

Chapter Six examined the diverse responses to the unsolved problems of knowing and considered some factors that influenced these various responses. I specifically attended to perceived shortcomings of government institutions and the CSG industry and discussed ramifications of the industry's rapid growth, perceptions of organised irresponsibility, and the industry's veil of secrecy. For some local actors these shortcomings led to unacceptable uncertainties and risks, whereas others came to terms with the new industry. I suggest that growing trust in ongoing scientific research played a crucial part in this regard. The conclusion contextualised these responses within the diverse attitudes towards the Western Downs' CSG industry. While noting this diversity, I also drew out overarching areas of concern among my interlocutors in relation to problems of knowing.

In Chapter Seven, I deconstructed debates over the science underlying CSG developments to demonstrate that scientific research itself can become the focus and locus of contestation. However, these debates cannot be understood as anti- versus pro-science conflicts. Rather, they are complex negotiations over right and wrong science. To develop this argument, I conceptualised scientific research efforts as situated practices that emerge within access-restricted epistemic spaces, or technological zone, and considered what some interlocutors perceived as wrong science and as prerequisites of adequate science. My proposition was that debates over right and wrong science often revolve around the root myth of pure science. In foreshadowing the importance of relations of definition, I suggested that conflicts over the appropriateness of scientific research can be understood as politics of (im)purity wherein actors attempt to impose definitions of science.

These insights led me to consider the wider politics of the (un)known and the limits of science in Chapter Eight. I demonstrated how claims of scientific knowledge and ascriptions of ignorance can mask normative positions. Through these cryptonormative claims, actors seek to determine legitimate concerns and whose voices ought (not) to be heard in the debate. The subsequent section examined the closely linked questions of who has the onus of proof and what counts as evidence when conflicting claims are made. I argued that these questions are a decidedly political aspects of the CSG controversy. Debates over science are also negotiations over legitimate participation in research and decision-making processes. I emphasised the importance of engagement, trust and participation to address conflict. My concluding proposition was that CSG risk debates do not just concern environmental hazards but are social commentaries that might address but go beyond questions of scientific adequacy. Neglecting the moral and political dimensions of CSG developments by scientising debates is thus likely stymying conflict resolution. I further cautioned that such scientisation can have negative implications for the status of scientific knowledge claims.

Following these findings, it is worth reiterating my overall rationale and argument that I outlined in Chapter 1.6. Throughout this thesis I aimed to move from a deconstruction of the sciences' role within the CSG risk controversy towards a broader analysis of knowledge and ignorance. In doing so, I intended to demonstrate how scientific knowledge claims are not merely an externality brought into the controversy, as though one only needed to replace emotions, values and opinions with proper science and evidence-based policies. Instead, I repeatedly argued that the sciences themselves are subject to uncertainties, that scientists might create new uncertainties, and that the sciences themselves can become sites of contestation. The sciences can thus be understood as situated practices. One implication of this situatedness is that scientific knowledge claims can remain limited, ambiguous and might lead to ambivalence. An analysis of actors' engagement with and utilisation of such scientific knowledge claims must therefore be positioned within the wider politics of knowledge and ignorance.

9.2. Critical Reflections

The sciences' situatedness and entanglements with the social and political not necessarily prevent conflict resolution if they are openly acknowledged and negotiated within the public realm. Issues can arise when particular scientific findings are taken at face value or promoted as irrefutable 'facts' in order to support political or moral agendas. I therefore concur with the arguments put forward by colleagues from the University of Queensland. Everingham *et al.* (2013) note that addressing the CSG controversy requires not simply technical and conventional approaches, which

usually include more data gathering, increased spending, the segmentation of complex issues, and a focus on 'logic' over emotion. Instead, they contend that (*ibid*.: 85, reference omitted):

> conventional solution processes, along with approaches that simply try to appease the majority, can exacerbate conflicts and negative consequences. This is partly because they assume a scenario with linear cause and effect and single 'culprits' and 'victims' when there are innumerable interconnected factors contributing to these challenging situations. … [R]ather than needing sophisticated scientific analysis, the challenge of co-existence is fundamentally one of contrasting values and interests and so requires a social solution that is inclusive, multidisciplinary, exploratory and adaptive and examines the issues 'as a whole through a panoramic social lens rather than a scientific microscope'.

However, I would suggest that *rather than* is misleading. What is required are social resolutions *in addition to* transparent scientific research and technical solutions. This makes it is possible to avoid deceptively facile approaches.

In this sense, technical solutions and calls for improved scientific research are warranted if these do not lead to a neglect of other ways of knowing and of the social dimensions of CSG risk debates. Claeson *et al.* (1996: 115) remind us that:

> [t]he 'facts' of science, important as they are, can never be more than tiny pieces of the maps that people devise to guide them in life. … [O]ur coming to know those 'facts' would entail our embedding them in the diverse social, political, moral, and metaphysical meanings with which we construct our daily lives.

The role of the sciences and their status in public and policy discourses in the context of CSG developments therefore require critical evaluation. I hope that the insights developed in this thesis contribute to such an evaluation.

Worth emphasising is the insight that the sciences are indispensable for knowing CSG's environmental impacts, despite the politicisation surrounding scientific practices. However, scientific research often remains ambiguous, limited and uncertain. This is not to suggest that scientific insight cannot improve over time. Rather, outlining the ambiguities and limits of science allows for an appreciation of the roles it can and cannot take within complex environmental risk debates. To determine these roles, it is essential to address the sciences' situatedness and debate reflexively what and why certain issues of concern are or ought to be researched. This also involves considering who tackles these research questions, in what ways, and how findings are communicated. In this regard, scientists can occupy diverse positions from 'pure' research to explicit issue advocacy (Pielke Jr. 2007). The sciences thus emerge as situated practices that are contingent upon a multitude of social, political and economic factors. Attending to these contingencies "does not thereby undercut the authority or significance of the sciences, but instead calls attention to what is at stake in whether and how those practices continue and develop" (Rouse

2014: 291). This may, in turn, preserve the merits of science without denying the open discussion of crucial moral and political questions.

An important aspect of these discussions is determining approaches to CSG-specific scientific uncertainties that can emerge from scientific research itself or once findings are debated within the public domain (cf. Stehr 2001: 150). In both cases, uncertainties need to be addressed overtly rather than masked or excluded from debates. I therefore, once again, agree with Everingham *et al.* (2014: 126) that "[u]ncertainties must be articulated in a way that is meaningful on the ground and provides a basis for negotiation and informed decision making". It is likely that incrementally improving scientific understandings and even more public involvement alone will not entirely resolve uncertainties and reduce ignorance. Newell and Smithson (2014) rightly note that "[s]cience, of course, is beset with ambiguity and uncertainty. Indeed, it might be said that anyone who demands certainty of scientists doesn't really understand how science works". Ambiguities and uncertainties are thus essential parts of scientific research and, as a senior policy officer in a Queensland State department noted, *"from a science perspective, you've actually got trouble if you don't keep asking questions, haven't you?"* (CSG-specific group meeting May 2015). In this sense, only relying on the natural sciences to ease anxieties and conflict is misleading (de Rijke 2017). It is, instead, crucial to openly articulate and negotiate these uncertainties and their acceptability.

This focus on uncertainties and acceptability brings us to the question of participation. I have argued that CSG, unlike most conventional resource extraction projects, affects a large number of geographically distant and socially diverse individuals and groups. I also contended that respectful engagement and public participation are crucial in resolving debates over the status of (scientific) knowledge concerning CSG's impacts and risks. These arguments require further elaboration. To be sure, the capacities necessary to conduct increasingly complex research certainly restrict direct involvement for many non-specialist actors. Democratic involvement in deciding on the agendas and contours of science, on the other hand, is not limited in the same way. As with democratic processes generally though, a high level of public participation is essential, but frameworks for appropriate participation must also be established. This point relates to the argument I developed regarding debates over precaution (see Chapter 8.2.). Without established thresholds to determine when the precautionary principle has been satisfied, precaution remains an ambiguous discursive device that, similar to notions of safety and sustainability, can be widely agreed upon. Yet, when those involved do not share similar interpretations — or at least openly discuss differences — and without tangible measures of success, such notions remain vague and often ineffective. This equally applies to public participation in CSG risk debates, which can create new social and political challenges.

In forecasting the contours of a post-industrial society, Bell (1973: 159), for instance, already cautioned that:

> the very increase in [public] participation leads to a paradox: the greater the number of groups, each seeking diverse and competing ends, the more likelihood that these groups will veto one another's interests, with the consequent sense of frustration and powerlessness as such stalemates incur.

This perspective is echoed by Stehr (2001) who observes the possibility of more public participation in many contemporary democratic societies. However, "as the potential for meaningful political participation is enlarged, some traditional attributes associated with the political system, especially its ability to 'get things done', or to impose its will, are increasingly diminished" (*ibid.*: 67). To be sure, growing public participation and increased pluralism are desirable from a humanistic and democratic standpoint. At the same time, merely demanding more participation is no panacea for environmental controversies generally and CSG risk debates in particular as they are frequently characterised by marked disagreement. As such, deadlocks between actors and groups with polarised positions and conflicting knowledge and ignorance claims can pose substantial obstacles for governments' decision-making, regulatory institutions that still need to legislate policies, or industries seeking a social license to operate.

The challenge is therefore to construct mutually acceptable, trustworthy frameworks of reference and democratic process that offer appropriate levels of participation and diversity in viewpoints. Determining those levels is highly context-dependent, but it is important to avoid (re)enforcing 'echo chambering' and fundamental schisms that prevent meaningful and productive conflict (Weinberger 2011: 71–91). A regional natural resource manager emphasised this insight:

> Communities that are truly resilient, they won't go to the extreme and become insular. … Because that is a defense mechanism of humans when they are under threat. You revert to your tribe. … You have to be quite courageous to get into a trust thing. It's very easy to build a wall and not let anybody over it.
> [Interview April 2015]

In this sense, a crucial task within CSG risk debates is to establish a respectful 'culture of conflict' (Yasmi *et al.* 2006). Within this cultural exchange, individuals and groups must work towards functional conflict that enriches and strengthens democratic processes rather than dysfunctional conflict where participants work against each other (Colvin *et al.* 2015; also Amason 1996). Regarding debates over new technologies, Renn (2014: 8–9) suggests that the cultural practices of weighing up risks and benefits require discursive processes and the setting of cognitive foundations. These foundations include discussions over participants' envisioned futures, the new technology's possible impacts and associated uncertainties, and the role of experts. In short, merely publishing

more information or research is not enough in this regard. Instead, all actor groups involved in risk debates need to be engaged into open dialogue in order to facilitate functional conflict.

Surely, not all actors who are affected by or take an interest in CSG developments might be willing or able to participate in these discursive processes. Critical anthropological perspectives and ethnographic research can reveal which categories of persons seek and are given attention, and whose voices remain relatively silent or unheard. In attending to the politics of representation, anthropological approaches are an important component of the social resolutions of the CSG controversy. These approaches demand reflexivity, transparency and an epistemological responsibility to acknowledge the multitude of possible interpretations and attitudes towards CSG's risks (e.g., Teo 2010). This requires studying 'up, down and sideways' (Nader 1972, 2013: 317; Stryker & Gonzalez 2014) and to be critical in, for instance, addressing social inequalities regarding actors' access to the epistemic spaces within which CSG-specific scientific knowledge is produced and utilised, or in attending to perceptions of unfair conduct. At the same time, however, it is also crucial to assess and, if apt, emphasise the valuable role of expert opinions and scientific accounts. In doing so, the task nonetheless remains to advocate against a crude 'scientism' that (Roscoe 1995: 500, original emphasis):

> deploys the term *science* as though it were a magical talisman guaranteeing the authenticity of whatever half-baked ideas are trotted out under its aegis. Unfortunately, such claims do exercise a sort of magic over the uninitiated - the lay populace and politicians who vote on funding priorities - thereby continually threatening to disenfranchise humanistic inquiry and other forms of inquiry as non-scientific.

By thus deconstructing debates over science without neglecting the value of research and scientific methods, anthropologists can assist in creating frameworks for the cultivation of a culture of functional conflict.

The insights developed throughout this thesis can contribute towards this goal. In particular, my aim was to reveal some of the underlying, often tacitly reproduced, factors that foster dysfunctional conflict. For instance, I demonstrated the problems associated with cryptonormative appeals to and strategic utilisation of the root metaphor of objective science. However, that the myth of objective science is, arguably, unachievable (Ingold 2016) does not imply that scientific research and knowledge claims ought not to have social authority. I suggested that, instead, the impasse of pro- versus anti-science discourses can be turned into a more nuanced debate over the particular arrangements of scientific research. Likewise, arguments over knowledge and ignorance claims can be transformed into more inclusive and openly conducted politics of the (un)known. I thus intended to go beyond merely stating that science and knowledge are contested and ambivalent notions in CSG risk debates by analysing the substructures of their contestation and ambivalence. The findings

of this analysis might be a starting point for a respectful discussion of science, knowledge and uncertainties in this context.

The insights developed in this thesis also contribute towards the literature from which my researched commenced. Following the complexities of the CSG controversy and proposed research questions, I combined a wider range of social scientific literature to conceptualise three main areas of interest: knowledge and ignorance; contemporary risks; and the sciences. This outlined my anthropological approach to knowing risks. Many of the understandings I developed transcend the disciplinary boundaries of (Environmental) Anthropology and incorporate the accounts of scholars in the Sociologies of Knowledge, the Environment and Risks, as well as from the internally diverse fields of Science and Technology Studies, the Environmental Humanities, and the Social Studies of Science. The rationale of this approach and combination of literature is, I believe, warranted by the socio-political, economic, and techno-scientific complexities of contemporary environmental risks. Such combinations also provide an opportunity to enrich the repertoire of either of those disciplines.

My modest contribution is to conceptually outline one possible approach and apply it analytically to a particular empirical case. Following this analysis, it is possible to acknowledge what I see as key insights that are relevant to the three main conceptual areas of interest. First, I noted that knowledge and ignorance can be understood as situated and relational social processes. Throughout the empirical chapters, I subsequently demonstrated a number of individual epistemic limitations that consequently arise within environmental risk debates, with (ascriptions of) ignorance and non-knowledge emerging as active forces. I subsequently also showed how this relationality between knowledge and ignorance can form the basis of social differentiation and positioning. My proposition was to understand knowledge and ignorance as opposite poles of a large spectrum of sense-making. These insights contribute towards a more nuanced understanding of the role of knowing and not knowing in environmental risk debates. While knowledge has been a central concern for anthropologists, notions of ignorance and non-knowledge have so far received comparably limited attention. As contemporary environmental risk debates are increasingly marked by uncertainties, partial knowledge and unknowns, this gap in the anthropological repertoire deserves to be addressed.

Second, the anthropological analysis of knowing potential impacts from CSG developments drew out findings that are important in how they correspond to aspects of many contemporary manufactured risks. With those risks often emerging as the unintended and unanticipated by-products of the application of techno-scientific capabilities, my analysis highlighted the indispensable, yet ambiguous, role of scientific predictions. I stressed the respective limitations and

inseparable interplay of different ways of knowing in these contexts. I also demonstrated how living with manufactured risks, associated unknowns, and persisting scientific uncertainties can have profound implications for some actors' everyday lives. These insights are important for environmental risk controversies more generally. The accounts of social scientists with backgrounds in, for instance, Science and Technology Studies or Sociology oftentimes do not address the role of direct phenomenological or by-proxy experiences within the sense-making of local and other actors. However, these experiences are crucial components for knowing environmental risks, especially when scientific research and knowledge claims are ambiguous and contested. Some actors' "experience of the truly indeterminate" (Minnegal & Dwyer 2008: 79) is then frequently also not sufficiently explored. The anthropological insights developed in this thesis can therefore be seen to contribute towards an appreciation of the diverse ways and experiences of (not) knowing, particularly for those unfamiliar with anthropological perspectives.

I, thirdly, articulated how in this setting the sciences are situated practices that invoke the root metaphor of disembodied objectivity and that rely on ongoing boundary-work. From this understanding, my argument reinforced the notion that the sciences need to be analysed with a relational focus on the social contexts within which they emerge. My analysis examined the limitations, ambivalence and role of particular sciences in the context of Queensland's CSG risk debates. I also addressed the contestation of CSG-specific scientific research. While a large number of social scientific accounts acknowledge such contestations within environmental risk controversies, they oftentimes remain vague about how such contestations are formulated and of which aspects of scientific research. However, it is frequently not science *per se* that is contested, but specific aspects of the arrangements of scientific research. By drawing out the most salient of these aspects, my analysis highlighted the importance of carefully unpacking the substructures of ambivalence and contestation in any given context. These findings can be seen as a contribution towards the conceptual literature in anthropology and related disciplines as they provide a starting point for the analysis of contested science within similar risk controversies. The insights and conceptual approach I developed may then be generalisable to some degree. I hope that these generalisations contribute towards understanding similar cases of contested science and provide an opportunities to transform such disputes into constructive social debates.

In conclusion, I propose that this thesis advances a more extensive and multifaceted understanding of the epistemic challenges arising from CSG risk debates in particular and environmental controversies generally. My aim was to position the question of getting the science right within the wider context of (not) knowing risks. In doing so, I attempted to follow the path of numerous anthropologists of science and Science and Technology Studies scholars by deconstructing the use of scientific research and knowledge claims. At the same time, my intent was

to go beyond this narrow focus and examine the so-called 'public understanding of science' as well as the fundamental anthropological question of the problem of knowledge. However, to suggest a strict analytical separation between these aspects would be misleading as the boundaries and tensions between the production and uptake of science might be blurry and can, perhaps increasingly so, become an area of contestation. As noted in the Preface, I therefore aimed to find middle ground in between a truffle hunting anthropology of science and a parachutist anthropology of knowledge. I believe that a drive for more holistic and inter- or transdisciplinary approaches are warranted by the complexities of contemporary debates over manufactured environmental risks.

9.3. Implications for Environmental Risk Debates

In an edited volume on the politics of knowledge, Rubio and Baert (2012: 2) contend that "[k]nowledge has today become a source of questions that need to be politically answered, rather than just means to answer political questions". While such generalisations require elaboration and contextualisation, the findings from the analysis of Queensland's CSG risk debates support this view. In the context of contemporary environmental risk debates that emerge in many late industrial societies scientific knowledge claims and particularly associated uncertainties can become a focus and locus of contestation. This contestation occurs not just for emerging controversies or 'ground-up' political challenges but also in debates that for many actors seemed to be settled and, like climate change, "to rest on a rock-solid consensus among those most qualified to judge" (Jasanoff 2011: 129–130; also Oreskes & Conway 2010). At the time of writing, the Trump administration's justifications for intending to withdraw from the 2015 United Nations Climate Change Conference's Paris Agreement on climate change mitigation might serve as a case in point.

Despite many late industrial societies being suffused by science, it therefore appears that the notion of scientific knowledge claims and their social authority as the sole basis for decision- and policy-making can be misleading. Instead, a broad range of actors frequently demand justifications for particular scientific research practices and the role of their practitioners.[101] In this sense, scientific knowledge claims are (no longer) merely the *explanans* for political decision-making processes but, to some degree, also become an *explanandum* together with those processes. A crude linear model of progressing, independent science that informs evidence-based policies, and which is often accompanied by a public scientific deficit model, thus seems outdated (Jasanoff 2011, 2012; Pielke Jr. 2007). In addition to revealing these social and political limitations, the presented anthropological approach allowed to grasp the sciences' more fundamental epistemic limitations

[101] I cannot develop this argument further here, but such demands for justification and 'but why' questions are important elements of the social theories developed by those who analyse contemporary industrialised societies through the lens of 'reflexive modernity' (e.g., Beck *et al*. 2003).

within individuals' sense-making of environmental risks. At the same time, I highlighted the importance of scientific research and knowledge claims for knowing and addressing contemporary environmental risks that transcend and re-define phenomenological, spatial and temporal boundaries.

Within the contexts of increasingly complex and global manufactured risks, current and future social challenges then not only concern the status and role of science but knowledge more generally. As Weinberger (2011: 173) notes, members of many late industrial societies experience a crisis of knowledge. The resulting challenges are cultural as much as they are epistemic (Irwin & Wynne 1996; Jasanoff 2011). Following this thesis, one crucial cultural question emerges from the situated multidimensionality of (not) knowing in combination with a growing reliance on inevitably uncertain and frequently contested sciences. One the one hand, it is important to determine how social and political conduct can account for the different ways of knowing within inhabited lifeworlds, and for the diversity that results from this local situatedness. On the other hand, it is necessary to respond to the transboundary scale of contemporary environmental risks and find ways to incorporate the contributions of detached, global scientific perspectives — with all their merits and limitations. In short, it is important to find ways to bring different ways of knowing into dialogue.

In regard to the ongoing climate change controversy, Jasanoff (2011) outlines one such approach. She advocates for "cosmopolitan knowledge that recognizes and respects justifiable differences" and that "may hold more promise for a global world than approaches that stress the purified integrity of experts and disciplines to the detriment of plurality of opinion" (*ibid.*: 140). The notion of cosmopolitanism has been promoted by a number of well-known social scientists (e.g., Beck 2006, 2009; Rorty 1991: 211–222), but its homogenising and universalising rhetoric is likely problematic from an anthropological perspective (Dwyer & Minnegal 2006; Jasanoff 2011: 131). While I do not advocate a cosmopolitan approach to address environmental risk debates, Jasanoff's argument nonetheless highlights the challenges created by the transboundary character of contemporary environmental risks. That is, how to bring into dialogue individual local particularities and ways of knowing with scientific knowledge that corresponds to increasingly global scales and transnational developments? Furthermore, how can this dialogue be achieved in a socially just and equitable manner?

These ongoing challenges ultimately require social and cultural resolutions deriving from a critical assessment of current political processes and institutional arrangements. In this sense, the challenges may have evolved but not fundamentally changed since Wynne (1996a: 78, original emphasis) noted two decades ago that (cf. Ingold 2016):

> The environment and risk debates around which much of modern politics has been shaped are quintessentially tied up with the larger crises of legitimacy of modern economic, scientific-technical and political institutions, and the search for new forms of legitimate order and authority. In this it seems that new forms of emergent political order, with new configurations of global vision and local rootedness, will emerge - are perhaps emerging - in which new imaginations of the relationship between universal knowledge and human values will be vital. … The romantic seductions of local knowledges and identities do not come as an *alternative* to modernity's ahuman and alienating universals, but as an inspiration to find the collective self-conceptions which can sustain universals that do not bury the traces of their own human commitment and responsibility.

Drawing polarising distinctions between local and scientific ways of knowing in an attempt to critique the latter and protect the former can therefore be misleading. It is then not about abandoning particular ways of knowing or advocating them against each other. Instead, it is crucial to accept the challenge of establishing an ongoing dialogue between science and other ways of knowing, of openly debating the limitations and merits of these diverse ways of knowing, and of creating procedures for functional conflict over environmental risks and envisioned futures.

These are essential cultural questions concerning the central 'problem of knowledge' in anthropology from which this enquiry began (Boyer 2005; Crick 1982). Those challenges also highlight the increasingly ambiguous relationship between science, politics and society. This complex relationship needs to be defined through politically, socially and culturally sensitive processes that respect both the limits of science and epistemic diversity (Bocking 2004: 226–228; Satterfield 2002: 160–171). To tackle these questions, Ingold (2014a: 236) reminds us, it is necessary to appreciate that the "rootedness of scientific inquiry in our inhabitation of the earth, its general messiness and incoherence, is something to be celebrated, not suppressed. … Only by doing so … can scientific knowledge and the wisdom of inhabitants meet in the common project of designing environments for life". Anthropologists are well-equipped to reflexively and critically address these fundamental questions of knowledge in contemporary life, which for many people involves a confrontation with ecological limits and the consequences of human activities on earth. In doing so, anthropologists must remain open to the complexities at hand and engage in productive dialogues with other disciplinary fields, diverse and increasingly eclectic methodologies, and the growing bodies of inter- and transdisciplinary literature. I hope that the insights in this thesis contribute towards this pressing agenda.

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11. Appendices

11.1. Appendix 1: Photo Essay of the Western Downs

Image 24 The open country near Wandoan (top) and Chinchilla (bottom) (source: author 2015)

Image 25 Prominent land uses: cotton field near Dalby (top) and feedlot near Miles (bottom) (source: author 2015)

Image 26 A quiet property near Miles (top) and a day at the rodeo in Wandoan (bottom) (source: author 2015)

Image 27 A moment of tranquillity after the annual rodeo in Wandoan (source: author 2015)

11.2. Appendix 2: Photo Essay of Coal Seam Gas in the Western Downs

Image 28 Gas-fired Condamine Power Station near Miles (top) and a CSG company's office building in Chinchilla (bottom) (source: author 2015)

Image 29 Parts of a CSG well (top) and an operating CSG well near Miles (bottom) (source: author 2015)

Image 30 Signs of resistance near Chinchilla (top) and near the Tara Estates (bottom) (source: author 2015)

Image 31 Two KNAGs in Chinchilla (top) and Lock the Gate paraphernalia at a protest in Brisbane (bottom) (source: author 2015)