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The Perception of Community Conflict Over Coal Seam Gas in the Western Downs, Queensland, Australia.

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The Perception of Community Conflict Over Coal Seam Gas in the Western Downs, Queensland, Australia

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Abstract

The Western Downs, Queensland, where some of Australia's earliest CSG extraction wells were productive at a large scale, now ~90% of one quarter of the global LNG supply comes from the Surat and Bowen Basins. The Western Downs is witness to the full gambit of rural communities and the CSG industry's interplay and attempts at co-existence. CSG extraction production began in 1995, it became a controversial topic around 2009. The controversy centred around water and access to stakeholder land. The gas industry possesses leased tenements they have acquired from the Queensland Government to major portions of the Western Downs permitting them to extract CSG from this land, most often on existing farmed land. To get to the coal seam(s) the gas company's drilling rigs need to drill down often over 200 to 3,000 metres through groundwater, varying geological strata and freshwater aquifers. The productive life of a CSG well can be up to 30 years in some cases, but often less. Fracking the coal seam is sometimes used to stimulate and extend CSG well productivity.

The controversy, community conflict and polarisation of opinion on CSG extraction impacts in the Western Downs, primarily regarding human and environmental health are examined. The use of an anonymous questionnaire has been employed to ensure and protect the confidentiality of the four stakeholder interest participant groups. The stakeholders: community group members; community individual participants; Australian Government officials; and gas industry employees. Social impact assessment, social licence and corporate social responsibility are discussed combined with a novel peacebuilding framework considered as a source of possible solutions. The findings on CSG extraction impacts on water systems are perceived as negative and the reason for the related perceived rural community conflict and polarisation of opinion in the Western Downs, Queensland, Australia. The means of mitigation are discussed with recommendations, together with the limitations of the study.

Key words

Western Downs, Queensland, coal seam gas (CSG), conflict and polarisation, water impacts, human and environmental impacts, social impact assessment, fracking, contamination.

Declaration of Author

This thesis is submitted to Bond University in fulfilment of the requirements of the degree of Doctor of Philosophy.

This thesis represents my own original work towards this research degree and contains no material that has previously been submitted for a degree or diploma at this University or any other institution, except where due acknowledgement is made.

July 2021
Date

Joseph Matthew Stroud

Ethics declaration

The research associated with this thesis received ethics approval from the Bond University Human Research Ethics Committee. Ethics application number JS00398.

Copyright declaration

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List of Abbreviations, Acronyms and Symbols IESC (2014*c* p. 10)

General abbreviations	Description
ABARE	Australian Bureau of Agricultural and Research Economics
ANZECC	Australia and New Zealand Environment Conservation Council
ARD	Acid rock drainage
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AVIRA	Aquatic value identification and risk assessment
BN	Bayesian Network
BTEX	Benzene, toluene, ethylbenzene and xylene compounds
C_2H_6	Chemical formula for ethane
CBM	Coal bed methane
CH_4	Chemical formula for methane
CIAT	Cumulative impacts assessment tool
cm	Centimetre
CO_2	Chemical formula for carbon dioxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSG	Coal seam gas
CWMP	Coal seam gas water management plan
DO	Dissolved oxygen
DVWSS	Dawson Valley Water Supply Scheme
EC	Electrical conductivity
ED	Electrodialysis
EDR	Electrodialysis reversal
EIS	Environmental impact statement
EPA	Environment Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
ERA	Ecological risk assessment
ERASC	Ecological Risk Assessment Support Centre
FRP	Filterable reactive phosphorus
GA	Geoscience Australia
GAB	Great Artesian Basin

General abbreviations	Description
GAC	Granular activated carbon
GDP	Gross domestic product
GL	Gigalitre (1000 million litres)
GRIDD	Groundwater and Resource Information for Development Database
H_2O	Chemical formula for water
IESC	Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development
IQQM	Integrated quantity quality model
LNG	Liquefied Natural Gas
L/s	Litre per second
m	Metre
MDB	Murray-Darling Basin
mg	Milligram
ML	Megalitre (1 million litres)
mm	Millimetre
MNES	Matters of National Environmental Significance
NH_3	Un-ionised ammonia
nm	Nanometre
NO_2	Nitrite
NO_3	Nitrate
NSW	New South Wales
NTU	Nephelometric turbidity units
NVDI	Normalised Vegetation Difference Index
NWQMS	National Water Quality Management Strategy
OWS	Office of Water Science
PCU	Platinum-cobalt units
PJ	Petajoules
PRA	Probabilistic risk assessment
RO	Reverse osmosis
RQ	Risk quotient
SAR	Sodium adsorption ratio
SS	Suspended Solids
TDS	Total dissolved solids (a measure of salinity)

Additional Abbreviations and Acronyms

BREE	**Commonwealth Bureau of Resources and Energy Economics**
BUREM	**Bond University Research Ethics Manual**
DEEDI	**Queensland Government, Department of Employment, Economic Development and Innovation**
DERM	**Queensland government, Department of Resource Management**
DFO	**Canadian Department of Fisheries and Ocean**
GDE	**Groundwater Dependant Ecosystems**
GISERA	**Gas Industry Social and Environmental Research Alliance**
GFCQ	**Gas Fields Commission Queensland**
KCB	**Klohn Crippen Berger**
OCE	**Office of the Chief Economist**
OGIA	**Office of Groundwater Impact Assessment**
MNES	**Matter of National Environmental Significance**
NICNAS	**National Industrial of Chemicals Notification and Assessment Scheme**
NTN	**National Toxics Network**
UQ-CCSG	**University of Queensland Centre for Coal Seam Gas**
SEWPaC	**Commonwealth Department of Sustainability, Environment, Water, Population and Communities**
SIA	**Social Impact Assessment**
SIMP	**Social Impact Management Plan**

General abbreviations	Description
TN	Total nitrogen
TOC	Total organic carbon
TP	Total phosphorus
TWS	Town water supply
US EPA	United States Environmental Protection Agency
USA	United States of America
WCM	Walloon Coal Measures
WRP	Water resource plan
WTP	Water treatment plant

Source: IESC, (2014*c*) table, retrieved from https://www.environment.gov.au/about-us/publications/archive#water

GLOSSARY IESC (2014*a*, pp.18-25)

Adsorption	The reversible binding of molecules to a particle surface. This process can bind methane and carbon dioxide, for example, to coal particles.
Advection	The process whereby solutes are transported by the bulk mass of flowing fluid.
Alkalinity	The quantitative capacity of aqueous media to react with hydroxyl ions. The equivalent sum of the bases that are titratable with strong acid. Alkalinity is a capacity factor that represents the acid-neutralising capacity of an aqueous system.
Analytical or numerical methods	Methods based on applying mathematical solutions derived from first principles to calculate how the rock mass will behave when an excavation is made within it.
Anisotropy	The condition of having different properties in different directions.
Anthropogenic	Relating to, or resulting from, the influence of human beings on nature.
Anticline	In structural geology, an anticline is a fold that is convex up and has its oldest beds at its core.
Aperture	Hole or opening.
Aquiclude	A hydrogeologic unit which, although porous and capable of storing water, does not transmit it at rates sufficient to furnish an appreciable supply for a well or spring.
Aquifer	Rock or sediment in formation, group of formations or part of a formation, that is saturated and sufficiently permeable to transmit quantities of water to wells and springs.
Aquifer connectivity	The degree to which groundwater can transfer between two adjacent aquifers or to the surface.
Aquifer discharge	Water leaving an aquifer.
Aquifer recharge	The amount of water replenishing an aquifer over a given time period.
Aquitard	A saturated geological unit that is less permeable than an aquifer and incapable of transmitting useful quantities of water. Aquitards often form a confining layer over an artesian aquifer.
Artesian	Pertaining to a confined aquifer in which the groundwater is under positive pressure (i.e. a bore screened into the aquifer will have its water level above-ground).
Aquatic ecosystem	Any watery environment from small to large, from pond to ocean, in which plants and animals interact with the chemical and physical features of the environment.
Bore/borehole	A narrow, artificially constructed hole or cavity used to intercept, collect or store water from an aquifer, or to passively observe or collect groundwater information. Also known as a borehole, well or piezometer.
Brecciation	The formation of breccia. Breccia is a rock made up of very angular coarse fragments; may be sedimentary or may be formed by grinding or crushing along faults.

Casing	A tube used as a temporary or permanent lining for a bore. *Surface casing*: the pipe initially inserted into the top of the hole to prevent washouts and the erosion of softer materials during subsequent drilling. Surface casing is usually grouted in and composed of either steel, PVC-U, or composite materials. *Production casing*: a continuous string of pipe casings that are inserted into or immediately above the chosen aquifer and back up to the surface through which water and/or gas are extracted/injected.
Cataclasis	The progressive fracturing and comminution of existing rock, which results in the formation of cataclastic rock. Cataclastic rock is mainly found associated with fault zones.
Clastic sediments	Composed predominantly of broken pieces or clasts of older weathered and eroded rocks.
Clay drapes	Thin irregularly shaped layers of low-permeability material that are often observed in different types of sedimentary deposits.
Cleats - butt cleats	Fractures that are perpendicular, or at a high angle, to the coal seam bedding planes.
Cleats - face cleats	Thin fractures that are perpendicular, or at a high angle, to the coal seam bedding planes but also orthogonal to the butt cleats.
Coal seam	Sedimentary layers consisting primarily of coal. Coal seams store both groundwater and gas and generally contain saltier groundwater than aquifers that are used for drinking water or agriculture.
Coal seam gas	A form of natural gas (generally 95-97 per cent pure methane, CH4) typically extracted from permeable coal seams at depths of 300–1000 m.
Compaction	The process by which geological strata under pressure reduce in thickness and porosity and increase in density.
Compressibility	A parameter that determines the potential for compaction. Compressibility is typically high for soft clays, intermediate for sands, low (but variable) for coals, very low for consolidated sedimentary rocks such as sandstones and mudstone, and extremely low for competent rocks such as granites and other intrusions.
Compression	A system of forces or stresses that tends to decrease the volume or shorten a substance, or the change of volume produced by such a system of forces.
Confined aquifer	An aquifer bounded above and below by confining units of distinctly lower permeability than that of the aquifer itself. Pressure in confined aquifers is generally greater than atmospheric pressure.
Contaminant	Biological (e.g. bacterial and viral pathogens) and chemical (see Toxicants) introductions capable of producing an adverse response (effect) in a biological system, seriously injuring structure or function or producing death.
Co-produced water	The water that is pumped out of coal seams in order to extract coal seam gas. Also referred to as produced water and associated water. Over time, the volume of produced water normally decreases and the volume of produced gas increases.

Cretaceous period	A period of geologic time, 145 million to 66 million years ago.
Darcy flow equation	The equation that describes the rate and quantity of groundwater flow.
Depressurisation	The lowering of static groundwater levels through the partial extraction of available groundwater, usually by means of pumping from one or several groundwater bores.
Desorption	The release of a bound molecule from a host particle into a flowing medium such as a liquid or gas.
Devonian age	A period of geologic time, 419.2 million to 358.9 million years ago.
Dewatering	The lowering of static groundwater levels through complete extraction of all readily available groundwater, usually by means of pumping from one or several groundwater bores.
Diachronic nature	The study of the changes in nature over a period of time.
Diffusion	Process whereby ionic or molecular constituents move under the influence of their kinetic activity in the direction of their concentration gradient.
Dilution	Dilution is the process of making a substance less concentrated by adding water. This can lower the concentrations of ions, toxins and other substances.
Discretisation	Size of blocks and time segments for which the groundwater flow equations will be solved.
Dispersion	When water with high solute concentrations mixes with water with low solute concentrations as flow velocities in a porous medium vary, leading to a reduction of concentration at the macroscopic scale.
Dispersivity	A geometric property of a porous medium which determines the dispersion characteristics of the medium by relating the components of pore velocity to the dispersion coefficient.
Drawdown	The reduction in groundwater pressure caused by extraction of groundwater from a confined formation, or the lowering of the water-table in an unconfined aquifer.
Effective porosity	The fraction of pores that are connected to each other and contribute to flow. Materials with low or no total porosity can become very permeable if a small number of highly connected fractures are present.
Effective stress	Stress applied between the solid matrix materials of rocks and soils. The effective stress of a reservoir or coal seam is the difference between the total stress and the pore pressure. Also known as stress relief.
Electromagnetics	Relating to electromagnetism, which is a force described by electromagnetic fields, and has innumerable physical instances including the interaction of electrically charged particles and the interaction of uncharged magnetic force fields with electrical conductors.
Elliptical	Related to, or having, the shape of an ellipse.
Equipotential line	Line along which the potential is constant.
Fault	A planar fracture or discontinuity in a volume of rock, across which there has been significant displacement along the fractures as a result of earth movement.

Flowback	The fluid that flows back, or is pumped back, to surface following hydraulic fracturing but prior to gas production.
Fracture	The separation of an object or material into two, or more, pieces under the action of stress.
Gamma-ray spectrometry	An instrument for measuring the distribution (or spectrum) of the intensity of gamma radiation versus the energy of each photon.
Geologic stratum	A layer of sedimentary rock or soil with internally consistent characteristics that distinguish it from other layers. The 'stratum' is the fundamental unit in a stratigraphic column and forms the basis of the study of stratigraphy.
Geological layer	A layer of a given sample. An example is Earth itself. The crust is made up of many different geological layers which are made up of many different minerals/substances. The layers contain important information as to the history of the planet.
Geological window	A geologic structure formed by erosion or normal faulting on a thrust system. In such a system the rock mass (hanging wall block) that has been transported by movement along the thrust is called a nappe. When erosion or normal faulting produces a hole in the nappe where the underlying autochthonous (i.e. un-transported) rocks crop out this is called a window. Windows can be almost any size, from a couple of metres to hundreds of kilometres.
Groundwater	Water occurring naturally below ground level (whether in an aquifer or other low permeability material), or water occurring at a place below ground that has been pumped, diverted or released to that place for storage there. This does not include water held in underground tanks, pipes or other works.
Groundwater injection bore	A bore installed to facilitate the injection of liquid (for example, H_20) or gas (for example, CO_2) into an aquifer. Commonly used in Managed Aquifer Recharge schemes or groundwater remediation.
Groundwater monitoring/ observation bore	A bore installed to: determine the nature and properties of subsurface groundwater conditions; provide access to groundwater for measuring level, physical and chemical properties; permit the collection of groundwater samples; and/or to conduct aquifer tests.
Groundwater pumping/production bore	A bore installed with the primary purpose to extract groundwater for productive use from a particular hydrogeological formation.
Heterogeneity	Composition from dissimilar parts.
Hydraulic conductivity	The rate at which a fluid passes through a permeable medium.
Hydraulic fracturing	Also known as 'fracking', 'fraccing' or 'fracture simulation', is the process by which hydrocarbon (oil and gas) bearing geological formations are 'stimulated' to enhance the flow of hydrocarbons and other fluids towards the well. The process involves the injection of fluids, gas, proppant and other additives under high pressure into a geological formation to create a network of small fractures radiating outwards from the well through which the gas, and any associated water, can flow.

Hydraulic gradient	The change in hydraulic head between different locations within or between aquifers or other formations, as indicated by bores constructed in those formations.
Hydraulic head	The potential energy contained within groundwater as a result of elevation and pressure. It is indicated by the level to which water will rise within a bore constructed at a particular location and depth. For an unconfined aquifer, it will be largely subject to the elevation of the water table at that location. For a confined aquifer, it is a reflection of the pressure that the groundwater is subject to and will typically manifest in a bore as a water level above the top of the confined aquifer, and in some cases above ground level.
Hydraulic pressure	The total pressure that water exerts on the materials comprising the aquifer. Also known as pore pressure.
Hydrodynamic dispersion	The spreading (at the macroscopic level) of the solute front during transport resulting from both mechanical dispersion and molecular diffusion.
Hydrogeology	The area of geology that deals with the distribution and movement of groundwater in the soil and rocks of the Earth's crust (commonly in aquifers).
Hydrology	The study of the movement, distribution and quality of water on Earth and other planets, including the hydrologic cycle, water resources and environmental watershed sustainability.
Hydrostratigraphic unit	Means any soil or rock unit or zone which by virtue of its porosity or permeability, or lack thereof, has a distinct influence on the storage or movement of groundwater.
Inter-aquifer leakage	Groundwater interaction between aquifers that are separated by an aquitard.
Intra-aquifer leakage	Groundwater interaction between different parts of the same aquifer. the lateral migration of fluids and solutes within an aquifer
Intrinsic permeability	The property of a porous medium itself that expresses the ease with which gases, liquids, or other substances can pass through it.
Isotropy	The condition in which the property or properties of interest are the same in all directions.
Jurassic period	A period of geologic time, 201.3 million to 145 million years ago.
Lineaments	Linear surface expressions of subsurface fracture zones, faults and geological contacts.
Lithology	The lithology of a rock unit is a description of its physical characteristics visible at outcrop, in hand or core samples or with low magnification microscopy, such as colour, texture, grain size, or composition.
Lithostratigraphy	A sub-discipline of stratigraphy, the geological science associated with the study of strata or rock layers. Major focuses include geochronology, comparative geology, and petrology. In general, a stratum will be primarily igneous or sedimentary relating to how the rock was formed.
Major unconformities	Prolonged periods of erosion without deposition of sediments

Mesozoic era	An era of geologic time, 252.2 million to 66 million years ago.
Microseismic monitoring	The monitoring of very slight tremors or quiverings of the earth's crust that are not related to an earthquake, usually from anthropogenic causes.
Mineback mapping	Observations of fractures within mining coal seams that were previously hydraulically fractured
Miocene	An epoch of geologic time, 23.03 million to 5.332 million years ago.
MODFLOW	A 'finite difference' numerical groundwater flow modelling code.
Molecular diffusion	The process whereby solutes are transported at the microscopic level due to variations in the solute concentrations within the fluid phases.
Overburden	Material of any nature, consolidated or unconsolidated, that overlies a deposit of useful materials such as ores or coal, especially those deposits that are mined from the surface by open-cut methods.
Palaeozoic	An era of geologic time, 541 million to 252.2 million years ago.
Peclet number	A relationship between the advective and diffusive components of solute transport expressed as the ratio of the product of the average interstitial velocity, times the characteristic length, divided by the coefficient of molecular diffusion; small values indicate diffusion dominance, large values indicate advection dominance.
Permeability	The measure of the ability of a rock, soil or sediment to yield or transmit a fluid. The magnitude of permeability depends largely on the porosity and the interconnectivity of pores and spaces in the ground.
Permeate	To spread or flow throughout.
Permian	The period of geologic time, 298.9 million to 252.2 million years ago.
Perturbation	Changes in the nature of alluvial deposits over time.
Phreatic	Matters relating to groundwater.
Physico-chemical parameters	Relating to both physical and chemical characteristics.
Pore-fluid pressure/pore pressure	See Hydraulic Pressure.
Porosity	The proportion of the volume of rock consisting of pores, usually expressed as a percentage of the total rock or soil mass.
Potentiometric surface	An imaginary surface representing the static head of groundwater and defined by the level to which water will rise in a tightly cased well.
Production well	A well drilled to produce oil or gas.
Proppant	A solid material, typically treated sand or man-made ceramic materials, designed to keep an induced hydraulic fracture open, during or following a fracturing treatment.
Quaternary	The period of geologic time, 2.500 million to zero million years ago.
Radiometrics	A measure of the natural radiation in the earth's surface, which can tell us about the distribution of certain soils and rocks.
Reinjection bores	See Groundwater injection bores.

Retardation	Retardation is a general term for processes that cause the solute front to move slower than the advective flow velocity. This can be caused by sorption, when ions or charged molecules become bound to the surface of aquifer or aquitard minerals, or reversible chemical reaction, or diffusion of solutes into pores that do not contribute to flow (adsorption).
Saturated zone	That part of the earth's crust beneath the regional water table in which all voids, large and small, are filled with water under pressure greater than atmospheric.
Screen	The intake portion of a bore, which contains an open area to permit the inflow of groundwater at a particular depth interval, whilst preventing sediment from entering with the water.
Sediment	A naturally occurring material that is broken down by processes of weathering and erosion, and is subsequently transported by the action of wind, water, or ice and/or by the force of gravity acting on the particle itself.
Shearing	The relative, near horizontal or low angle movement between two sections of a rock stratum or a number of strata due to failure of the rock along a shear plane.
Slug test	A particular type of aquifer test where water is quickly added (i.e. slug test or falling head) or removed (i.e. bail test or rising head) from a groundwater well and the change in hydraulic head is monitored through time, to determine the near-well aquifer characteristics.
Solute	The substance present in a solution in the smaller amount. For convenience, water is generally considered the solvent even in concentrated solutions with water molecules in the minority.
Specific storage	The amount of water that a portion of an aquifer releases as a result of changes in the hydraulic head usually through pumping.
Specific yield	A ratio indicating the volume of water that an aquifer will yield when all the water is allowed to drain out of it under the forces of gravity.
Storativity	A dimensionless ratio that relates to the volume of water that is released per unit decline in pressure head for a defined vertical thickness of the formation.
Stratigraphy	A branch of geology which studies rock layers (strata) and layering (stratification).
Subduction	The process that takes place at convergent boundaries by which one tectonic plate moves under another tectonic plate and sinks into the mantle as the plates converge.
Subsidence	Usually refers to vertical displacement of a point at or below the ground surface. However, the subsidence process actually includes both vertical and horizontal displacements. These horizontal displacements, in cases where subsidence is small, can be greater than the vertical displacement. Subsidence is usually expressed in units of millimetres (mm).
Sodium Adsorption Ratio	The ratio of sodium to calcium and magnesium in water. Water with high SAR causes dispersion of soil particles, loss of the ability of the soil to form stable aggregates and a reduction in infiltration and permeability

	with consequences for crop production. Water with high SAR requires treatment if it is to be suitable for irrigation.
Sorption	A physical and chemical process by which one substance becomes attached to another.
Stratification	The formation of density layers (either temperature or salinity derived) in a water body through lack of mixing. It can create favourable conditions for algal blooms and can lower dissolved oxygen levels in the bottom layers with the associated release of nutrients, metals and other substances.
Tension	A system of forces which stretch rocks in two opposite directions. The rocks become longer in a lateral direction and thinner in a vertical direction. One important result of tensile stress is that it creates joints or fractures in the rock. Tensile stress is rare because most subsurface stress is compressive, due to the weight of the overburden.
Tertiary	A geologic period (from 66 million to 2.588 million years ago) that is no longer recognized as a formal unit by the International Commission on Stratigraphy but is still widely used.
Tiltmeter	An instrument designed to measure very small changes from the vertical level, either on the ground or in structures.
Toxicant	A chemical capable of producing an adverse response (effect) in a biological system at concentrations that might be encountered in the environment, seriously injuring structure or function or producing death. Examples include pesticides and heavy metals.
Triassic	The period of geologic time, 248 million to 206 million years ago.
Triaxial cell	An apparatus that applies stress to a core in three dimensions and is able to subject a sample to its original in situ stresses.
Unconfined aquifer	An aquifer which has the upper surface connected to the atmosphere.
Unconsolidated sediments/materials	Sediments or materials that are not bound or hardened by mineral cement, pressure or thermal alteration.
Vadose zone	The 'unsaturated' zone, extending from the top of the ground surface to the water table. In the vadose zone, the water in the soil's pores is at atmospheric pressure.
Viscosity	A measure of a fluid's resistance to gradual deformation by shear stress or tensile stress. For liquids, it corresponds to the informal notion of 'thickness'. For example, honey has a higher viscosity than water.
Water quality	The physical, chemical and biological attributes of water that affects its ability to sustain environmental values.
Water quantity	Water quantity describes the mass of water and/or discharge and can also include aspects of the flow regime, such as timing, frequency and duration.
Water table	The upper surface of a body of groundwater occurring in an unconfined aquifer. At the water table, pore water pressure equals atmospheric pressure.

Well	A human-made hole in the ground, generally created by drilling, to obtain water (also see bore).
Yield	The rate at which water (or other resources) can be extracted from a pumping well, typically measured in litres per second (L/s) or megalitres per day (ML/d).

Source: IESC, (2014*c*) table, retrieved from https://www.environment.gov.au/about-us/publications/archive#water

CHAPTER 1: Introduction

1.1 Background of the Study

Australia has the largest and deepest artesian basin in the world, The Great Artesian Basin (GAB). Which consists, in some cases, of water over millions of years old, of many and varied quantities and qualities, and is connected by water bearing aquifers to other major basins, such as: the Bowen; Clarence-Moreton; Galilee; and Surat Basins (Exon, 1976; Independent Expert Scientific Committee on CSG and Large Mining Development (IESC, 2014*a*, *c*).

Coal seam gas (CSG) is a natural gas adsorbed in pore spaces and fractures of coal seams. Australia's eastern seaboard states, principally Queensland but including New South Wales (NSW) have rich deposits of black coal and other sources of onshore petroleum resources, such as CSG in coal seams (measures). Full scale CSG production began in the Western Downs, Queensland in 1995 (Geosciences and BREE, 2012; Moore, 2012; Davies *et al.*, 2015; Mudd, 2015; IESC, 2014*a*, *b*, *c*, *d*; Geosciences, 2018; Queensland Government, 2019). The greatest volumes of CSG occur in the Surat and Bowen Basins (Figure 1.1).

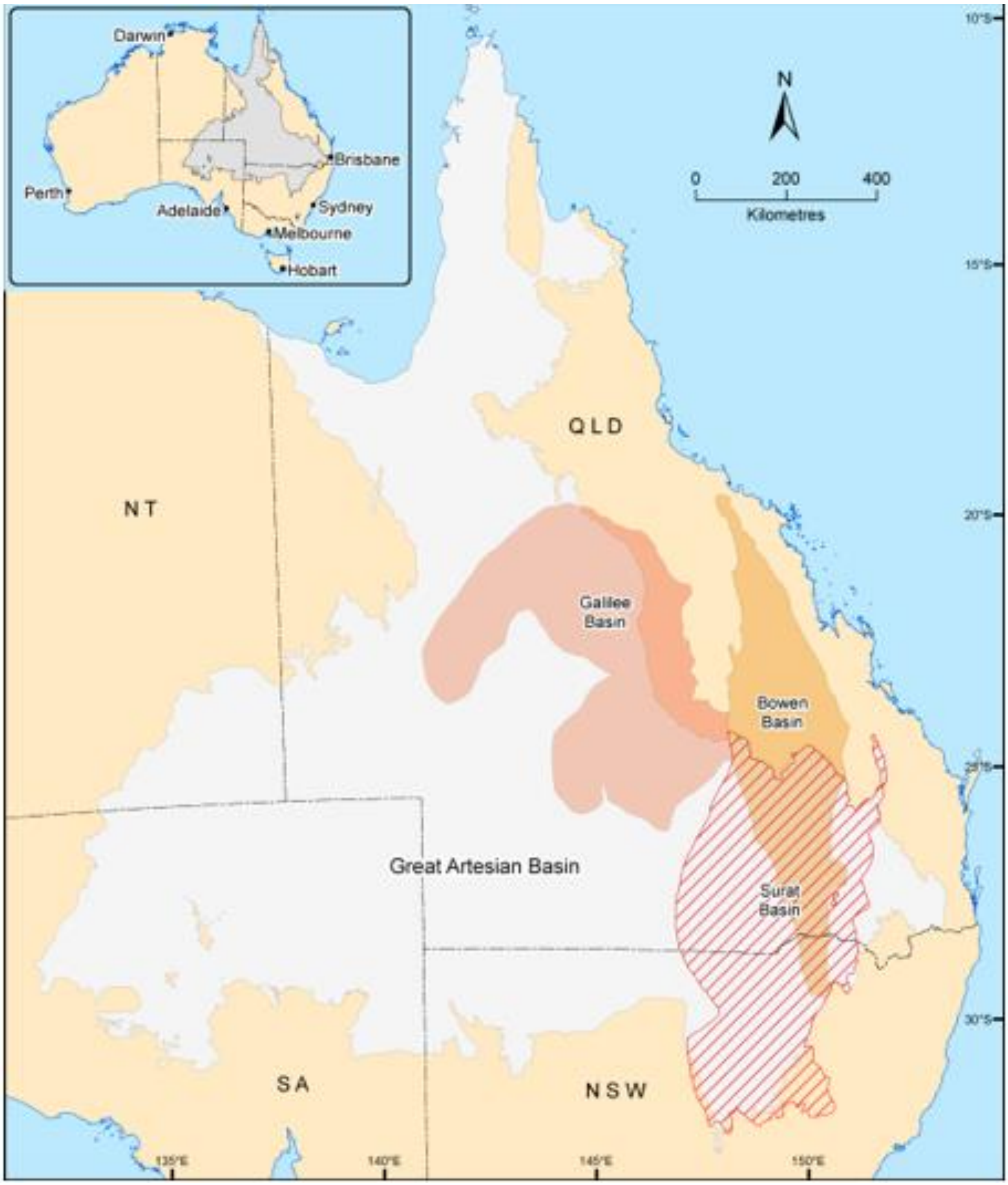

Figure 1.1: Location of the Great Artesian Basin, Surat Basin, and Underlying Bowen and Galilee Basins

Source: IESC, (2014*a*) figure, retrieved from https://www.environment.gov.au/about-us/publications/archive#water Creative Commons Licence CC BY 4.0

CSG is primarily methane, hydrocarbons and carbon dioxide found '*in situ'* in groundwater, held in suspension, in the water basin's geologic coal composite strata in seams. The porous coal seams have fractures, or cleats, and pores (Moore, 2012; KCB, 2011*c*; IESC, 2014*a*, *d*; Davies *et al*., 2015; Ferrer and Thurman, 2015; Askarimarnini, 2017). The hydrostatic pressure in the coal seams and geologic strata contains the CSG. The internal surface area of coal seams can retain ~7 times the volume of conventional gas sources (Nuccio, 2000; Cherry *et al*., 2004; Moore, 2012; IESC, 2014*b, d*; Askarimarnini, 2017). CSG is identified as unconventional gas (other types are shale[1] and tight[2] sand) requiring advanced technology for gas extraction.

CSG consists of organic matter such as flora found in sedimentary basins principally during the Permian era between 250-290 million years old. CSG can be biogenic, geogenic and thermogenic, and mixtures of all three (Moore, 2012; Taulis and Milke; 2013, Davies *et al*., 2015; Mudd, 2015; IESC, 2014*a*).

Biogenic and thermogenic methane are also continuously created and destroyed due to changes in temperature, coal seam constituents and ecosystem, allowing for the possibility of renewable energy production from coal seams (Moore, 2012; Singh *et al*., 2012). CSG supplies energy to homes and industry throughout Australia and is transported by pipelines to processing plants where it is purified into liquified natural gas (LNG) for exporting to China, Japan, and Korea (IESC, 2014*a, d*).

Fracking (fraccing), invented in the USA by the Halliburton Corporation in the 1940s, allows the drill to change directions from the traditional vertical to horizontal drilling, enabling access to the rich source of fuel energy found in coal seams, or measures (Haliburton, 2011; Denny, 2011; CSIRO, 2012*a*). This generated a global ‘gas rush’ starting in the USA and later Queensland, Australia around 1995. However, CSG exploration began as early as 1976 in the Bowen Basin, Queensland (Moore, 2012; IESC, 2014*d*; WA Onshore Gas, 2014; Davies *et al*., 2015). Fracking of coal bearing geological strata to extract CSG (less than 92% methane (CH_4) is not economically viable for mining), or coalbed methane (CBM), is seen as an ‘amazing turn around’ in energy efficiency in this ‘cleanest’ of the petroleum fuel derivatives in its impacts on human and environmental health, and as having potentially extensive, long term economic opportunities of 20-30 years for Australia (Queensland Government, March 2013, 2013*a*, 2019; Cheshire *et al*., 2014; Huth *et al*., 2014; IESC, 2014*d*; Measham and Fleming, 2014; Davies *et al.,* 2015; Fleming and Measham, 2015*a*, *b*; Towler *et al*., 2016; Keywood *et al*., 2018; Nelson, 2019).

Foot note. 1. Shale gas is mostly found trapped in deep layers of sedimentary shale rocks. 2. Tight gas is found trapped in deep (2-5 kms.) sandstone or limestone formations with relatively low permeability.

Australia's principal CSG reserves are located in Queensland's Bowen and Surat Basins (Moore, 2012; Hamawand and Hamawand, 2013, 2014; SEWPaC, 2013; Queensland Government, 2013; March 2013, 2019; Commonwealth of Australia, IESC, 2014*a*, *b*, c, *d*; Davies *et al.,* 2015; Geosciences, 2018; Australian Government, 2019). Since March 2016, central west Queensland's Galilee Basin, has been receiving attention from the gas industry for its potential as a source of CSG.

1.2 Study Rationale

The CSG extraction is a large and growing in Queensland. There is an ongoing concern in the Western Downs over the potential of CSG industry's perceived benefits and impacts, regarding human and environmental health. The failure of the government and industry to resolve these concerns has attributed to the negative attitudes towards the industry and the polarisation of community opinion in the Western Downs. There is a need for research to be undertaken to better understand the basis of community concerns, address the underlying causes of conflict, and develop workable conflict resolution strategies. The study rationale briefly is supported by the following information and the thesis is founded and expands upon these concepts.

Australian CSG production has grown from zero in 1995, to 10% of the natural gas used in Australia in 2012 (30% of the eastern seaboard gas supply) and a quarter of global production for LNG (2018), and a major export (Moore, 2012; Hamawand and Hamawand, 2013; Davies *et al*., 2015; Queensland Government, 2019). The LNG is transported almost continuously in purpose made tankers; via the Great Barrier Reef Marine Park (GBRMP) (DIP, 2013; Queensland Government, March 2013; IESC, 2014*c*). In Australia CSG well fields, consisting of tens or more of CSG wells, are often drilled 250-3,000 metres deep and sometimes over 3,000 metres, through numerous types of geological strata and potable aquifers to access coal seams (measures) often only 1.5-2 metres wide (may be over 5 metres), but extensively below, within, and above the huge water basins in Queensland. There are many thousands of CSG wells in Queensland, with some ~50,000 proposed CSG wells (Queensland Government, March 2013, 2015, 2019; Huth *et al*., 2014; IESC 2014*a, b, c, d*; Towler *et al.*, 2016; Nelson, 2019).

In Queensland, co-produced water is often kept in tanks or evapouration ponds, up to several kilometres in surface area. It can be transported to treatment plants for processing for potential land use purposes (Hamawand and Hamawand, 2013, 2014; DIP, 2013; IESC, 2014*b*, *c*, *d*; DNRM, 2015*a*, *c*). Co-produced water may be treated in onsite infrastructure, transported away, or discharged into water courses, and dispersed on to land (CSIRO, 2011 2012*b*; DNRM, 2015*a*, *c*; Lester *et al*., 2015).

In May 2012, the Interim Independent Expert Scientific Committee on CSG and large mining development (IIESC) was established by the Commonwealth of Australia. In 2013, the IIESC became the Independent Expect Scientific Committee on CSG and large mining development (IESC). In 2018, the Department of Energy and the Environment has this administration. The lack and gaps in knowledge surrounding CSG and mining prompted this:

'A substantial challenge for the IESC is the lack of appropriate 'baseline' data and other significant information' (Queensland Government, March 2013; IESC, 2014*b, c, d*; NSW Government, 2014*a*).

During the urgency to exploit CSG, many thousands of wells or bores have been drilled. Many are unproductive for CSG extraction, and have and are being simply decommissioned or abandoned, many 'inappropriately', known as legacy wells. (GHD, 2010; DEEDI, 2011*a*, *b*, 2013; IESC, 2014*b*; Queensland Government, 2015).

Although exact figures are difficult to determine, it is likely that in excess of $200 billion has been invested so far into CSG by the Australian Government and the petroleum industry in Australia by 2015, with ~$200 billion in the future (Financial Review, 2015). The economic and political leverage of these pro-CSG large investments, have given the gas industry stakeholder and legislative power and huge government tax advantages and subsidies (Huth *et al*., 2014; Mercer *et al.*, 2014; Tan *et al.*, 2015; Vickas *et al*., 2015; Hauter, 2016, Towler *et al*., 2016; Nelson, 2019). The economic, social, political, human, and environmental health effects and their ramifications are yet to be fully appreciated or determined (Huth *et al*., 2014; IESC, 2014*a, b, c, d*; Lacey and Lamont, 2014; Tan *et al.*, 2015; Towler *et al*., 2016; Hauter, 2016; Nelson, 2019).

There exists major community conflict and polarisation of opinion on the topic of CSG between those who are pro-CSG: often with a vested interest (directly and indirectly) in CSG production, and those that are anti-CSG who are often concerned with real and perceived, existing, and future, human, and environmental health impacts regarding CSG exploration and production, particularly concerning ground and surface water system impacts. Pro-CSG proponents have identified that there are potential impacts and real impacts to human and environmental health. But, with gas industry ‘best practice’ methodology, have assumed it is safe to proceed CSG exploration and production on a large scale with principally: self-management; monitoring and reporting of CSG activities by the gas industry. Social licence, social impact assessment and corporation social responsibility are discussed (Tan *et al*., 2015; Towler *et al*., 2016; Keywood *et al*., 2018; Nelson, 2019). There persists a low level of ‘transparency’ in data and information available to the public by the gas industry concerning CSG hydraulic fracking proppants and ‘commercially sensitive’ data (IESC, 2014*d*; Vickas *et al*., 2015; Askarimarnani, 2017, Dresse *et al*., 2018) on CSG extraction in Queensland. The perceived failure of the government and the gas industry to resolve these concerns has possibly contributed to negative attitudes towards the industry and the polarisation of community opinion in the Western Downs. This potentially exacerbates the conflict. There exists an ethical dilemma because of the delicacy and safety issues which arise when researching this polarisation and controversy enshrouding the study of CSG globally. The rationale and motivation of this study is: to shed light on these issues with research into CSG extraction and its affects in the Western Downs, Queensland and surrounding areas that have experienced CSG extraction activity which will be applicable globally. An environmental peacebuilding theoretical framework developed by Conca and Dabelko 2002, may provide a “cooperation and a ‘win-win’ alternative to avoid the zero-sum logic of conflict”. The peacebuilding framework is based on the concept that ‘environmental natural aspects can be beneficial for co-existence, rather than contention’ (Dresse *et al*., 2018).

1.3 Research Gaps and Research Questions

The previous section indicates there is extensive literature on CSG, as is manifest in the literature review in the next chapter on related CSG issues, however, there still exists significant gaps and incompletely, or unanswered answered questions, in the CSG research pertaining to water, the environment and human impacts. Most frequently the research that has and is being undertaken is conducted on behalf of the governing bodies by gas industry related researchers. The self-management and monitoring of CSG activities by the gas industry further exacerbates this conundrum and may be the source of some of the antagonism expressed and may contribute to the explanation of the polarisation of opinion and conflict surrounding CSG extraction. The lack of transparency and commercial sensitivity of CSG operational information and the legally binding non-disclosure in the Conduct and Compensation

Agreements (CCAs) signed by farmers and other stakeholders when entering into compensation contracts with gas companies to allow the CSG companies to extract CSG on their, often agricultural, land adds to the general ‘air of mystery’ enshrouding CSG and does not assist with the freedom to research perceived impacts without causing ethical dilemmas. The underlying premise of independent research of the promised research into CSG by the IIESC and IESC still appears to be wanting and the necessity for further research has not lost its relevance or importance. The need and justification of the research undertaken herein is directed at answering the four proposed research questions and aims relating to the concerns and contentions of CSG activities and extraction.

When the researcher undertook research in 2014-2015 perceived CSG impact references appeared sparse and often outdated. In 2021 this is no longer true. Further, the ‘Factiva’ media search engine has been employed throughout the research period to monitor and record media reports concerning CSG from 1982 onwards to 2019.

1.4 Research Aims and Questions

Research aim

To accomplish the aim the thesis has four key research objectives:

1) To ascertain the current state of knowledge about the possible nature and extent of the impacts on groundwater and surface water systems in the Western Downs, Queensland, Australia;

2) To examine the CSG stakeholder’s perceived perspectives on impacts of CSG activities on groundwater and surface water systems in the Western Downs, Queensland, Australia;

3) To study CSG stakeholder’s perceptions and interpretations of the causes of conflict and community polarisation relating to CSG extraction; and

4) To develop conflict mitigation strategies to reduce the perceived community conflict about CSG extraction.

Research Questions

1) What is the current state of knowledge about the possible nature and extent of the impacts on groundwater and surface water systems from unconventional coal seam gas (CSG) extraction in the Western Downs, Queensland?

2) How have these impacts been perceived and experienced by different stakeholders and represented in the traditional media?

3) What is the nature and extent of the perceived community conflict and polarisation of opinion over CSG extraction in the Western Downs, Queensland? and

4) What is the perceived potential for community conflict over CSG to be resolved and what strategies could contribute to this?

The thesis research questions are studied with the help of data derived from the opinions of four specific stakeholder groups from their perspectives: community group members; community individual participants; Australian government officials; and gas industry employees. A comprehensive media study will also be undertaken. The stakeholder's and media study are discussed in detail in Chapters 3 and 4.

1.5 Significance of Study

The research value of examining the human, economic, health and social impacts regarding gas industry activities, and their self-monitored 'best practice' CSG drilling and fracking extraction methods; their impacts on water systems; and the resultant ramifications potentially experienced by communities and the environment, are highly significant in the Western Downs, Queensland, Australia. These perceived impacts are extremely important with respect to the study of past, present, and future: human, economic, health and social impacts and their assessment; social licence and corporate social responsibility; environmental health impacts; and economic loss impacts. These impacts are applicable globally.

The need to tread-lightly and delicately ethically and distance the researcher and protect any participants while studying potential coal seam gas impacts cannot be understated. Due to the potentially extreme risks involved *i.e.*, to human and environmental health; social and legal risks; and their global applicability. Ethically, the necessity to ensure the safety of the participants is paramount and requires the researcher to rely on qualitative research that is at arms-length and primarily desk top research with discreet interviews with whistle blowers to achieve and ensure this ethical safety is strictly adhered to and to always protect any participant's anonymity. The possibility of more direct research methods, such as one-on-one personal participant interviews and water sampling in the Western Downs may present themselves in future post-doctoral research with the permission of, and under the supervision of, the relevant government bodies and the gas industry. At present, these proposed methods present an ethical dilemma to the researcher and posing severe: economic; health; legal; and social risks to potential participants who may or may not be impacted by CSG extraction practices in the Western Downs, Queensland, Australia, and the researcher.

1.6 Structure of Thesis

The thesis structure, including the content and rationale is presented in this section.

Chapter 1: Introduction. Introduces the research and states the: rationale; research gaps: research questions; aims; objectives; and the significance of the thesis.

Chapter 2: Literature Review. Reviews the extensive body of literature relating to the CSG industry and the Western Downs, Queensland, Australia. The chapter has been divided into two: part 1 general and social content (including: social impact assessment; social licence; and a theoretical environmental peacebuilding framework) and part 2 CSG extraction and water. The chapter reviews the pertinent literature on CSG activities and extraction, its economic, legal, social, environmental, and human health issues, and perceived potential and real CSG impacts.

Chapter 3: Ethical Dilemma Constraining Research Methods. The necessity to comply with BUREM guidelines and the *National Statement on Ethical Human Research 2007 (Updated May 2015*) is discussed. Discusses the ethical dilemma and the restrictions placed on achieving the aims and research questions and the reasons for the anonymisation strategies which have been employed due to the perceived prohibition of more direct research methods. A transcript with a CSG industry employee whistle blower is included which has CSG extraction activity information with perceived far reaching global impact implications. The research method is then related and the rationale for the choice of methodology is explained.

The group selection and data collection methodology and the sample size for the anonymous survey are discussed in chapter 4.

Chapter 4: Research Method. Explains the qualitative social scientific inquiry, interpretively grounded, research approach that has been adopted. How the forty (40) anonymous survey participants (four (4) groups of ten (10)) were selected and how the fourteen (14) research questions in the anonymous survey (Appendix 4) were developed. How the anonymisation strategy and data collection were employed and achieved to ensure and protect the anonymity of the participants found in chapter 5. It provides a study of the small word excel content, and the data collected using the media content study to assist in answering the thesis research aims 1, 2, 3 and 4 and the thesis research questions 1, 2, 3 and 4. Firstly, developing, and discussing factors involved in the respective participant individual and group data. Secondly, to develop constructs from the survey data, involving the individual participant and group participant responses to the survey questions relating to their opinions on primarily – their experiences of CSG, CSG activities, possible CSG impacts, CSG management and government regulation and guidelines, discussed in chapter 7. The qualitative interpretive mixed methodology is also used in chapter 6 to investigate the thesis research of the extensive media data on the Western Downs, Queensland using an interpretive perception of a media content study (MCS) (comprehensive 'Factiva' data (local, national and international newspaper articles) is found in the accompanying Thesis Annex Document). MCS is used to examine the data, providing further thesis research results with respect to thesis research aims 1, 2, 3 and 4 and research questions 1, 2, 3 and 4, discussed in chapters 5, 6 and the general blending discussion chapter 7.

Chapter 5: Results and Discussion. Representative answers from the fourteen questions in the anonymous survey, from each of the four (4) interest group pools consisting of ten (10) participants will be presented and their perceived views, knowledge and firsthand experiences will be compared, discussed, and interpreted. In addition, it presents and discusses the results of the word excel and NVivo qualitative mixed methodology research study. It will attempt to provide representations of the research data to assist in data interpretation. Including interpretations of the perceptions of the results and any perceived or potential impacts that the data indicates, to answer the thesis research questions 1, 2, 3 and 4 and provide possible interpretive perceived explanations for thesis research aims 1, 2 3 and 4. A blended interpretive discussion of the thesis research is found in chapter 7.

Chapter 6: Factiva Research. Qualitative interpretive methodology. Consisting of CSG/CBM and Bowen, Clarence Moreton, and Surat Basin 'key word' research data collated from October 2015 to 31st December 2018 (the research period) from the traditional media (international, national, and local newspaper articles) computer search engine Factiva. This data will be condensed, highlighting specific themes of CSG content that can be followed up in the Thesis Annex Document for further or intensive research, due to the massive volume of relevant information collected over the four year collation period, and subjectively studied data from 1982 to 31st December 2018, with required caution due to the perceived possible media reporting bias which unfortunately has been found by researchers in media article content in many social studies (The comprehensive Factiva data is found in the Thesis Annex Document). It will highlight and interpret article references perceived as specifically relating to data concerning the Western Downs, Queensland and relevant CSG/CBM information chronologically. Also, an MCS using the computer tool NVivo will provide interpretive visual representations of the research data using word frequency with 'word clouds', to attempt to assist in research data interpretation. Due to the size and mass of Factiva CSG data, unfortunately, only a relatively brief study is included.

The Factiva and word MCS may provide research data to help answer research aims 1, 2, 3 and 4 and thesis research questions 1, 2, 3 and 4 with possible perceived recommended resolutions and solutions to the thesis, discussed in chapter 7. Also, the extensive Factiva Thesis Annexation Document attached, contains a wealth of extensive and intensive research data collected daily over four years (data from 1982-December 2018) for a wide variety of further CSG research topics to assist the researcher and other CSG researchers.

Chapter 7: General Discussion. The relevance of the whole body of data will be interpretively discussed. A blending of the research findings and further general discussion which may arise from this, and other relevant information, bringing together an amalgamation of the thesis research questions 1, 2, 3 and 4 and possible resolutions and solutions to the thesis research aims 1, 2, 3 and 4. The thesis research's interpretive theoretical perceived contributions concerning new research and the thesis research contributions to existing CSG research will be discussed with an emphasis on its broader context.

Chapter 8: Conclusion and Limitations. Provides a comprehensive study of the thesis and its findings based on the thesis research. Condensing the interpretive qualitative mixed methodology approach body of results to present the perceived recommendations for the mitigation of any of the thesis research questions and thesis research objectives found in chapter 7. Chapter 2 will provide the basis of literature which is the substance of the study.

References and Appendices

1.7 Conclusion

This chapter has established the reasoning behind, and basic structure and of this thesis. Chapter one has outlined the foundations of this thesis and put forward the aims and four research questions. This chapter has in addition introduced the qualitative interpretive mixed methods of a social scientific inquiry approach and explained its pertinence to this research. The chapter has given an overview of the beneficial contribution of this thesis.

CHAPTER 2: Literature Review

2.1 Introduction

In the previous chapter, the basis, structure, the rationale, research gaps and questions, aims, objectives and the significance of this study were stated. This chapter will examine and review the relevant literature regarding CSG and the Western Downs, Queensland, Australia, and the premises of CSG impacts in general, and potential CSG impacts. Due to the comprehensive scope of the literature review it will be divided into two primary research areas focusing on the human and social and CSG based literature, followed by water and CSG based literature, to address the thesis aims and research questions in a more manageable and coherent way for other researchers.

Part 1: The General and Social Context of CSG Extraction: A Review of the Research

2.2 Historical Perspective

Coal seams consisting of primarily organic matter, date from the extinction event in the Permian era 250-300 million years ago, probably caused by volcanic activity. They are found globally from ground level to over 3 kilometres below ground. CSG is a volatile mix of mainly: methane, hydrogen, carbon monoxide, ethylene, and other hydrocarbons (IESC, 2014*a*, *d*). Coal gas, or town gas was used as a power utility beginning in London 1812, and Sydney, Australia in 1841 (Tinsdale, 1927). Coal gas's first practical use was lighting. The gas was extracted from mainly black coal or coke, by baking it in large cylinder-like retort vessels (ovens) to release coal gas (lime was used with iron oxide as part of the purification process, principally to remove hydrogen sulphide) and piped to domestic and council end users to provide power for domestic and commercial fuel and street lighting (Tinsdale, 1927; Broomham, 1987). CSG (methane, CH_4) is a much richer, more plentiful, and easier to extract source of gaseous power. It is taken for granted, the readily accessible gas that is supplied with the turn of a knob on our gas stoves. It is surprising more accidents do not occur from this: invisible; scentless (the sulphurous odour is an additive, mercaptan); highly combustible; and under pressure, explosive source of power. Onshore exploration and production of economically viable amounts of CSG began in Australia as early as the 1940s in Sydney, New South Wales. Full scale exploration began in and near the Western Downs, Queensland by the early 1980s, targeting coal seams. The gas industry had spent an estimated $150 million on CSG /CBM exploration between the early 1980s to 1992 (BRW, 1995)

2.3 Introduction to the Western Downs, Queensland

Geographically, the Western Downs are found in south-eastern Queensland: bordering the Banana, Central Highlands, Darling Downs, Isaac, and Woorabinda Local Government areas (LGAs). It is a rural, agricultural and resource mining area, about the size of Switzerland, 38,039km^2. It is an area susceptible to droughts though below its surface there is enormous quantities of groundwater of varying quality and age, some possibly 100,000s of years old, in the Surat and Bowen Basins (GABCC 1998, 2010, 2011; Scott *et al*., 2007; QWC, 2012; Queensland Government, March 2013; Huth *et al*., 2014; IESC, 2014*a, c, d*; Nelson, 2019).

The Western Downs population was 33,799, in 2015, the largest townships being Dalby and Roma. Roma was the first location in Australia where natural gas was discovered and produced and attempted to use it in 1906 for town lighting, but with limited success (Towler *et al*., 2016). The region developed from an agricultural base and agriculture remains an important source of employment, along with health care, retail trade and education (Office of the Chief Economist (OCE), 2015). The major contemporary change in employment has been the mining and CSG sector which employed only 1% of the working population in 2006, but had grown to 3% in 2011 (OCE, 2015, Western Downs Regional Council, 2015). While such a small percentage change may not appear significant, it represents over ~600 persons.

Geologically, coal seams are found '*in situ'* with groundwater and water basins. Coal seams often only ~1-2 metres wide, are situated in the GAB and linked via aquifers to the Bowen and Surat Basins, above, found between the surface and as much as three kilometres below. It is a geologically complex area featuring a variety of geological formations and histories (Scott *et al*., 2007; Towner *et al*., 2016). Full scale onshore production of CSG began in Australia around 1995 near Chinchilla, Western Downs, Queensland, at the Dawson River area, Moura, Bowen Basin, and near Injune in 1998 (WA Onshore Gas, 2014; DNRM, 2015*a*; Towler *et al*., 2016). Commercial production of CSG from the Surat Basin commenced in 2006 near Dalby and Berwyndale South near Chinchilla (Scott *et al*., 2007; Queensland Government, March 2013; IESC, 2014*a, b, c, d*; WA Onshore Gas, 2014; Commonwealth Government, Department of Industry, Innovation and Science (DIIS); OCE, 2015; Towler *et al*., 2016).

2.4 An Overview of the Western Downs Coal Seam Gas (CSG) Industry

Most CSG extracted in Queensland is for export use, purchased by China, Japan, and Korea earlier this century with long-term 20-30-year average contracts from multinational petroleum companies at a fraction of the price per petajoule, that it costs in Australia. Complex and extensive corridors of pipeline systems supply massive amounts of water to the CSG fields and take gas away to the port of Gladstone and Curtis Island, Queensland. At these ports, the gas is refrigerated and transferred to purpose-built gas tankers to ship the CSG the international market (IESC, 2014*c*, *d*). Figures 2.1 and 2.2 are aerial photographs of some of the CSG extraction well fields, including fracking extraction wells, evaporation ponds and other CSG infrastructure in Dalby and Tara, in the Western Downs, Queensland[1].

In the late 1990s, CSG accounted for only ~3% of Queensland's CSG, ~285 PJ of production. There has been rapid growth in the gas industry in the past 15 years, peak drilling of ~1634 CSG wells in 2013-14 making it the major source of Queensland's CSG. Total CSG production had grown very significantly producing ~26 million tonnes per year of LNG in 2018. One quarter of the global production of LNG is from central Queensland, 90% of which is produced from the Surat and Bowen Basins. (Queensland Government, 2019). See Appendices 14 and 15 for Queensland and Australian gas tenements.

Figure 2.1: Dalby, Western Downs, Queensland. CSG Wells and Infrastructure

Source: Google Earth, (2016). Map data © 2019 Google.

[1] See Appendices 11 and 12 for further photographs of Western Downs, Queensland CSG activities.

Figure 2.2: A CSG Field in the Surat Basin at Tara, Just South of Chinchilla, Queensland. Showing Well Pads and Access Roads in and Near State Forest. See Appendices 14 and 15.

Source: Map data © 2019 Google.

The lack and gaps in data regarding CSG extraction and its impacts is exacerbated by there being: no establishment of any 'baseline' measurements or, any information on 'natural', or native formative constituents: methane and elements, chemicals, products and other potential organic and inorganic, environmental contaminant levels; before the commencement of CSG exploration or the production of CSG (CSIRO, 2011, 2012*b*; Lloyd-Smith and Senjen, 2011; Day *et al*., 2012, 2014, 2015; Saddler, 2012, 2013; Santos and Maher, 2012; SKM, 2012; Comino *et al*., 2014; Huth *et al*., 2014; IESC, 2014*d*; Maher *et al*., 2014; Davies *et al*., 2015; Tan *et al*., 2015, Vickas *et al*., 2015; Lafleur *et al*., 2016; Towler *et al*., 2016; Nelson, 2019).

2.5 The Coal Seam

Coal seams are found almost globally (the terrestrial land mass, supercontinent Pangea, in the Permian era), between the surface and over 3 kilometres below, varying in thickness from 1-2 metres to huge reservoirs of coal and petroleum. Access to coal seams by the CSG industry is often through may types of geologic strata, some of which are rich in toxic, and or radioactive, heavy metals.

The coal seam ecosystems are most often found in groundwater and consist primarily of flora from Permian era extinction event, some 250-300 million years old. They are one of several niches for 4-billion-year-plus old methanogen species (*Archaea*) extremophile life forms, which are one of the earliest known life forms. Singh *et al.,* 2012 found some of the earliest evidence regarding biogenic origin in significant proportion, of microbial communities involved in methanogenesis. *Archaeal* and bacterial communities were present in formation water, using epifluorescence microscopy and PCR amplification of mcrA gene. Hydrogenotropic methanogens and proteo-bacteria were found to reduce poly cyclic aromatic hydrocarbons to methane: "*elucidated by the capability of in situ biotransformation of coal to methane."* This organic combination makes up the matrix that produces CSG, principally: methane (CH_4), hydrogen, carbon monoxide, ethylene, hydrocarbons, and mono and polycyclic aromatic hydrocarbons (many extremely carcinogenic). Forming an 'active' varying ratio of biogenic (methanogenesis); and thermogenic (heat assisted) CSG, which is a source of fuel for human energy generation. Ambient temperatures in the coal seams are generally around 40-60^{o}C. (Mukesh and Kumar, 2005; Singh *et al*., 2012; Queensland Government, March 2013; IESC, 2014*a*, *b, c, d*).

The introduction of CSG extraction fracking chemicals to the coal seam has been found to add 'geogenic' synthesis to this matrix, dependent on the fracking chemicals added, altering the coal seam ecosystems (IESC, 2017).

2.6 The Perceived Socioeconomic Impacts of CSG Extraction in the Western Downs, Queensland.

The Commonwealth Government, (DIIS), Office of the Chief Economist (OCE) 2015, literature review on socioeconomic impacts, principally relies on two organisations conducting ongoing research into the socioeconomic impacts of CSG development, the Gas Industry Social and Environmental Research Alliance (GISERA), and University of Queensland's Centre for Coal Seam Gas (UQ-CCSG). Now Centre for Natural Gas (UQ-CNG). These organisations assisted the OCE to identify pertinent literature in its review (OCE, 2015). Augmented by stakeholders from the CSG sector in meetings debating the conclusions of the literature. The stakeholders included (OCE, 2015, p.7):

- *Social science and other researchers, including GISERA, and UQ-CCSG;*

- *Queensland Government representatives, including Office of Groundwater Impact Assessment (OGIA) and the Department of Natural Resources and Mines (DNRM);*
- *Representatives from the GasFields Commission Queensland (GFCQ);*
- *Industry associations, including the Queensland Resources Council (QRC) and APPEA; and*
- *Representatives from CSG companies and joint ventures operating in Queensland.*

The OCE 2015 review was based on the views of the GFCQ and researchers, studying the approach of peak construction timing of the gas industry in 2014. However, they did not meet with local individuals or community groups. The GFCQ found ongoing research was necessary to study the still developing socioeconomic impacts (Hamstead and Fermio, 2012; McDonald *et al*., 2013; Williams and Walton, 2013; Walton *et al*., 2013, 2014; Fibbens and Mak, 2014; Huth *et al*., 2014; Measham and Fleming, 2014; Uhlmann *et al*., 2014; Witt, *et al*., 2014; Fleming and Measham 2015*a*, *b*; OCE, 2015; Vickas *et al*., 2015; Towler *et al*., 2016; UQ-CCSG, 2016; Nelson, 2019).

2.7 Geospatial Dispersion

The OCE 2015 found CSG development leaves a large dispersed geospatial footprint, above and below ground, which included impacts from CSG operations of CSG wells, roads, pipelines, processing infrastructure and evaporation ponds. This is compounded by cumulative impacts on communities and regions due to several projects run by different gas companies in proximity of agriculture, *e.g*., '*CSG wells are being drilled on active farms and grazing properties.*' (OCE 2015, p.18). This is a major contributing factor of social and economic impact making 'co-existence' an ongoing maintenance and development issue during active CSG extraction. Over 5,000 Conduct and Compensation Agreements (CCAs) between stakeholders and gas companies have been signed in gasfield and pipeline impacted areas (OCE, 2015 p. 18; APPEA, 2015). OCE 2015, p.22 stated, *'a major component of the coexistence between CSG and communities is land access. The Queensland Government's land access laws have been updated to ensure that:*

- *Landholders are fairly compensated for activities on their land; and*
- *Resource companies minimise the impact on existing land and business operations.'*

There is a ‘make good’ provision of water for landholders with impacted bore level drops of 5 metres or more, which is the responsibility of gas companies (OCE, 2015).

2.8 Rural Decline

Rural decline is a phenomenon in many developing countries including Australia (McDonald *et al*., 2013). Inherent in the phenomenon is a reduction in rural populations, particularly in younger demographics and this falling population has flow on impacts to the viability of regional businesses and functioning infrastructure, and in some cases the viability of the regions themselves (McKenzie, 1994). For regions dependent on agriculture, resource projects such as CSG extraction has the potential to alleviate the decline by diversifying the economic base of the community and increasing regional economic activity. Measham and Fleming, 2014 undertook a detailed assessment of social demographics of residents in communities with CSG projects and compared it to similar communities without them. They found that CSG projects did contribute positively to mitigating aspects of rural decline, and that in a number of instances it differed positively from other types of resource development projects. This was particularly the case in terms of gender with more young females staying or relocating to the area where CSG projects were occurring. They also demonstrated that regions with CSG projects had improved educational outcomes with a greater proportion of youth with vocational or university qualifications.

While the diversification of a regional community can mitigate the negative aspects of rural decline, it can lead to social impacts including creating inequities and changing the character or values of a region. Studies by Mckenzie, 1994; Wester-Herber, 2004; Hamstead and Fermio, 2013; McDonald *et al*., 2013; Huth *et al.*, 2014; Measham and Fleming, 2014; Uhlmann *et al*., 2014; Fleming and Measham, 2015*a, b*; Towler *et al*., 2016; and Nelson, 2019 noted the ‘boomtown’ impact of sudden economic growth and rises in local mining employment and wages, but the loss of agricultural and experienced labourers, rises in rent, and lifestyle changes, away from the more traditional rural, or country ways of life. These lifestyle changes are not always a good thing, even if it means some landholders are financially better off. Changes can disrupt families and communities. Not all landholders and residents gain, some remain unchanged, and inequality is often present. Everingham *et al*., 2015 noted a reduction in the Western Downs of people’s rural bonds, networks, or ‘social capital’. Studies by UQ-CCSG, 2016 recorded a rise in drug related arrests and crime above other places in Queensland. Perry 2012, assessment of Bradford County, USA demonstrates how internationally, farming communities appeared initially optimistic with the prospect of CSG development on a large scale and the benefits that would come from it, however coping with significant developments that accompanied the changes resulted in a common thread internationally (Anderson and Theodori, 2009; Perry, 2012; Evans and Kiesecker, 2014; Hauter, 2016). That is, of local farming communities feeling like they were being invaded by outsiders is expressed by Wester-Herber, 2004; Perry, 2012; Hamstead and Fermio, 2013; Huth *et al*., 2014; Uhlmann *et al*., 2014; Vickas *et al*., 2015; Hauter, 2016; Towler *et al*., 2016; Keywood *et al*., 2018; and Nelson, 2019.

OCE 2015, identified that impacts (real or perceived) on water were of major concern to individual and community well-being, and this was reinforced by Huth *et al*., 2018. This included impacts to the groundwater through a reduction in water pressure and the extraction of a large volume of water and the liberation of potential contaminants and the difficulty of effective disposal once liberated. Similar concerns have also been expressed in other countries where CSG activities have been undertaken (Anderson and Theodori, 2009; Perry, 2012; Hauter, 2016). However, these concerns have not always been realised (Mckenzie, 1994; Wester-Herber, 2004; Perry, 2012; McDonald *et al*., 2013; Huth *et al*., 2014; OCE, 2015; Towler *et al*., 2016; UQ-CCSG, 2016; Keywood *et al*., 2018; Nelson 2019). There are also potential biosecurity concerns due to CSG for the agriculture sector. Impacts are managed by regulation, *e.g*., washing vehicles to minimise weed dispersal. Other impacts may be reduced by company contributions to roads, industrial traffic and changing driving practices (Colson, 1973; Mckenzie, 1994; Wester-Herber, 2004; Perry, 2012; McDonald *et al*., 2013; Cheshire *et al*., 2014; Huth *et al*., 2014; Measham and Fleming, 2014; Uhlmann *et al*., 2014; Fleming and Measham, 2015*a, b*; Everingham, *et al*., 2014; OCE, 2015; Towler *et al*., 2016; UQ-CCSG, 2016; Nelson 2019).

2.9 Physical and Mental Illness

There are many studies regarding human and environmental health, not many indicate a definite link between CSG activities and negative health, or a relationship (OCE, 2015). Werner *et al.* 2015, found ‘tenuous’ epidemiological evidence, with some studies giving evidence of relationships due to health impacts related CSG and detrimental health outcomes recommended further research to assess risks (OCE, 2015). Resource extraction activities have the potential to impact individual mental health and community identity (Colson, 1973; Mckenzie, 1994; Wester-Herber, 2004; Perry, 2012; McDonald *et al*., 2013; Huth *et al*., 2014;

Measham and Fleming, 2014; Fleming and Measham, 2015*a*, *b*; Morgan *et al*., 2015, OCE, 2015; Hauter, 2016; Towler *et al*., 2016; UQ-CCSG, 2016; Nelson, 2019). In the case of CSG, these impacts are potentially exacerbated by uncertainty regarding timing of impacts relating to the different stages of the CSG activities. Uncertainty about CSG impacts of a significant level may cause stress and anxiety to the individual and community (Mckenzie, 1994; Wester-Herber, 2004; Perry, 2012; McDonald *et al*., 2013; Walton *et al.*, 2013. 2014; Fibbens and Mak, 2014; Huth *et al*., 2014; Measham and Fleming, 2014; Fleming and Measham, 2015*a*, *b*, Morgan *et al*., 2015; OCE, 2015; Hauter, 2016; Towler *et al*., 2016; UQ-CCSG, 2016; Keywood *et al*., 2018; Nelson, 2019).

2.10 Well Being

Huth *et al*. 2014 provides a detailed assessment of some of the key issues associated with individual wellbeing and community identity. Wellbeing, the subjective feeling of being positive about one's welfare. The contentment and happiness of CSG affected community residents are dependent on the economic impacts of CSG, including health, and socio-environmental impacts. Surveys concerning community wellbeing and their response to change due to CSG activities in the Western Downs by Walton *et al.*, 2013, 2014 (CSIRO), found political aspects were negatively felt by the community. The quality of services and infrastructure were found to be only moderately adequate and road surface, safety and traffic volume were perceived negatively. Huth *et al*. 2014 in their studies relate other, peer reviewed, commonly mentioned factors such as locals being tired of CSG related meetings, preoccupation with legal matters and draw parallels with McKenzie, 1994; Wester-Herber, 2004; Hajkowicz *et al*., 2011; Perry, 2012; McDonald *et al*., 2013; Walton *et al.*, 2013, 2014; Huth *et al*., 2014; Uhlmann *et al*., 2014; Adger, 2016; Towler *et al*., 2016; Hauter, 2016; Dresse *et al*., 2018; Keywood *et al*., 2018; Lucas, 2018; and Nelson, 2019 of individual and community loss of esteem, and pride in the their farms and towns due to their perceptions of beauty and tidiness, being compromised or lost, replaced by industrial landscapes, trucks and heavy traffic, and bothered by accompanying CSG related infrastructure and door-knocking representatives. All affect community feelings of wellbeing. These community values and their loss appear not to be understood by the industrial minded newcomers often from the city (Wester-Herber, 2004; Hajkowicz *et al*., 2011; Perry, 2012; McDonald *et al*., 2013; Williams and Walton, 2013; Walton *et al.* 2013; 2014, Huth *et al*., 2014; Measham and Fleming, 2014; Witt *et al*., 2014;

Fleming and Measham, 2015*a*, *b*; Uhlmann *et al*., 2015; Adger, 2016; Towler *et al*., 2016; Hauter, 2016; Keywood *et al*., 2018; Nelson, 2019).

A perception of the lack of fairness and transparency regarding Conduct and Compensation Agreements (CCAs) was found to concern landholders. Some 5,000 CCAs have been signed in Queensland (APPEA, 2015, OCE, 2015). The inherent, confidential substance of the negotiated CCA by individuals created a community perception that the settlement amount received represented negotiation skills rather than the value of possible economic loss. Also, time and productivity loss, were not included in their recompense (Hamstead and Fermio, 2012; Fibbens and Mak, 2014; Cavaye and Kelly, 2015; Vickas *et al*., 2015; Adger, 2016).

2.11 Cumulative Impacts

The importance of considering the cumulative environmental impacts of developments is well established (Comino *et al*., 2014; Evans *et al*., 2014; Huth *et al*., 2014; Uhlmann *et al*., 2014; Tan *et al*., 2015; Vickas *et al*., 2015; Towler *et al*., 2016; Nelson, 2019) There is clear scope for, and a need to consider, cumulative impacts associated with CSG projects in the Western Downs. It is apparent from the extensive literature reviewed on this well studied complex, compounded issue that all impacts whether positive or negative cannot be assessed separately. Case by case, but not separately. There are never simple scenarios, particularly when CSG extraction and rural communities attempt to co-exist globally. Actions create reactions and become chain reactions. Impacts create multiple impacts that have far reaching ramifications. Invariably, best practice guidelines cannot produce short or long term satisfactory effective, accepted outcomes with optimal mitigation of impacts. Only strong regulatory framework supported and implemented by ongoing management of all resources and stakeholders can achieve desirable and sustainable development. Most of the types of industrial development whether past, present, or planned are a litany of ignored cautionary tales. Making similar, if not the same mistakes, most often driven by short-term pecuniary interest instead of basic commonsense, sustainable choices. Environmental management is the management of people and what we chose to do. There has been comprehensive work undertaken on cumulative impacts of CSG projects in Australia to support this by researchers including: Nuccio, 2000; Vink *et al*., 2008; McDonald *et al*., 2013; Comino *et al*., 2014; Evans *et al*., 2014; Huth *et al*., 2014; Uhlmann *et al*., 2014; Tan *et al*., 2015; Vickas *et al*., 2015; Towler *et al*., 2016; Nelson, 2019.

2.12 The Legislative Framework of CSG extraction in Queensland

2.12.1 Commonwealth of Australia Legislative Framework for CSG Fracking and Extraction

Like all Australian onshore petroleum deposits, CSG resources are owned by the Crown '*in right of the State*' and are the property of the states and territories.

The state and territory governments are responsible for licensing petroleum development, through petroleum leases, and charge royalties on petroleum production paid usually by international corporations. The states are responsible for the approval, environmental impact assessment and the regulatory conduct of CSG activities (Parliament of Australia, 2013). In March 2012, the National Partnership Agreement on Coal Seam Gas and Large Mining Development sort to:

'…*strengthen the regulation of CSG and large mining development by ensuring that future decisions are informed by substantially improved science and independent expert advice.*' *EPBC Act 1999 Amendment, Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development, 2012* (Royal Assent 24th October 2012) no: 145 2012 (IESC, March 2013).

Australian Government spokesman Ian Macfarlane suggested that the existing environmental permitting and ~1500 state and ~300 federal conditions already concern water. Further legislation and investigation by federal scientists, independent scientists and research institutions was said to be an expensive, unnecessary duplication of state, and mining industry funded, scientific investigation and self-monitoring by mining companies (Parliament of Australia, 2013).

Guidelines that are administered under a process of the Australian Government's, Department of Energy ongoing bioregional assessments, monitoring by the IESC of the risk assessment of the controlled action CSG mining. By collecting data for bioregional assessments (BAs), for spatial risk assessment, to determine the impacts of CSG extraction with scientific quantitative data, and semi-quantitative and qualitative judgments, where more scientific data is lacking on the impacts on human and environmental health by CSG extraction conducted under the *EPBC Act 1999 Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development Amendment 2012* (IESC, 2013).

Peer reviewed CSG Monitoring, and Management Plans will manage impacts to groundwater and surface water system impacts on case-by-case bases. Providing rigorous conditions, reviews, and updated data, concerning impacts, management of impacts, and MNES. (Queensland Government, Department of Infrastructure and Planning (DIP), 2013). The bilateral agreements commit the '*party states*' seek advice from the IESC for the human and environmental assessment of actions, but the states are not obliged to take advice or follow their recommendations. IESC is seen as a 'toothless tiger', an expensive and unnecessary duplication of administrative resources. The 'one stop shop' method of environmental assessment being favoured as it is more simplistic (Parliament of Australia, 2013).

2.12.2 *EPBC 1999 Amendment 2013* Regarding MNES Significant Impact 'Trigger' Water

Water is a Matter of National Environmental Significance (MNES), a '*trigger*' for significant impacts by the Controlled actions of CSG and large coal mining developments *EPBC Act 1999 Amendment 2013.* Royal Assent 21/06/13 *Act no: 60* Year: 2013. The purpose of the Amendment is to establish a new matter of NES, the protection of water resources from '*Coal Seam Gas and Large Coal Mining Development'* (Parliament of Australia, 2013).

'*Significant impact is an impact which is important, notable, or of consequence, having regard to its context or intensity*' (IESC, 2014*c*). Significant impacts for the trigger water, at this time, have no definitions only guidelines and advice.

If actions are 'significant impacts' depends on the extent of the water resource affected, the level, temporal nature, size, and extent of the impact. These conditions are to be considered if an action is likely to have a significant impact. See '*Significant Impact Guidelines* 1.1: *Matters of National Environmental Significance'* and 1.2. '*Actions on, or Impacting Upon, Commonwealth land, and actions by Commonwealth Agencies' EPBC Act 1999* Policy Statement.

A 50% assessed risk by a controlled action is considered a 'likely' significant impact (SEWPaC), 19th June 2013.

Enforcement of breaches of the *EPBC Act 1999* by controlled actions has maximum fines up to $8.5million and 10-year imprisonment (though rarely implemented, and usually of small consequence to corporate lessees).

2.12.3 Queensland Legislation for CSG and Water Management

The primary regulatory framework in Queensland is the *Petroleum Act 1923* and *Petroleum and Gas (Production and Safety) Act 2004*. This is bolstered by several legislations, and codes of practice and policy (Table 2.10) (IESC, 2014*d*, p. 24):

Table 2.1: Queensland Legislation and for CSG and Water Management

Act/Code of Practice/Policy	Description/Purpose
Petroleum Act 1923	Regulates the exploration and mining for petroleum and natural gas in the State and the conveying of petroleum and natural gas, wherever recovered.
Petroleum and Gas (Production and Safety) Act 2004 (including the Land Access Code)	Addresses the interests of the agricultural and resource sectors to address issues related to land access for resource exploration and development.
Environmental Protection Act 1994	Primarily concerned with environmental pollution. Sets out a program for the identification and protection of important elements of the environment and by creating a range of regulatory tools for controlling the activities of individuals and companies.
Petroleum Regulation 2004	Regulatory system for the carrying out of responsible petroleum activities and the development of a safe, efficient and viable petroleum, coal seam gas, pipeline and fuel gas industry.

Act/Code of Practice/Policy	Description/Purpose
Water Act 2000	Vests all rights to the use, flow and control of Queensland's water with the state government. Amended in 2010 to improve management of water in the petroleum and gas industry. Created a new role for the Queensland Water Commission (now known as the Office of Groundwater Impact Assessment), who is tasked to manage cumulative impacts on groundwater via the declaration of cumulative management areas.
Strategic Cropping Land Act 2011	Legislative and planning framework commenced on 30 January 2012 designed to protect Queensland Strategic Cropping Land (SCL) from developments (including coal seam gas activities) that lead to permanent impact or diminished productivity on important cropping lands
Water Supply (Safety and Reliability) Act 2008	Further strengthen the safety and reliability of Queensland's water supplies.
Water and Other Legislation Amendment Act 2010	Introduced in November 2010 to address the issue of impacts on groundwater resources from coal seam gas water extraction by petroleum tenure holders.
Waste Reduction and Recycling Act 2011	Beneficial use of resources.
Code of practice for constructing and abandoning coal seam gas wells	Introduced in December 2011 and updated in October 2013 to ensure that all coal seam gas wells are constructed to a minimum standard resulting in long term well integrity.
Coal Seam Gas Water Management Policy	In December 2012, the Queensland government approved the Coal Seam Gas Water Management Policy 2012. This policy supersedes the 2010 Coal Seam Gas Water Management Policy.

Source: IESC, (2014*d*) figure, retrieved from https://www.environment.gov.au/about-us/publications/archive#water

The regulatory regime for CSG impacts in Queensland is founded on adaptive environmental management (DEHP, 2013*a*).

The *Environmental Protection Act 1994* was amended in October 2010 to regulate the use of BTEX chemicals in fracking. BTEX chemicals are not permitted in fracking fluids (IESC, 2014*d*). BTEX concentrations must not exceed the limits of the *Australian Drinking Water Guidelines* for benzene (0.001 milligrams per litre (mg/L)), and the ANZECC & ARMCANZ, 2000 for toluene (0.18 mg/L), ethylbenzene (0.08 mg/L), meta-xylene (0.075 mg/L), ortho-xylene (0.35 mg/L) and para-xylene (0.2 mg/L). One milligram is equal to 0.001 grams.

CSG companies must notify the government and landholders when fracking within two months of any fracking, with fracking constituents. Under the *Petroleum and Gas (Production and Safety) Act 2004,* CSG proponents can withdraw an unlimited amount of groundwater without requiring a water entitlement (IESC, 2014*d*). This leaves CSG activities open to criticism for benefiting from privileges that are not available to other water-using industry sectors such as agriculture (Queensland Government, 2006; Norton Rose, 2012; Cheshire *et al*., 2014; Comino *et al*., 2014; Everingham *et al*., 2014; Tan *et al*., 2015; Vickas *et al*., 2015; Nelson, 2019).

Common conditions imposed on CSG activities include (IESC, 2014*d*, pp. 45-46):

- *Prohibiting fracking fluids containing BTEX, naphthalene, phenanthrene or diesel;*
- *Risk assessment to ensure fracking is managed to prevent environmental harm;*
- *Fracking impact monitoring program that considers the risk assessment to the government for review, prior to fracking, to ensure any adverse impacts to water are detected;*
- *Publicly available composition of the fracking fluid used, and a fracking chemical impact assessment submitted prior to carrying out fracking;*
- *baseline bore assessment to collect water quality data to represent the water in the well prior to fracking;*
- *Conducting long-term monitoring of wells that have been fracking; and*

- *Monitoring groundwater and all active landholder bores within a two-kilometre horizontal radius prior to and following fracking.*

The CSG industry, to a large extent self-manages, monitors, and reports to Australian state and territory governments (IESC, 2014*a, b, c, d*, NSW Government, 2014, Queensland Government, 2015). This may possibly contribute to the low level of 'transparency' by the CSG industry, community conflict and polarisation of opinion.

The introduction in September 2014 of Queensland's *Mineral and Energy Resources (Common Provisions) Act 2014* regarding overlapping tenements, access, mining rights, arrangements, and arbitration "*as a right of grant*". It is broadly consistent with the White Paper '*Utilisation of Queensland's Coal and Coal Seam gas Resources – A New Approach to Overlapping Tenure in Queensland*'. Though most tenements will remain governed by the *Mineral Resources Act 1989 (Qld)* and the *Petroleum and Gas (Production and Safety Act) 2004*.

2.12.4 The Regulatory Requirements for Chemicals that may be used in CSG Fracking Fluids

Industrial chemicals are complex involving ~140 legislative requirements. They are regulated by the National Industrial Chemicals Notification and Assessment Scheme (NICNAS). An assessment certificate issued under the *Industrial Chemicals (Notification and Assessment) Act 1989* (*ICNA Act 1989*) to permit the introduction of a new industrial chemical into Australia. Enforcement of NICNAS is via state and territory legislation (IESC, 2014*d*).

Additives used in fracking fluids are to be notified and assessed by NICNAS and listed on the Australian Inventory of Chemical Substances (AICS). Any person or company intending to use that chemical for a new application may be required to submit a secondary notification to NICNAS for assessment. If a CSG proponent wants to use it for fracking, then the company is required to notify NICNAS and a secondary notification assessment may be conducted (IESC, 2014*d*).

The Commonwealth Government recognises that a large number of fracking additives on the AICS have not been assessed for fracking by NICNAS (Senator Ludwig, 2011). National Toxics Network (NTN) (2011) estimates only 2 out of the 23 commonest additives in fracking fluids in Australia have been assessed by NICNAS. NICNAS is leading a National Assessment of Chemicals Associated with CSG Extraction (NICNAS, 2013; IESC, 2014*d*).

The primary legislation for CSG mining is the *Petroleum and Gas (Production and Safety) Act 2004 (P&G Act),* which states its "*main purpose is to facilitate and regulate responsible petroleum activities and the development of a safe, efficient and viable petroleum and fuel industry*". The lack of scientific independence, however, is indicated in the Queensland Government's 2015 *Code of Practice. For the construction and abandonment of petroleum wells and associated bores in Queensland,* formulated by DNRM and APPEA. Tan *et al*. 2015, pp. 686-687 found, '*Our analysis of the Queensland law, argues that the regulatory framework for CSG mining gives primacy to the P&G Act and subordinates other entitlements under water legislation*'. And further, '*the Water Act 2000 (Qld) provides for water planning, after which water entitlements for agriculture and other users are issued with limited volumes. In contrast, the CSG regime under the P&G Act allows unlimited volumes of underground water to be extracted as a little or no opportunity for a little or no opportunity for assessment and consideration of the broader strategic planning context.'*

2.13 Social Impact Assessment

Social Impact Assessments (SIA) apply to the evaluation of all project EIS (*Environmental Protection Act 1994)* and address the following for the full life cycle of projects (Queensland Government 2018 p.2):

- Community and stakeholder engagement.
- Workforce management;
- Housing and accommodation;
- Local business and industry procurement; and
- Health and community well-being.

Ongoing Social Impact Management Plans (SIMPS) are required to monitor potential impacts, managerial measure, and outcomes.

De Rijke 2013 pp. 10-11 post-doctoral research on CSG and SIA on CSG developments surrounding Dalby, Darling (Western) Downs highlights CSG developments and the substantial conflict and the emergence of the anti-CSG movement. Addressing CSG based on anthropological perspectives, *e.g.*, social dynamics and the concept of community from the Queensland Government guideline for SIAs and the SIA for Arrow Energy's Surat Gas Project.

It focuses on the social aspects of CSG debates and SIA policies broadly. De Rijke describes the severe suspicion he was met with by local anti-CSG community groups ‘who distrust the University of Queensland as a result of its Centre for Coal Seam Gas which receives funds from the gas industry’. And ‘these issues are a normal…SIA researchers will be subject to similar sentiments.’ And ‘the implications of the researcher’s reception in the field including data gathering and the scope of research…rarely addressed in SIA reports.’

De Rijke 2013 p. 15 notes that the more recent SIA guidelines have reduced significantly as part of a state agenda to reduce ‘red tape’ (100 pages to 25 of requirements). Thus ‘failing to adequately support vulnerable groups throughout the life of projects *and* failing to recognise and promote the full variety of community opportunities that may arise from such projects.’

2.14 Social Licence and Corporate Social Responsibility (CSR)

Paragreen and Woodley 2013 pp 48-49, view early interpretations of social licence in the gas industry studying existing mining operations as concerning procedural justice (decision making), distributive justice (the degree in which the allocation of outcomes is fair) and community identity – a shared trait or set of traits which exist in the minds of people allowing the collective perception of a community group. The definition of social license remains founded in interpretation, the progress towards an encompassing definition appears to be challenging.

Curran 2017 p. 427 states the importance of accountability in a more transparent world. Even hidden from view impacts making CSR effective, threatening corporate legitimacy and their reputation. Curran 2017 pp. 429-431 sees social licence as a response to ‘past disasters, conflicts and challenges’, and a more effective management tool and a new standard. Social licence as a democratic frame for gas proponents to defend their projects and opponents to challenge them. Providing an established ‘strategic risk management’ tool. Social licence being underpinned by transparency, trust, and ‘genuine’ community engagement. Providing gas companies and communities with legal and social requirements for CSG projects. Curran explores the contestation dynamics underlying conflict and polarisation ‘through the prism to operate’. Where ‘Framing’ - how the social movement’s actors and their values (anti-and pro-CSG protagonists) create and communicate meaning in their narratives in resource mobilisation and politics.

Curran 2017 pp. 429- 431 further cites the Bentley Blockade case study of CSG contestation. Where Metgasco began CSG exploratory drilling at Lismore in New South Wales. Alleged 'professional' protestors ('hippy unemployed'), but also, environmentalists and farmers and other concerned citizens adding legitimacy for social license. The usual 'corporate strategy' to de-legitimise the anti-CSG contestants was diminished. In the ensuing legal battles however, corporate and community legitimacy has hinged on the lack of definition of 'effective community consultation' and the notion of a 'concrete' definition of social license. Curran p. 433 states Anti-CSG group 'Lock the Gate' observed: the 'massive groundswell of the majority of public opinion' as the determinant of social license and to ignore these flies in the face of democratic processes.

Makki 2015, in his unpublished University of Queensland PhD thesis, appears to seek to de-legitimise and discredit the anti-CSG movement, he describes 'founding members' from the outskirts of Chinchilla and Tara in the Western Downs. From his research he uses the label 'Blockies'- self-interested, unemployed individuals, seeking publicity and possible financial gain, from their stance against CSG and gas companies. Makki appears to seek to minimise CSG activity potential impacts (discussed further in chapter 7).

2.15 Environmental Peacebuilding: Towards a Theoretical Framework

A novel underlying environmental peacebuilding theoretical framework based on the work of Conca and Dabelko 2002 has been developed and integrated by Dresse *et al*., 2018 and Lucas and Warman, 2018 to assist in avoiding conflict scenarios with no positive outcomes and replace them with incentives towards cooperation (Dresse *et al*., 2018, Lucas, 2018, Lucas and Warman 2018). Dresse *et al*., 2018 believe that 'environmental peacebuilding represents a paradigm shift from a nexus of environmental scarcity to one of environmental peace'. Conca and Dabelko's 2002 book propound an 'environmental peacemaking' approach of sharing natural resources as a conflict tool. The 'biophysical environment's inherent characteristics can act as incentives for cooperation and peace, rather than violence and competition'.

Representing 'cooperation as a win-win solution and an escape from zero-sum logic of conflict', Dresse *et al*., see this developing into a 'transformative framework that encompasses conflict prevention and post-conflict peacemaking'. It is now being used by the United Nations for Peacebuilding, UN-EU partnership on natural resources and other UN environmental cooperation and peacebuilding programmes. It however remains challenging. The epistemological assumptions rest on three main building blocks: initial conditions;

mechanisms; and outcomes, respectively corresponding to when, how and why conflict parties can engage in environmental cooperation and peacemaking (Dresse *et al*., 2018):

It establishes 'causal linkages between each building block to assemble them into a framework synthesis made of three generic, non-exhaustive trajectories: technical, restorative and sustainable environmental peacemaking.' Discussed in chapter 7 and chapter 8.

Part 2: CSG Extraction and Water: A Review of the Research

2.16 Impacts to Groundwater and Surface Water Systems by CSG Extraction

There have been many studies of water resources in Queensland, including: Cox and Barron, 1998; GABCC, 1998, 2010, 2011. The more recent major Queensland studies pertaining to potential groundwater and surface water system impacts, have been conducted by the Queensland Water Commission, Queensland Government (QWC, 2010, 2012*a*, 2012*b*), and by WorleyParsons (2010, 2012, March 2013) commissioned by the Queensland Government (March 2013), studying CSG activity impacts ('*Heathy Headwaters CSG Water Feasibility Study, Activity 5 – Surat and Southern Bowen Basins'*) which is the most comprehensive to date. The IESC, 2014*a, b, c, d, etc*., Background reviews have based their initial findings heavily upon these sources for water system knowledge and CSG impacts in the Western Downs. In addition, studies commissioned by the Commonwealth's NWC carried out by Sinclair Knight Mertz and the National Centre for Groundwater research - Barnet, *et al*., 2012. And also, the Centre for Water in the Minerals Industry (CWiMi) - Vink *et al*., 2008 (ongoing research studies by the UQ-CCSG), the Office of Groundwater Impact Assessment (OGIA) and the CSIRO. The earlier reviews are concerned with primarily surface or near surface impacts, due to the complex difficulties of deeper underground studies, though this is being continually advanced and improved with more sophisticated groundwater, aquifer, and surface water research by the IESC, UQ-CCSG, OGIA and the CSIRO.

With respect to groundwater systems, CSG contaminants tend to migrate downward and/or laterally to receptors. Groundwater impacts from CSG, originate below the surface *e.g.*, water drawdown at coal seams and depressurisation. Drawdown can propagate in all directions, eventually reaching the surface. Drawdown propagation in confined aquifers is controlled by water and pore space compressibility and porosity of pore space (Habermehl, 2002; Ali *et al*., 2004; Cherry *et al*., 2004; Pyne, 2005; Scott, *et al*., 2007; Bryant *et al*., 2010; Golding, *et al*., 2010; Hillier, 2010; Maliva and Missimer, 2010; Barnett *et al*., 2012; Batley, *et al*., 2012; Moore, 2012; Hamawand and Hamawand, 2013, 2014; Cavaye and Kelly, 2015; Askarimarnani, 2017; Nelson 2019).

Depressurisation of the coal measures is the principal risk to aquifers of the Surat and Bowen basins. Groundwater within pore space of coal deposits exists under pressure created by hydrostatic gradients, *e.g*., 9.8 kPa per metre of freshwater, lithostatic gradient created by the overlying rock and soil formations *e.g*., 20 kPa per metre depth, holding the gases in the seams. CSG, comprised mostly of methane, is adsorbed onto the surface of coal pores (micro pores and fractures or cleats) and is held in place by the water pressure. Leading to the depressurisation of the seams that allow the CSG to flow out of the coal and towards the CSG production wells (Habermehl, 2002; Gogu *et al*., 2003; Ali *et al*., 2004; Scott *et al*., 2007; Barnett and Muller, 2008; Bakker, 2010; Batley, *et al*., 2012; Moore, 2012; Hamawand and Hamawand, 2013, 2014; Queensland Government, 2013; Askarimarnani, 2017; Nelson 2019).

The Walloon Coal Measures (WCM) of the Surat Basin, are estimated to produce more water to recover CSG compared to the Bowen Basin. Groundwater production by the CSG industry is ~18,000 ML/a (2011), co-produced water for the Surat Basin may increase to ~175,000-200,000 ML/a between ~2025-2030 (KCB, 2012). Cumulative production of CSG water over the life of the industry is ~4,500,000-5,100,000ML (Queensland Government, March 2013, IESC, 2014*c*).

CSG activity occurring particularly in agricultural areas, increases risks of soil salinisation from leaks or spills of co-produced water. Similarly, after co-produced water is treated, either a solid or concentrated waste remains, which requires proper disposal either at the surface in engineered containment cells (large evaporation ponds) or into the subsurface via injection into wells. The higher the water-to-gas ratios, the greater the volumes of water that will require handling, treatment, and waste stream (Shavet, 1994; Stumm and Morgan, 1996; Singh *et al*., 1998; Fetter, 2001; Habermehl, 2002; Mallee CMA, 2005; QWC, 2009; 2012; Geoscience Australia and Habermerhl, 2010; APLNG, 2011*b*; Nghiem *et al*., 2011; Batley, *et al*., 2012; Moore, 2012; Hamawand and Hamawand, 2013, 2014; Queensland Government, March 2013; Higgins *et al*., 2014; IESC, 2014*a, b, c*; Nelson 2019). See Appendices 8 and 9.

Dewatering of a CSG well can take up to ~3 to 5 years of pumping to lower the water pressure. CSG fields have a productive life of up to ~25 years but the residual drawdown after CSG field depressurisation has ended may act much longer as a risk factor because of the time it takes for water pressures within the coal seams to return to predevelopment levels. For the WCM, the QWC 2012 groundwater modelling predicts a ~50% recovery of groundwater, occurring ~30 to ~50 years after CSG production ceases (Queensland Government, March 2013), groundwater quality unknown. Please refer to specific review sections in this chapter.

2.16.1 Groundwater, Aquifers, Springs, and Risk Assessment

Groundwater sustains groundwater dependent ecosystems (GDEs), without groundwater they would not exist. Many springs in the GAB and in the Surat CMA (cumulative management area), are of national significance. The Queensland Government, March 2013 risk assessment considered the following GDEs:

- Springs; and
- Baseflow receiving streams (*e.g.*, watercourse springs).

Supporting unique ecological habitats and are often associated with a range of cultural heritage values (QWC, 2012*d*). The Surat Basin central and south-west springs and to the southwest are discharge springs that have low groundwater flow-paths a great distance from recharge areas, with deep structural control from faulting or folding. The variance in flow-path lengths makes recharge springs more resilient to potential impacts from CSG water extraction in comparison to discharge springs (CSIRO, 2008; Conics, 2010; Fensham *et al*., 2010; Bond *et al*., 2010; Geoscience Australia and Habermerhl, 2010; Nevill *et al*., 2010; Reich, 2010; Shaw, 2010; Queensland Government, March 2013; Towler *et al*., 2016; Nelson, 2019).

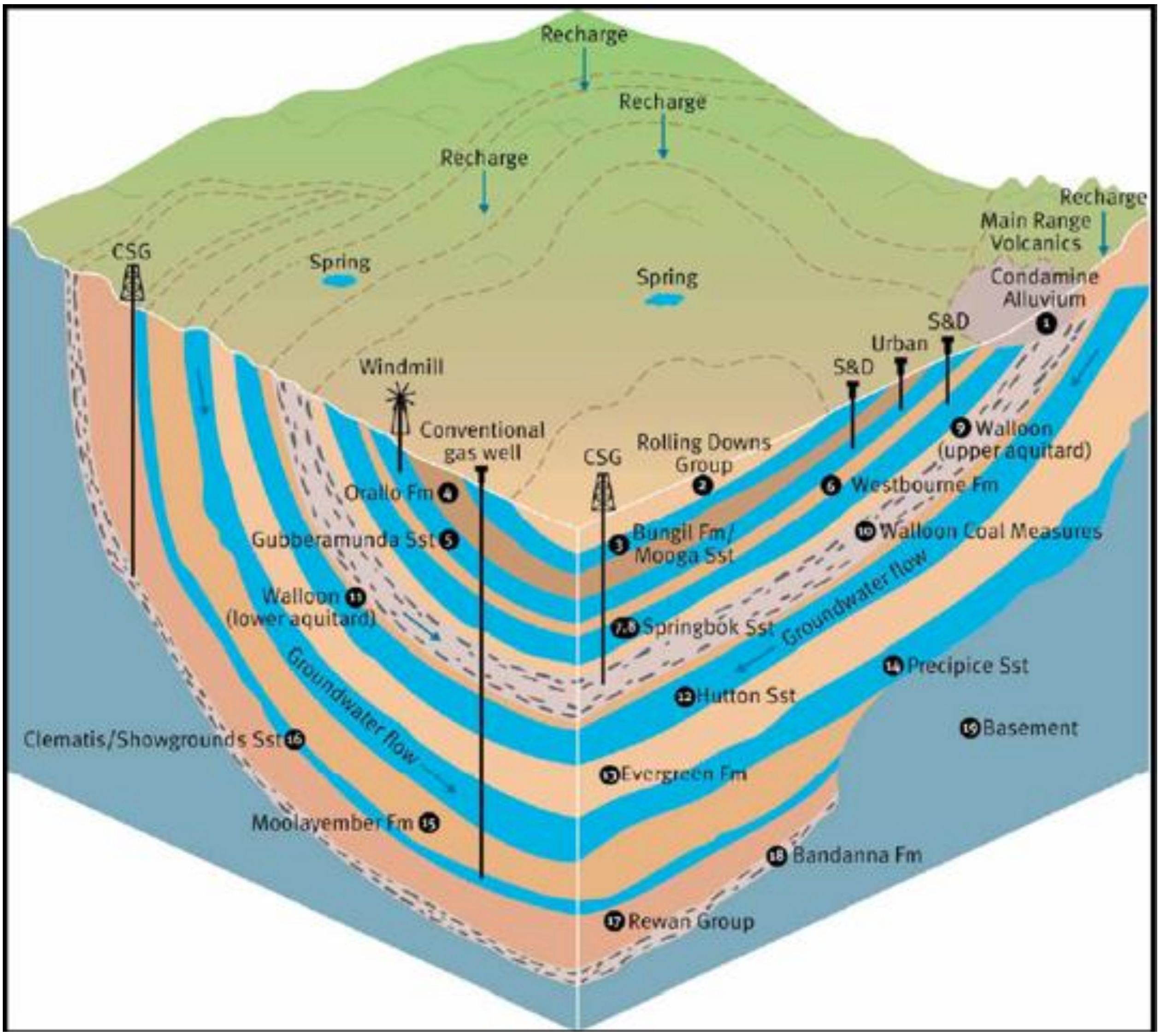

Figure 2.3: Aquifers and Aquitards in the Surat Basin and Southern Bowen Basin
Source: QWC, (2012*d*) figure, retrieved from
http://www.dews.qld.gov.au/__data/assets'pdf_file/0005/82274/qwc_annual-report_1-july-31-dec-2012-1.pdf
Creative Commons Licence CC BY 4.0 Note: aquifers are shaded in blue

The impacts connected to surface contamination to groundwater systems would be higher in unconfined areas (*e.g.*, the Surat Basin) where GAB aquifers outcrop, than in areas where significant confining strata exist above major aquifers. See Figure 2.3 (Queensland Government, March 2013). In addition, see Appendices 10 and 11.

Land use change affects aquifers when they are above intake beds, rainfall naturally recharges the subsurface through exposed surface formations, and where water features are exposed at the surface. Clearing of ground cover *e.g.*, levelling, resurfacing, or compaction due to CSG infrastructure may lower recharge, also affecting soil permeability, increasing runoff instead of allowing permeation through the soil, diminishing aquifer storage (Queensland Government, March 2013). Further, Underschultz *et al.*, 2017 researching with UQ-CCSG, OGIA and CSIRO has questioned the understanding of existing groundwater flows directions in the Surat Basin, in contrast to those determined by QWC, 2012. CSG infrastructure near the intake beds affects aquifers greater than CSG activities at the centre of basins. The fracking impact depends on their geology and hydrogeology, size, and duration of fracking. (QWC, 2012*a*). The QWC, 2012*a* (now OGIA) estimated the groundwater movement from the Condamine Alluvium into the WCM as a result of CSG activities predicted declining water level affecting the Condamine Alluvium by 2017 based on regional groundwater flow modelling, ~1100 ML per year over the next 100 years (IESC, 2014*d*). See Appendix 10.

With any resource extraction activity, there are potential benefits and potential impacts, with the distribution of these benefits and impacts in a community or region an important consideration (Queensland Government, March 2013; Cheshire *et al*., 2014; Comino *et al*., 2014; Evans *et al*., 2014; Huth *et al*., 2014; Uhlmann *et al*., 2014; Tan *et al*., 2015; Vickas *et al*., 2015; Werner *et al*., 2015; Towler *et al*., 2016; Keywood *et al*., 2018; Nelson 2019). See Appendix 12.

Regional communities that are dependent on agricultural activities reliant on the groundwater resources for supply are also at risk due to human induced impacts to these resources, but it is some agricultural practices themselves which pose the risk (Peck and Williamson, 1987; Ali *et al*., 2014; Thayalakumaran *et al*., 2015). A challenge with groundwater is that once impacts arise, it can take many decades before recovery occurs (De Marsily, 1986; Foster, 1987; Peck and Williamson, 1987; Domenic and Schwartz, 1990; Gelhar *et al*., 1992; Doerfliger and Zwahlen, 1998; Doerfliger, 1999; Ali *et al.*, 2004; Cherry *et al*., 2004; Eamus *et al*., 2006; Crosbie *et al*., 2007; Bakker, 2010; Barnett and Muller, 2008; Barnett *et al*., 2012; James and Barnes, 2012; Mackay *et al.*, 2012; Ali *et al*., 2014; Towler *et al*., 2016; Nelson, 2019). This makes it an imperative to avoid impacts wherever possible.

All forms of CSG extraction in the Western Downs will potentially impact groundwater resources through the extraction or drawing down of this resource as a necessary requirement for extracting the gas (Eamus *et al*., 2006; Barnett *et al*., 2012; Nevill *et al*., 2010; Barnett *et al*., 2012; James and Barnes, 2012; Tan *et al.*, 2015; Nelson 2019). This impact will differ spatially due to underlying features of the groundwater resource itself, as well as the volume of water extracted in an area (Eamus *et al*., 2006; Nevill *et al*., 2010; Comino *et al*., 2014; Tan *et al*., 2015; Nelson 2019). The cumulative impacts may also be considerable and requires adaptive management (Vink *et al*., 2008; Geoscience Australia and Habermerhl, 2010;

Habermehl, 2010; Cheshire *et al*., 2014; Comino *et al*., 2014; Evans *et al*., 2014; Uhlmann *et al*., 2014; Tan *et al*., 2015; Vickas *et al*., 2015; Werner *et al*., 2015; Towler *et al*., 2016; Nelson 2019). The potential impacts to groundwater from CSG extraction in the Western Downs was assessed by Worley Parsons 2013, using a mixed methodology including a traditional overlay/index (Multi Criteria Analysis: MCA) and a quantitative Groundwater Model. The assessment approach targeted key potential hazards including aquifer storage volume; consideration of other groundwater users; and groundwater dependent ecosystems. The assessment differentiated between discharge springs and recharge springs due to their different functioning within a groundwater system. The assessment identified geographical variation in the potential impacts, and this was consistent with previous but more limited assessments (QWC, 2012). There was a greater risk to discharge springs from CSG activities with the risk increasing to discharge spring ecosystems located away from recharge areas. In contrast, recharge springs with an underlying aquifer and a short flow-path types with greater natural variability in flow were potentially more resilient to CSG-induced changes in flow. Thus, the assessment provided important information for prioritizing groundwater resources more likely to be impacted by CSG extraction activities in the region. Impacts from groundwater usage has the potential to directly impact the environment, with specific risks to groundwater dependent ecosystems (GDEs) (Ryan *et al*., 2002; Astles *et al*., 2003; Bjornsson *et al*., 2003; Reich and Downes, 2003; Eamus *et al*., 2006; Fensham, 2006; Clifton *et al*., 2007; CSIRO, 2008, Tomlinson and Boulton, 2008; Bond *et al.*, 2010; Conics, 2010; Fensham *et al*., 2010; Nevill *et al*., 2010; Reich *et. al*., 2010; Shaw, 2010; King *et al*., 2011; Rogers *et. al*., 2011; Takahashi *et al*., 2011*a*, 2011*b*; James and Barnes, 2012; Rolls *et.al*., 2012; Mackay *et al*, 2012; Green *et* ***al*.,** 2013; Nelson 2019).

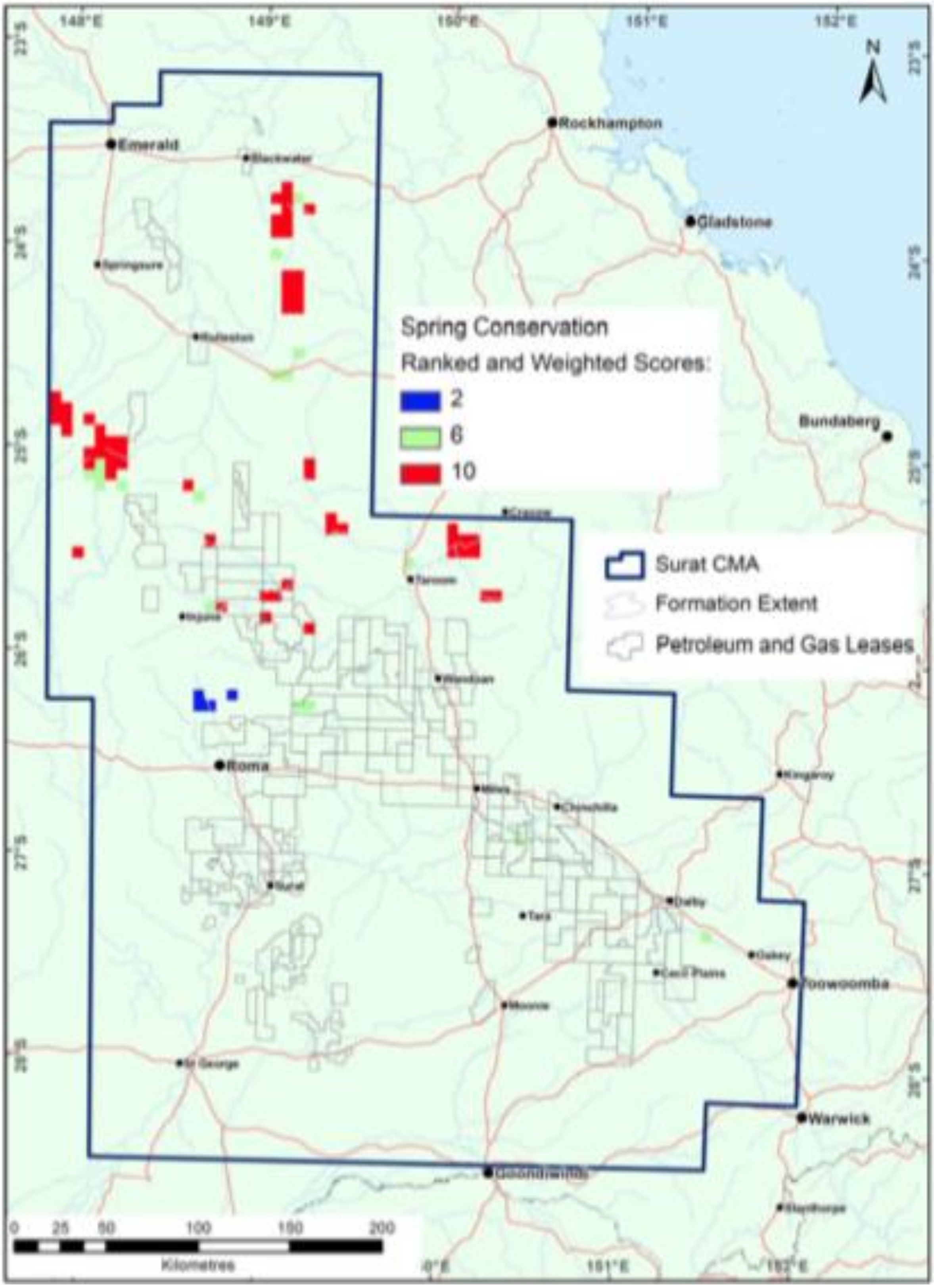

Figure 2.4: Spring Conservation Ranked and Weighted Scores (Excluding Non-Ranked Springs)

Source: QWC, (2012*c*) figure, retrieved from
http://www.dews.qld.gov.au/__data/assets'pdf_file/0005/82274/qwc_annual-report_1-july-31-dec-2012-1.pdf Creative Commons Licence CC BY 4.0

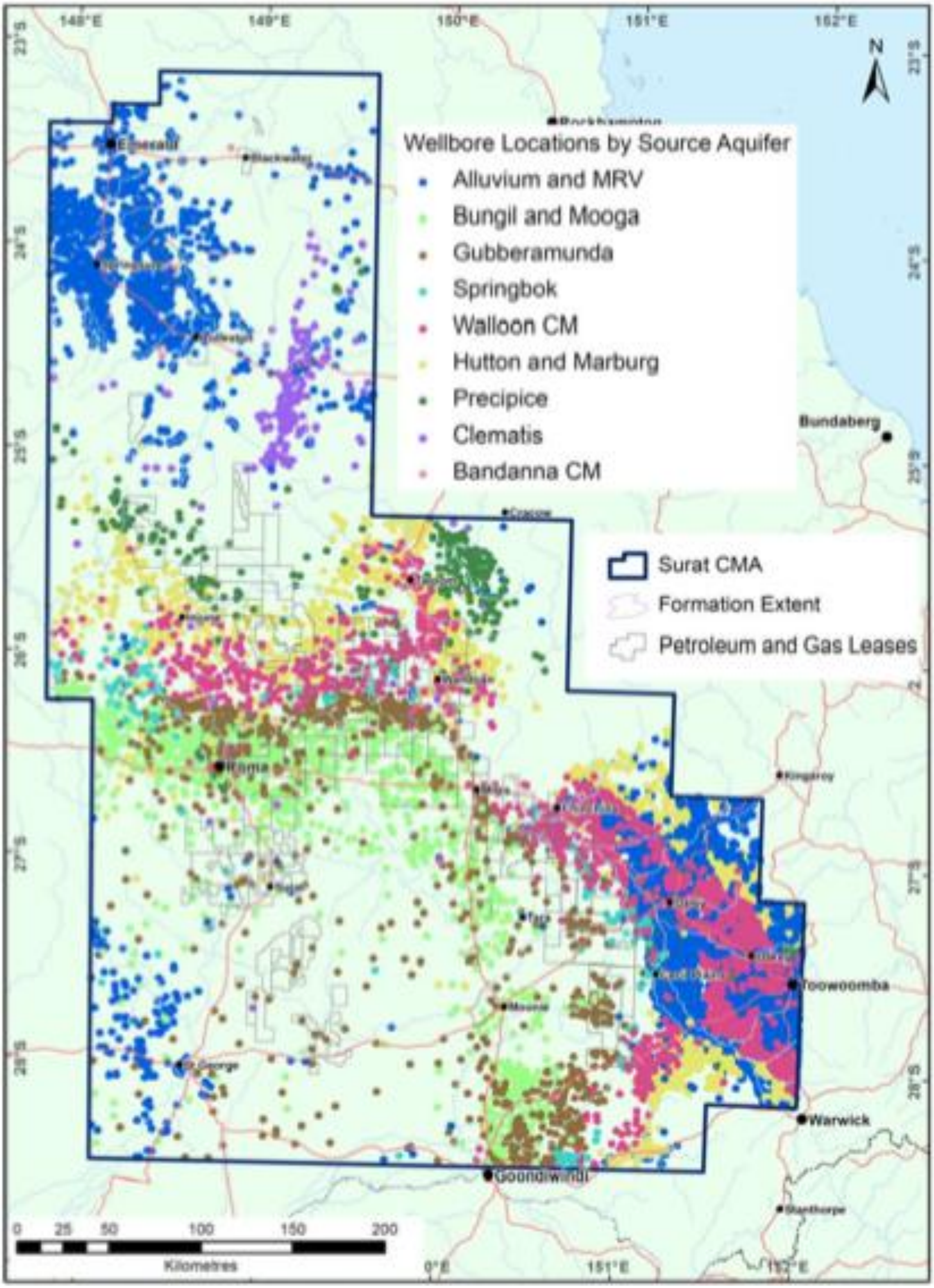

Figure 2.5: Identified Source Aquifers for Water Use

Source: QWC, (2012*c*) figure, retrieved from
http://www.dews.qld.gov.au/__data/assets'pdf_file/0005/82274/qwc_annual-report_1-july-31-dec-2012-1.pdf

Springs inventories have been completed for the entire GAB (Fensham, 2006; Fensham *et al.*, 2010), as well as for the Surat CMA specifically (QWC, 2012*c*). Within the Surat CMA, there are 71 spring complexes (containing 330 spring vents) and 43 watercourse springs (QWC, 2012*c*). Risk assessment was not available for all of the springs and Figure 2.4 shows only those springs considered in the study (Queensland Government, 2013).

Ranking of ‘discharge’, ‘watercourse’ fields for QWC spring and hydrostratigraphic database for springs (Queensland Government, March 2013):

- Discharge springs - higher value than recharge springs – historical and cultural content. Ecosystems away from recharge areas affected by water and flow change. Ranking of 10;
- Recharge springs - underlying aquitard. Intermediate flow conditions and slight groundwater. Ranking of 6; and
- Recharge springs - underlying aquifer. Low discharge flow systems *i.e.* greater natural flow with greater resilience to CSG water flow change. Ranking of 2.

Watercourse springs viewed as discharge springs (QWC, 2012*c*). Rankings were assessed from the QWC database: if discharge or watercourse database fields ‘TRUE’, rank of 10. QWC database: discharge and watercourse fields ‘FALSE’ if recharge springs (Queensland Government, March 2013). Rankings in Figure 2.4

QWC 2012 stated aquifer extent layers impacts are available for major aquifers, not for source aquitards. Southeast of Surat, springs may attach to Main Range Volcanics. Springs linked to underlying aquifer in the Surat Regional Groundwater Flow Model based on aquifer layer (Queensland Government, March 2013). Figures 2.4 and 2.5.

The springs connected to aquitards, had vulnerability attributes for underlying aquifers used for hydrostratigraphic units above Walloon Coal Measures (WCM). Vulnerability risk assessment is low for aquitard recharge springs. Given a weighting factor of 1 ($Wt_9 = Wt_{10} = 1$). Total weighting of 2 (Queensland Government, March 2013).

CSG impacts highest for aquifers and receptors within the WCM (Surat Basin) and Bandanna Formation (Bowen Basin), the CSG targets. Impacts greatest at Lower, Upper Springbok Sandstone, Hutton Sandstone, Gubberamunda Sandstone, Surat Basin. Drawdown impact greatest: east Roma aquifers; west Chinchilla; and Dalby.

This is consistent with 2008 Centre for Water in the Minerals Industry (CWiMI). The CWiMI 2008 found higher drawdown impacts at Condamine Alluvium (Queensland Government, March 2013). In addition, see Appendices 10 and 11.

Also consistent with the QWC 2012 assessment conducted - Underground Water Impact Report (UWIR) (QWC, 2012*d*). Some results did differ between the studies (Queensland Government, March 2013):

- *QWC found three impacted spring ecosystems, two at Roma and one at southeast of Miles;*
- *QWC found one spring ecosystem at Taroom; and*
- *Springs ecosystems at Blackwater and Rolleston at the Bandanna Formation.*

CSG migration impacts spatial, drawdown impact at: WCM; Lower, Upper Springbok Sandstone, Surat Basin; north Roma; northeast of CSG production, Bowen Basin; and wellbores overlapping Bowen Basin CSG tenements (Queensland Government, March 2013).

Assessment data gaps of GMMCA methodology were (Queensland Government, March 2013):

- *Reservoir processes controlling water volume during CSG production;*
- *Condamine Alluvium: hydraulic connectivity between WCM and CA;*
- *Open pathways along fault lines at Bowen Basin;*
- *Baseline studies;*
- *Groundwater, surface water, inter-aquifer flows, and storage;*
- *water use at Surat and southern Bowen basins; and*
- *Spring ecosystems, land use, and groundwater extraction.*

Data near CSG tenements is limited *e.g.*, southern Surat. Declines at depth in both basins. Limited for fault mapping, groundwater (Queensland Government, March 2013). Data needed for future modelling for UWIR assessments regarding future temporal impacts, and risk assessment. Also, regarding future proposed gas production, with multiple adjacent developers and potential negative impacts on groundwater (Gelhar *et al*., 1992; Doerfliger and Zwahlen, 1998; Doerfliger, 1999; Gogu *et al*., 2003; Ali *et al*., 2004; Cherry, 2004; Barnett and Muller, 2008; Bakker, 2010; Nevill *et al*., 2010; Queensland Government, March 2013; Nelson 2019).

Resulting groundwater usage has the potential to impact the environment, GDEs, communities, and considerable agricultural and industrial interests reliant on the groundwater resource for supply, but groundwater level recovery may take decades or much longer (Boulton and Brook, 1999; Baldwin and Mitchell, 2000; Schiller, and Harris, 2001; DNRE, 2002; Ryan *et al*., 2002; Astles *et al*., 2003; Bjornsson *et al*., 2003; Reich and Downes, 2003; Eamus *et al*., 2006; Fensham, 2006; Clifton *et al*., 2007; CSIRO, 2008; Tomlinson and Boulton, 2008; Bond *et al*., 2010; Conics, 2010; Fensham *et al*., 2010; Nevill *et al*., 2010; Reich *et. al*., 2010; Shaw, 2010; QWC, 2012; Green *et al*., 2013; Ali *et al*., 2014; Thayalakumaran *et al*., 2015; Nelson 2019). CSG best practices such as fracking may potentially result in permanent impacts to regional groundwater systems. (Queensland Government, March 2013). Impact assessments were predicated on analytical and numerical models. Poorly constructed wellbores may provide preferential pathways between the coal measures and adjacent aquifers (Habermehl, 2002; Ryan *et al*., 2002; Astles *et al*., 2003; Bjornsson *et al*., 2003; Reich and Downes, 2003; Clifton *et al*., 2007; Crosbie *et al*., 2007; Scott *et al*., 2007; CSIRO, 2008; Conics, 2010; Fensham *et al*., 2010; Bond *et al*., 2010; Geoscience Australia and Habermerhl, 2010; Nevill *et al*., 2010; Reich, 2010; Shaw, 2010). Model boundaries, *e.g*., simulated drawdown due to CSG extraction may or may not be stopped by these boundary conditions (Geoscience Australia and Habermerhl, 2010; Habermerhl, 2010; Barnett *et al*., 2012). Potential cumulative groundwater impacts across the CSG development areas was recommended committed to an adaptive environmental approval regime for the industry, designed to deal with any significant unintended environmental outcomes of CSG development (Vink *et al*., 2008; Geoscience Australia and Habermerhl, 2010; Habermehl, 2010; Queensland Government, March 2013; Cheshire *et al*., 2014; Comino *et al*., 2014; Evans *et al*., 2014; Huth *et al*., 2014; Uhlmann *et al*., 2014; Everingham *et al*., 2015; Tan *et al*., 2015; Vickas *et al*., 2015; Werner *et al*., 2015; Towler *et al*., 2016; Keywood *et al*., 2018; Nelson 2019). Seven LNG projects have been announced in Queensland. Of the seven LNG projects, three have been granted state and federal approval (Santos GLNG, Australia Pacific LNG, and BG/QGC QCLNG), located at the Surat

Basin (Queensland Government, 2013). See Appendices 14 and 15.

2.17 Water Use and Well Data

Water licences, and volumes are recorded in DNRM's Water Management System, and bores taking water are recorded in DNRM's Groundwater Database. Bores with volumetric limits are metered, but S&D bores are not (QWC, 2012*d*). Wellbore construction intervals (*e.g.*, well completion depths, aquifers, wellbore age) were leveraged from the DERM Activity 1.2 study, '*Spatial Analysis of Coal Seam Gas Water Chemistry*' (WorleyParsons, 2012). This database of groundwater levels and water quality was developed from two primary datasets (QWC, 2012*d*): Queensland Government Groundwater Database, containing bore registry data for 138,534 registered bores within Queensland (2010), and the Geological Survey of Queensland Petroleum Exploration Database, containing data for 7,362 petroleum wells (2010). Some 160, 428 bores were assessed in the database, with 26,543 within the Bowen and Surat basins (WorleyParsons, 2012). See Figure 2.6

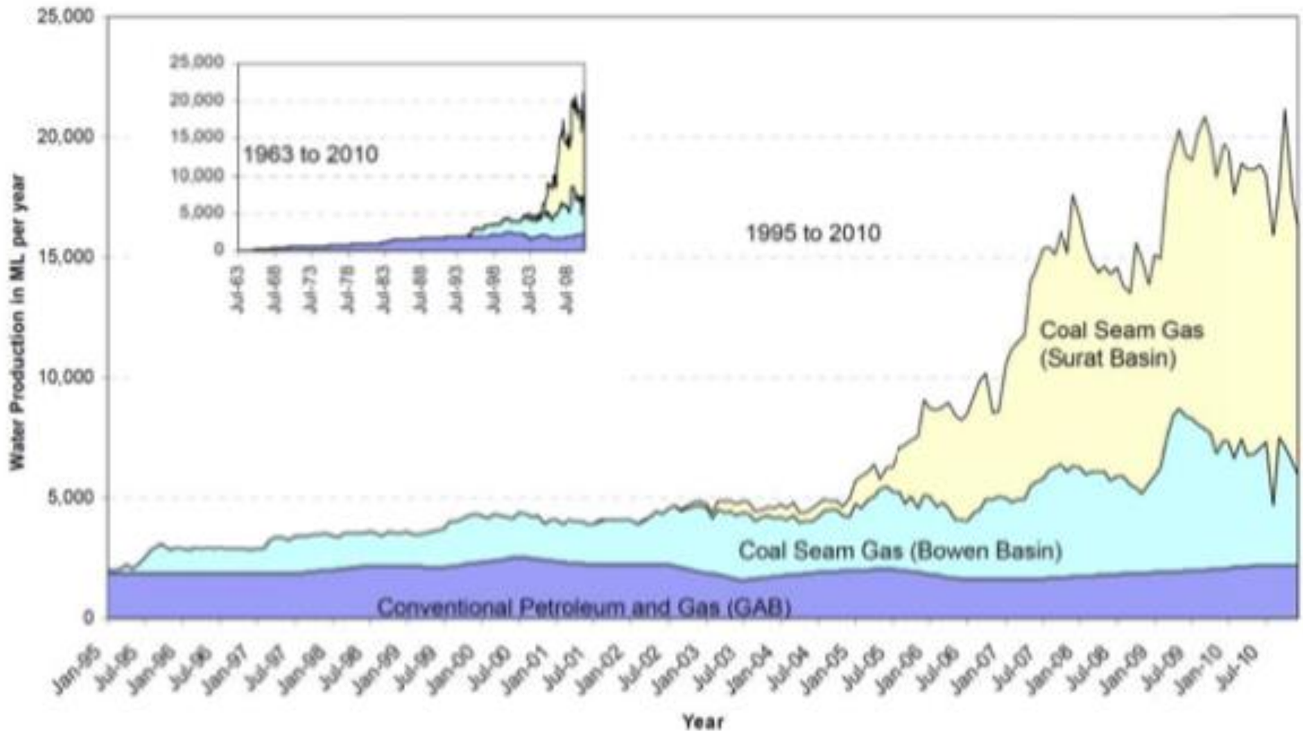

Figure 2.6: Historic Water Production from Petroleum and CSG Wells

Source: QWC, (2012*d*) figure, retrieved from http://dnrm.qld.gov.au/ogia/surat-underground-water-impact-report Creative Commons Licence CC BY 4.0

The CSG production statistics as of December 2018, have shown a rapid growth in the gas industry's production in the past 15 years, drilling ~1634 CSG wells in 2013-14. With central

Queensland producing a quarter of the global production of LNG, 90% of the CSG wells of which are in the Surat and Bowen Basins. A production of ~26 million tonnes of LNG per year. The growth has increased in worth from an estimated ~$14.7 Billion in 2012-13 to some ~$57 Billion by 2018 (Queensland Government, 2019).

2.18 Groundwater Interaction, Aquifer Connectivity, and Interference

Aquifer connectivity describes groundwater interaction between aquifers separated by aquitards (inter-aquifer leakage), and parts of the same aquifer (intra-aquifer connectivity). Dependent on the lithology of aquitards, aquicludes (aquitards, semi-permeable aquifer constraining strata, aquicludes, impermeable constraining geologic strata) and aquifers, their integrity, and spatial continuity. Fractures, faults, open or inadequately sealed boreholes can form preferential flow paths affecting connectivity. Connectivity, the rate of water, and solute transfer between aquifers are often controlled by hydraulic pressure and dissolved mineral concentration gradients. Aquifer systems are dynamic, with gradients constantly changing, as groundwater is recharged (Radke *et al*., 2000; Timms *et al*., 2000; Habermehl, 2002; Worrall, 2002; Hills and Reynolds, 2003; Worrall and Kolpin, 2004; Cherry, 2004; Pyne, 2005; Scott *et al*., 2007; Hillier, 2010; Maliva and Missimer, 2010; Volk *et al*., 2011; Hennings *et al*., 2012; Moore, 2012; IESC, 2014*a*; Davies *et al*., 2015; Towler *et al*., 2016; Askarimarnani, 2017).

In an aquifer system under natural conditions, differences in hydraulic pressure will be present, both within aquifers and between aquifers that are separated by aquitards. These pressure differences result in flow of water and solutes within and between aquifers. When groundwater is pumped from a well it is intuitive that water pressure in the aquifer being pumped will decrease, leading to a localised increase in the rate of flow of water and its dissolved constituents towards the well. However, prolonged groundwater pumping from multi-layered aquifer systems will also affect aquifers other than the pumped aquifer (Moore, 2012; IESC, 2014*a*; Davies *et al*., 2015; Askarimarnani, 2017).

Consequently, unforeseen impacts can occur, not limited to the following (Golding *et al*., 2010; Moore, 2012; Hamawand and Hamawand, 2013, 2014; Taulis and Milke, 2013; IESC, 2014*a*; Davies *et al*., 2015; Towler *et al*., 2016; Askarimarnani, 2017):

- Enhanced leakage of water from overlying and underlying aquifers and aquitards, resulting in coincidental depletion of water resources;

- Mobilisation of salts in overlying and underlying aquifers and aquitards, resulting in coincidental deterioration of water quality in the pumped aquifer;
- Mobilisation of anthropogenic contaminants from overlying and underlying aquifers and aquitards;
- Changes in fluxes between surface water and groundwater systems near the surface; and
- Declining levels in shallow aquifers, leading to changes in recharge and/or discharge rates.

Large-scale groundwater development, *e.g*. CSG production and dewatering of coal mine voids, should be managed with a full understanding of aquifer connectivity (Habermehl, 2002; Worrall, 2002; Hills and Reynolds, 2003; Worrall and Kolpin, 2004; Cherry, 2004; Pyne, 2005; Scott *et al*., 2007; Golding *et al*., 2010; Hillier, 2010; Maliva and Missimer, 2010; Volk *et al*., 2011; Hennings *et al*., 2012; Moore, 2012; Hamawand and Hamawand, 2013, 2014; IESC, 2014*a*; Davies *et al*., 2015; Askarimarnani, 2017).

There is a significant body of literature, including studies from within Australia and overseas, that indicate hydraulic connectivity increases with increasing scale of measurement; this is primarily due to the presence of preferential flow paths at larger scales. Accordingly, most existing groundwater models that claim to address aquifer connectivity, via implementation of measured hydraulic conductivity data, will under-predict the magnitude of inter-aquifer leakage (Golding *et al*., 2010; Moore, 2012; Hamawand and Hamawand, 2013, 2014; IESC, 2014*a*; Askarimarnani, 2017).

Natural (*e.g*., fractures and faults) and manmade (*e.g*., well and boreholes) structures can significantly influence aquifer connectivity because they can act as preferential pathways for flow. In addition, they can cause changes to connectivity over time. Mechanical deformation of geological formations due to either depressurisation of aquifers by pumping, reinjection of co-produced water or hydraulic fracturing (fracking) can enhance fracture connectivity and thus bulk hydraulic properties of the formation (Timms *et al*., 2000; Habermehl, 2002; Worrall, 2002; Hills and Reynolds, 2003; Worrall and Kolpin, 2004; Cherry, 2004; Pyne, 2005; Scott *et al*., 2007; Golding *et al*., 2010; Hillier, 2010; Maliva and Missimer, 2010; Volk *et al*., 2011; Hennings *et al*., 2012; Moore, 2012; IESC, 2014*a*; Davies *et al*., 2015; Askarimarnani, 2017). In these instances, most of the induced fractures are propagated extensions of the natural fracture network, with characteristics determined by the geomechanical properties of the formation (IESC, 2014*a*; Askarimarnani, 2017).

Aquifer connectivity, expressed in terms of flux, can change from natural conditions solely by changing the hydraulic gradient. Mine dewatering, coal seam depressurisation, pumping for groundwater supply and co-produced water reinjection are all examples of how this could be achieved. Uncertainty lies in what happens to the natural system as multiple operations come online over time (cumulative impact) and after the resources have been exhausted and the infrastructure is decommissioned. This is particularly the case for the situation where aquifer connectivity has been enhanced by the creation of new preferential pathways (*e.g*. fractures in aquitards, leaking borehole seals, reactivated faults, that will remain in place post-production) (Vink *et al*., 2008; Golding *et al*., 2010; Hillier, 2010; KCB, 2010; 2011*a*, *b*, *c d*; Maliva and Missimer, 2010; Volk *et al*., 2011; Hennings *et al*., 2012; Love *et al*., 2012; Moore, 2012; Green *et al*., 2013; Queensland Government, March 2013, 2015; IESC, 2014*a*, *b*; Davies *et al*., 2015; Lester *et al*., 2015; Werner *et al*., 2015; Towler *et al*., 2016; Askarimarnani, 2017).

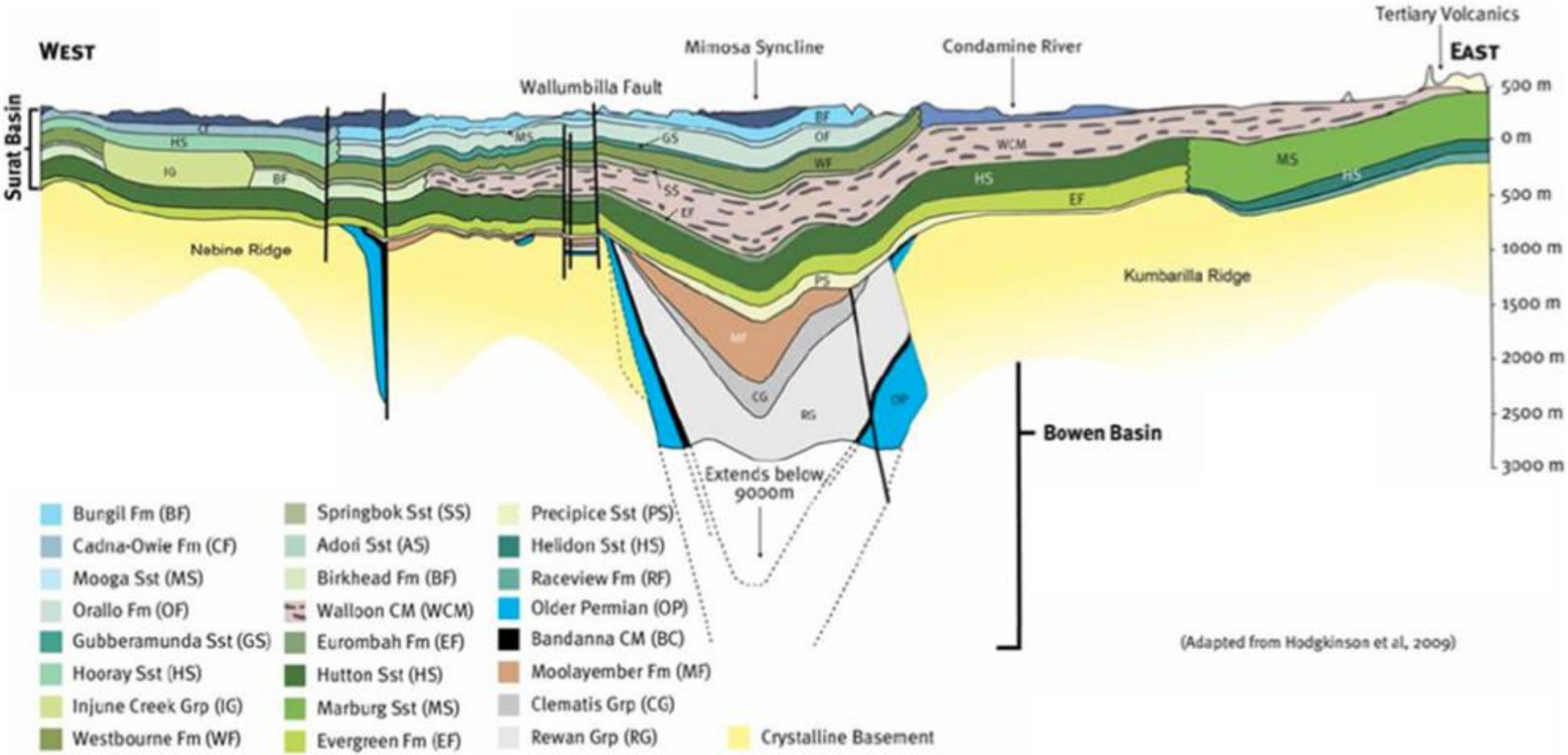

Figure 2.7: Geological Cross-Section Across the Bowen and Surat Basins

Source: QWC, (2012*d*) figure, retrieved from http://www.dews.qld.gov.au/__data/assets'pdf_file/0005/82274/qwc_annual-report_1-july-31-dec-2012-1.pdf

Contrary to the common perception that groundwater systems are simple layer-cake organisations of geologic strata, aquifers and aquitards are seldom laterally continuous or structurally undisturbed (Figure 2.7). For example, aquitards can pinch out or laterally transition into sediments with different hydraulic conductivity. Structural deformation, uplift, erosion, and deposition can all result in the formation of faults and fractures in both aquifers and aquitards the density and orientation of faults and fractures will ultimately affect the permeability of a geological layer, and fractures that traverse an entire aquitard will provide localised, preferential flow paths connecting two or more aquifers. Groundwater wells that have been screened over multiple aquifers or completed with faulty or inadequate casing can provide similar preferential flow paths (Scott *et al*., 2007; Economides and Martin, 2007; Bellabarba *et al*., 2008, 2009*a, b*; Gasda *et al*., 2010; GHD, 2010; Manifold, 2010; Nygaard, 2010; Arrow Energy, 2011, 2012; Costanza-Robinson *et al*., 2011; DEEDI, 2011*a*, *b*, 2013; Denney, 2011; APPEA, 2011; Day, 2012; Hennings *et al*., 2012; NUDLC, 2012; DNRM, 2013*a*, *b*, *c*, *d*; Queensland Government, March 2013, 2015; Taulis and Milke, 2013; Day *et al*., 2014, 2015; IESC, 2014*a, b*; Davies *et al.*, 2015; Lester *et al*., 2015; Towler *et al*., 2016).

Chemical variation and subsequent under estimation of Cl, Ca, CO_2, and TDS during sampling due to exposure to the atmosphere: and during laboratory measurement of samples can be common due to low optimum drying temperatures of samples (Taulis and Milke, 2013; Davies *et al.,* 2015). Taulis and Milke, 2013 found CSG water chemistry is important as an exploration tool and to assess environmental implications.

The IESC, 2014*a*, p.42, concludes: *"the connectivity of aquifers is dependent upon the lithology of the aquitards, their integrity and spatial continuity. Fractures, faults and open or inadequately-sealed boreholes may form preferential flow paths between aquifers*."

The IESC, 2014*a* p.42, further concludes: "*stressing of aquifers through pumping will alter the magnitude and potentially the direction of hydraulic gradients and will induce greater flow across aquitards. Flow through preferential flow paths can contribute considerably to the propagation of drawdown in aquifers overlying pumped aquifers. While transport of solutes through continuous aquitards is generally slow (as it is dominated by diffusion), the presence and characteristics of preferential flow paths will be a major factor in determining inter-aquifer transport of solutes, although retardation may help to slow this transport."*

2.18.1 CSG Well Installation and Completion

Horizontal in-seam wells are gaining in popularity because they provide greater contact area with the coal seam and allow more CSG to be extracted (Maricic *et al*., 2005; Arrow Energy, 2012; IESC, 2014*b*). These include directional, horizontal, and multilateral wells (Arrow Energy, 2012). Horizontal and multilateral wells also have the advantage of reducing the impact of surface infrastructure because fewer wells need to be drilled (IESC, 2014*b*).

Well design and completion are an important aspect of CSG extraction (Arrow Energy, 2012). Wells are designed to prevent gas or water leakage from the well into the subsurface. This mechanical isolation of the well from the subsurface is described as well integrity (API, 2009, Arrow Energy, 2012). The Australian Petroleum Institute (API) provides very specific guidelines on the construction of fracking CSG wells. A *Code of practice for constructing and abandoning coal seam gas wells* operates in Queensland (DNRM, 2013*a*, *b, c, d*). This code of practice includes both mandatory requirements and 'good industry practice' guidance (Arrow Energy, 2012, IESC, 2014*b*, *d*). Which include:

- A 'Blow Out Preventor' to stop release of fluid at the surface;
- Casing design including conductor, surface, intermediate and production strings, to be installed with best practice requirements;
- Casing centralisers;
- Cement to completely fill gap between casing and the rock; and
- Logging of bore hole conditions.

API (2009) suggests wells should be monitored. Even correctly completed wells can eventually fail due to down hole stresses and corrosion (Driscoll, 1986; McLaughlan *et al*., 1993; 1996, Dunnivant *et al*., 1997; Bourgoyne *et al*., 1999; API, 2002; McLean and Beveridge, 2002; Corneliussen *et al*., 2007; Economides and Martin, 2007; Bellabarba *et al*., 2008, 2009*a*, *b*; Gasda *et al*., 2010; GHD, 2010; Manifold, 2010; Nygaard, 2010; Arrow Energy, 2011, 2012; Costanza-Robinson *et al*., 2011; DEEDI, 2011*a, b*, 2013; Denney, 2011; APPEA, 2012; Day, 2012; NUDLC, 2012; DNRM, 2013*a, b, c, d*; Queensland Government, March 2013, 2015; Day *et al*., 2014, 2015; IESC, 2014*a, b*). No evidence that testing and exploration bores is carried out in Australia, though it may be a reporting requirement (Arrow Energy, 2012; IESC, 2014*d*).

2.19 The Extraction Process and the Role of Fracking

The 2012 of economic demonstrated resources (EDR) of CSG in Australia was 35,905 petajoules (PJ). This is equivalent to nearly 10 times the total yearly energy used in Australia based on 2007 total energy use (DEWHA, 2008). Resources are considered as EDRs if there is at least a 50% probability that they can be commercially extracted. Queensland has the clear majority of EDR CSG with 92% of Australia's EDR in the Surat and Bowen Basins (Arrow Energy, 2012; IESC,2014*d*).

Since 1995, ~3% of total EDR has been extracted from the Surat and Bowen Basins (GA and BREE, 2012). With increased growth in CSG production in the past 15 years, drilling ~1634 CSG wells in 2013-14. Producing a quarter of the global production of LNG, 90% of which are in the Surat and Bowen Basins. Producing ~26 million tonnes of LNG per year. The growth has increased in worth from an estimated ~$14.7 billion in 2012-13 to some ~$57 billion by 2018 (Queensland Government, 2019). Australia has production rates projected to last ~175 years (Arrow Energy, 2012; CEDA, 2012; IESC, 2014*d*)

Generally, after extensive geological investigation of a region suitable for CSG extraction, the 'lessee' domestic and international corporation will begin exploratory drilling until a 'target' coal seam, or measure is located. The process of investigatory drilling is highly intensive, requiring 'dewatering' (the removal of water) of the potential CSG bearing coal measure which can take up to ~3-5 years (Arrow Energy, 2012). Large amounts (typically around $40m^2$/day to up to $100m^2$/day per well, (Taulis and Milke, 2013)) of groundwater are removed (Arrow Energy, 2012; Hamawand, 2013; Queensland Government, 2013, March 2013; IESC, 2014*b, c, d*; Davies *et al*., 2015).

During onshore petroleum exploration, it is most likely that in the exploratory drilling stage, with the blasting of fracking fluids and dewatering of the porous coal seam, that degradation and pollution of groundwater and aquifer sources begins and is probably most serious, this then is exacerbated with the productive stage (Driscoll, 1986; McLaughlan *et al*., 1993, 1996; Bourgoyne *et al*., 1999; API, 2002; McLean and Beveridge, 2002; Corneliussen *et al*., 2007; Economides and Martin, 2007; Bellabarba *et al*., 2008, 2009*a*, *b*; Gasda *et al*., 2010; GHD, 2010; Manifold, 2010; Nygaard, 2010; Arrow Energy, 2011, 2012; Costanza-Robinson *et al*., 2011; DEEDI, 2011*a, b*, 2013; Denney, 2011; Lloyd-Smith and Senjen, 2011; APPEA, 2012; Batley and Kookana, 2012; Day, 2012; Green *et al*., 2012; Love *et al*., 2012;

NUDLC, 2012; DNRM, 2013*a, b, c, d*; Hamawand and Hamawand, 2013; Queensland Government, March 2013, 2015; Day *et al*., 2014, 2015; IESC, 2014*a, b*; Davies *et al*., 2015).

CSG extraction can take up a substantial part of an area, with well fields consisting of dozens or more of CSG wells drilled over many hectares (Arrow Energy, 2012). Millions of litres of groundwater are potentially impacted during the exploration and productive stage (>15 years in most cases) of a CSG well (Figure 2.8) (Arrow Energy, 2012). The non-productive CSG well's now redundant protective cement surrounded casings of steel, which extends through substrata, overlying rock strata formations, groundwater resources and drinking water aquifers, typically 200-1,000 metres below ground level to the coal measure, or seam, are then capped and left to eventually deteriorate making leakage of remnant CSG and related fracking fluids 'likely' (Driscoll, 1986, Dunnivant *et al*., 1997, Gasda *et al*., 2004, Duguid and Tombari, 2007, Forward, 2008, Houben, 2008, GHD, 2010, DEEDI, 2011*a*, *b*, 2013, Karacran *et al.*, 2011, Arrow Energy, 2012, Batley and Kookana, 2012, Moore, 2012, NSW Government (T&I), 2012*a, b, c, e, g*, Hamawand, 2013, Queensland Government, 2013*a*, 2015, Taulis and Milke, 2013, IESC, 2014*b, c, d,* NSW Government, 2014*a, e,* Davies *et al*., 2015).

Groundwater mixing with existing elements such as heavy metals, soluble hydrocarbons, salts and acids, varying dependent on: rock strata; groundwater dynamics drilled into; the amount of damage incurred during drilling and fracking on the rock strata; and normal groundwater dynamics, increases this 'likelihood' of impacts to the MNES, water (Geosciences Australia and BREE, 2010; Green *et al*., 2012; URS, 2010*a*; USQ, 2010; ADITC, 2011; APLING, 2011*a*, 2013*b*; Ecological Australia, 2011, 2012; Batley and Kookana, 2012; CSIRO, 2012*a*; DEEDI, 2012; DEHP, 2012*b*; Penny, 2012; DEHP, 2013*a*, *b, d*; DIP, 2013; FracFocus, 2013; Hamawand and Hamawand, 2013; Queensland Government, 2013*a*, 2015; Santos, 2013*a*, *b*; IESC, 2014*b*, *c*, *d*; Davies *et al*., 2015; DNRM, 2015*c*; Ferrer and Thurman, 2015; Lester *et al.*, 2015; Towler *et al*., 2016; Alloway, 2017; Geosciences Australia, 2018).

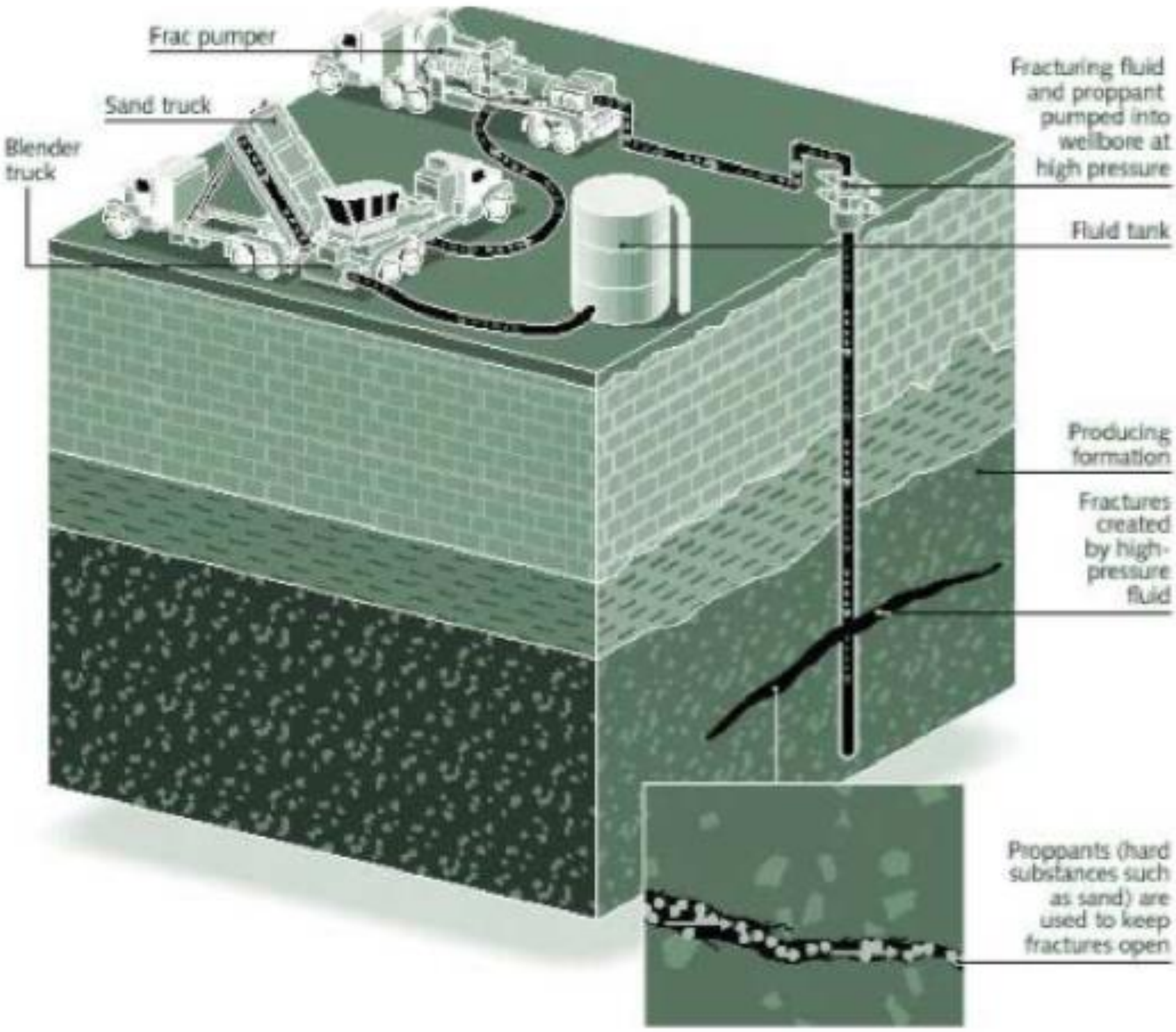

Figure 2.8: Schematic of the CSG Hydraulic Fracturing Process

Source: Queensland Government, (March 2013) figure, retrieved from https://www.dnrm.qld.gov.au/__data/assets/pdf_file/0013/106015/act-5-groudwater-risks-report-text.pdf. Creative Common Licence CC BY 4.0

There are two potential sources of contamination of water that can result from CSG extraction. The first is the liberation of potential contaminants (co-produced water) from the coal seams and other geologic features. The second is the addition of various compounds to the water injected into wells to make the process efficient and practical from an engineering perspective (Scott *et al*., 2007; Economides and Martin, 2007; Bellabarba *et al*., 2008, 2009*a*, *b*; Houben, 2008; Schlumberger, 2008; SKM, 2009; DEHP, 2009*a*; Gasda *et al*., 2010; GHD, 2010; Manifold, 2010; Nygaard, 2010, 2012*a*; Beckworth, 2010; DERM, 2010; Geosciences Australia and BREE, 2010; Green *et al*., 2012; URS, 2010*a*; USQ, 2010; ADITC, 2011; APLING, 2011*a*, 2013*b*; Ecological Australia, 2011, 2012; Lloyd-Smith and Senjen, 2011;

Batley and Kookana, 2012; CSIRO, 2012*a*; DEEDI, 2012; DEHP, 2012*b*; Penny, 2012; DEHP, 2013*a*, *b*, *d*; DIP, 2013; FracFocus, 2013; Hamawand and Hamawand, 2013; Queensland Government, 2013*a*, 2015; SANTOS, 2013*a*, *b*; Taulis and Milke, 2013; IESC, 2014*b*, *c*, *d*; Davies *et al*., 2015; DNRM, 2015*c*; Ferrer and Thurman, 2015; Lester *et al.*, 2015; Towler *et al*., 2016; Alloway, 2017; Geosciences Australia, 2018).

To extract CSG, the CSG well is uses drilling fluids to: lubricate and cool the drill rods and drill bit; remove the rock cuttings; maintain pressure control of the well; and stabilise the drill hole (Arrow, 2012). Fracking fluids hold open cracks and fissures creating and widening the cracks and fissures helping release the CSG from the groundwater saturated, porous coal of the coal seam (Arrow Energy, 2012). Fracking and fracking fluids are used to increase the productivity of the coal seam, and CSG migration to the well. The well is encased with steel and then pressure cemented from the: groundwater; aquifer water; and geological strata type, generally sandstone, strata aquitards with aquifers within, to the ground surface. Groundwater is pumped for up to 3-5 years to dewater the coal seam in preparation for CSG extraction (Miyazaki, 2005; Houben, 2008; SKM, 2009; Haliburton, 2011; KCB, 2011; SRW, 2011; SKM; 2011, 2012, *a, b*; Arrow Energy, 2011, 2012; Batley and Kookana, 2012; ISWD, 2012; Moore, 2012; Wright, 2012; Hamawand and Hamawand, 2013, 2014; Taulis and Milke, 2013; IESC, 2014*d*; Davies *et al*., 2015; Mudd, 2015; Askarimarnani, 2017).

Water is critical to the extraction process. Some CSG extraction processes use over one million litres per day (Arrow Energy, 2012; IESC, 2014*b*, *c*, *d*; Lester *et al*., 2015; Hauter, 2016; Towler *et al*., 2016; Askarimarnani, 2017; Nelson, 2019), which is pumped under great pressure repeatedly down the well fracturing the coal seam with added fracking proppants. The CSG rich co-produced water is recovered at the surface and processed. The water can contain a variety of elements and compounds. See Appendix 8 for comprehensive typical co-produced water quality data and ARMZECC/ARMCANZ guidelines.

Arrow Energy 2012 chapter 4, p. 18 mention several innovative well improvements:

- Standalone horizontal production wells;
- Multi-seam horizontal production wells; and
- Multi-branched lateral wells.

In combination, drilling multiple wells from a single surface location (Arrow Energy, 2012).

Arrow Energy may possibly be describing in the second point a multiple CSG fracking based extraction method consisting of accessing multiple coal seam depths of the ‘same’ coal seam, and or, different coal seams by CSG drilling from the same CSG well location(s).

Arrow Energy may possibly be describing in the third point a multiple CSG fracking based extraction method consisting of multiple lateral CSG drilled fracking branches from the same CSG well location(s).

In CSG projects, 600 metre grid patterns (well heads between ~350-1,000m), with ~30 -250 well per CSG field. Well pads may cover an area of ~8,100m^2 (90 by 90 metres), with individual wells productive at multiple coal seams. ~200m^3 of fracking fluid for individual CSG wells. With~30year CSG productive operating for 24 hours, 365 days per year. Production wells are installed by 18 truck mounted or ‘hybrid’ drilling rigs expected to drill 6,625 CSG wells by 2016 (Arrow Energy, 2012).

During CSG site preparation, on intensively farmed land, access will be by tracks, preparing CSG well drilling areas: removing all vegetation; stripping and piling soil; grading and compaction; fencing; and excavation of small pits for drilling fluids and ground flares. Surface tanks will also be utilised for drilling fluids (Arrow, 2012).

The CSG and water pipelines are made of high-density polyethylene. Buried ~0.75m. CSG and water will be transported from the wells to the compression and treatment facilities. Well head pressure (~100 (kPag) for CSG, ~200kPag-600 kPag water) used for transportation of CSG and water through the system. Production facilities will be fully automated. Controlled and monitored by computer based integrated systems for minimal operator intervention (Arrow Energy, 2012).

On well decommissioning Arrow Energy 2012, predicts potential adverse environmental impacts, though minimised, including but not limited to contaminated run-off into local waterways, air quality from dust, and soil contamination from hydrocarbons or other chemicals.

2.19.1 Injection of Hydraulic Fracking Fluids and Proppants

The injection of proppant into the well to initiate fracking in the coal seam and hold the fractures open assisting CSG and water flow to the well (Arrow Energy, 2012; IESC, 2014*d*). Injection can take from minutes to hours. The intention is to target the coal seam only, not the surrounding stratum. Though some fracking is meant to produce fractures that extend to other close coal seams (including: ADITC, 1992; Nuccio, 2000; Bennett *et al*., 2005; Houben, 2008; Schlumberger, 2008; SKM, 2009; DEHP, 2009*a* 2012*a*; Taleghani, 2009; Beckworth, 2010; DERM, 2010; Geosciences Australia and BREE, 2010; Green *et al*., 2012; URS, 2010*a*; USQ, 2010; ADITC, 2011; APLING, 2011*a*, 2013*b*; Ecological Australia, 2011, 2012; Batley and Kookana, 2012; CSIRO, 2012*a*; DEEDI, 2012; DEHP, 2012*b*; Penny, 2012; DEHP, 2013*a*, *b*, *d*; DIP, 2013; FracFocus, 2013; Hamawand and Hamawand, 2013; Queensland Government, 2013*a*, 2015; Santos, 2013*a*, *b*; IESC, 2014*b*, *c*, *d*; Davies *et al*., 2015; DNRM, 2015*c*; Ferrer and Thurman, 2015; Lester *et al.*, 2015; Alloway, 2017; Geosciences Australia, 2018).

The fracking fluid consists of mainly water, then proppants, principally sand, carried into fractures to hold them open when the high hydrostatic pressure is reduced. Proppant can have nut shells, ceramics, or bauxite added (Beckwith, 2010; Lloyd-Smith and Senjen, 2011; Arrow Energy, 2012; IESC, 2014*d*).

Fracking fluids also consist of many additional additives including: a gel to increase viscosity; and friction-reducing additives (Lloyd-Smith and Senjen, 2011, Arrow Energy, 2012). Viscosity is a measure of a fluid's resistance to flow. Typically contains a 0.1- 0.5% volume of additives (Lloyd-Smith and Senjen, 2011, Arrow Energy, 2012, APLNG, 2013*b*). The gas industry in Australia uses water-gel mixtures (Economides and Martin, 2007; Golder Associates, 2010*b*; Lloyd-Smith and Senjen, 2011; Arrow Energy, 2012; APLNG, 2013*b*; FracFocus, 2013; Ferrer and Thurman, 2015). Most common gelling agents are natural polymers such as guar gum (Lloyd-Smith and Senjen, 2011; IESC, 2014*d*). See Appendices 5, 6 and 7 for comprehensive lists of fracking fluid additives.

The fracking fluids vary in constituents and amount with respect to the geology of the CSG well including: (IESC, 2014*d*. p.25):

- A mixture of acid and inhibitors of corrosion to adjust pH to cleaning tunnel perforations:
- Highly pressurised water stimulating fracking, biocides, inhibitors for corrosion and stabilising chemicals and compounds;
- Gels to reduce pressure recorded when stimulating fracking;
- Proppant fracking fluid slurries;

- Gel additives controlling slurry release and to lower viscosity to enhance flowback;
- Additional water and additives for flushing; and
- Another water flush to help remove residual additives.

There is concern regarding chemical and compound additives used for fracking in Australia and other countries. In Queensland, a list of additives, volumes and concentration is required for approval by authorities (DEHP, 2013*b*; IESC, 2014*c*, *d*).

Hydraulic fracturing fluids have the potential to mobilise geogenic contaminants. Potential mobilisation is affected by elevated temperature, pressure, coal type and fracturing fluid composition. Improved understanding is needed of the transformation and fate of geogenics, including volatile geogenics and new products formed during fracturing, under different physico-chemical conditions (IESC, 2017).

2.20 Coal Seam Gas Co-Produced Water

Co-produced water is site-specific, but generally of poor quality and may have elevated TDS (salinity) and mineral content. Also, drilling enhancers and residual fracking fluids (Shaw, 2010; KCB, 2010, 2011*a, b, c, d*, 2012; Alley *et al*., 2011; SKM, 2011; Arrow Energy, 2012; FracFocus, 2013; Ferrer and Thurman, 2015). When fracking is employed, there is initial 'flowback' of varying quality water, thereafter it is known as CSG or co-produced water (Stephenson *et al*., 2003; Arrow Energy, 2012; Batley and Kookana, 2012; Hamawand and Hamawand, 2013, 2014; IESC, 2014*c*; Lester *et al*., 2015; Towler *et al*., 2016; Nelson 2019). See Figure 2.9

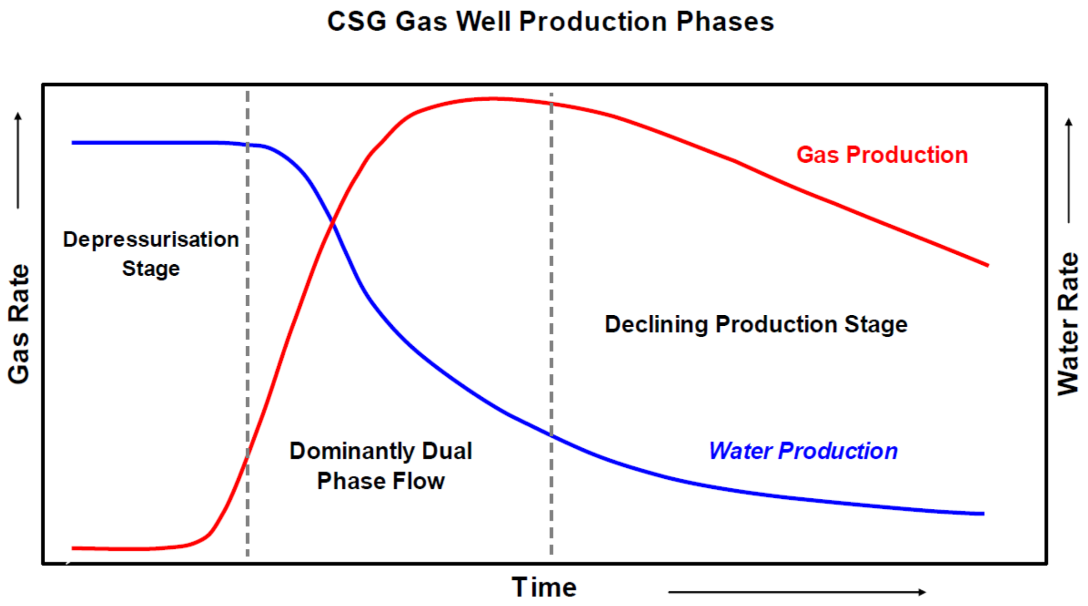

Figure 2.9: A Typical Gas and Water Flow in CSG Production

Source: QWC, (2012*d*) figure, retrieved from
http://www.dews.qld.gov.au/__data/assets'pdf_file/0005/82274/qwc_annual-report_1-july-31-dec-2012-1.pdf
Creative Common Licence CC BY 4.0

During and after production co-produced has; high salinity; bicarbonate content; an elevated pH (~8-10), a high SAR; hydrocarbons; and residual fracking additives (Shaw, 2010; Nghiem, *et al*., 2011; SKM, 2011; Arrow Energy, 2011, 2012). Co-produced water usually has a temperature > 40°C (URS, 2009*a*), with high levels of aluminium, copper, lead and zinc (URS, 2009*a*; Nghiem *et al*., 2011). May also be nutrient rich (ammonia and phosphorous) (URS, 2009*a*; IESC, 2014*c*).

The TDS of untreated co-produced water in Australia has salinities of ~1000 to 6000 mg/L (Nghiem *et al*., 2011; Arrow Energy, 2012). WorleyParsons 2010, found brine injection salinities ~25,000-40,000 mg/L (Queensland Government, March 2013). The elevated and very low TDS and co-produced water's high (or low) pH, SAR have demonstrated impacts on biota and are poor sources of irrigation water (including: Hart *et al*., 1990; Oliver, 1990; Williams and Smith, 1996; Nielsen and Chick, 1997; Puckridge *et al*., 1998, 2000; Humphries, 1999; ANZECC/ARMCANZ, 2000; Humphries, 2000; Neilsen *et al*., 2000, 2005; Schiller and Harris, 2001; SKM, 2001; Humphries and King, 2002; King, 2004; Humphreys, 2006; Nilsson and Renofait, 2008; Tomlinson and Boulton, 2008; Fensham *et al*., 2010; Griffith and Biddulph, 2010; Nevill *et al*., 2010; Shaw, 2010; King *et al*., 2011; McGregor *et al*., 2011; Rogers *et al*., 2011; Batley and Kookana, 2012; Mackay *et al*., 2012; Marsh *et al*., 2012; Rolls *et al*., 2012; Takahashi *et al*., 2011*a*; James and Barnes, 2012; IESC, 2014*c*; Hamawand, 2013; Davies *et al*., 2015; Lester *et al*., 2015; Towler *et al*., 2016; Nelson 2019).

The fate of the water produced in CSG extraction varies. Large amounts are held to evaporate in 1-100-hectare evaporation holding ponds. The groundwater settles here, and TDS can be typically 1000-6000mg/litre (Nghiem *et al*., 2011; Arrow Energy, 2012; IESC, 2014*c, d,*). Taulis and Milke 2013, ~TDS of 2,000-10,000 mg/Litre, up to ~25,000-45,000 mg/litre of salts, chloride, fluoride, heavy metals, ammonia, etc., from CSG ponds of millions of tonnes of collected solid waste (Arrow Energy, 2012; Queensland Government, March 2013, 2013*a*; Queensland Government (DIP), 2013). Discharging co-produced water into waterways, has serious impacts to water system ecosystems, particularly perennial and ephemeral, and directly on land, also occurs (Hart *et al*., 1990; Oliver, 1990; Williams and Smith, 1996; Nielsen and Chick, 1997; Puckridge *et al*., 1998, 2000; Humphries, 1999; ANZECC/ARMCANZ, 2000; Humphries, 2000; Neilsen *et al*., 2000, 2005; Schiller and Harris, 2001; SKM, 2001; Humphries and King, 2002; King, 2004; Humphreys, 2006; Nilsson and Renofait, 2008; Tomlinson and Boulton, 2008; Fensham *et al*., 2010; Griffith and Biddulph, 2010; Nevill *et al*., 2010; Shaw, 2010; King *et al*., 2011; McGregor *et al*., 2011; Rogers *et al*., 2011; Batley and Kookana, 2012; Mackay *et al*., 2012; Marsh *et al*., 2012; Rolls *et al*., 2012; Takahashi *et al*., 2011*a*; James and Barnes, 2012; IESC, 2014*c*; Hamawand, 2013; Davies *et al*., 2015; Lester *et al*., 2015; Towler *et al*., 2016; Nelson, 2019).

Co-produced water is also treated in treatment plants (IESC, 2014*c*), which do not address all the concerns of co-produced water due to problems relating to its constituents and the quality of water required for human drinking and irrigation. It may also cause other problems of being ‘too clean’ for its introduction into waterways (low turbidity) (Takahashi *et al*., 2011*a*; Arrow Energy, 2012; Davies *et al*., 2015; Lester *et al*., 2015; IESC, 2014*c*). Hamawand and Hamawand, 2013, 2014, found these treatment plants to be too expensive for the purification of co-produced water for irrigation water purposes.

It is expected that most of the fracking fluid will be removed over time, however a large proportion of the fluid constituents will adsorb to surfaces within the coal seam on the coal (Rogers *et al.*, 2007). Fracturing fluid will also be trapped in the coal seam when the cleats close stopping the fluid from flowing back to the well (Economides and Martin, 2007; Moore, 2012) and trapped in isolated fractures (Golding *et al*., 2010; Batley and Kookana, 2012; Moore, 2012; IESC, 2014*d*. Davies *et al*., 2015; Towler *et al*., 2016).

The fracking chemicals added vary depending on the: amount of groundwater present; its pressure; the type of geological formations; and the depth of the CSG well drilled (Lloyd-Smith and Senjen, 2011; Arrow Energy, 2012; Batley and Kookana, 2012; Davies *et al.,* 2015; Ferrer and Thurman, 2015; Lester *et al.,* 2015; Towler *et al.*, 2016). See Appendices 5,6 and 7.

If the existing groundwater is insufficient, 'piped in supplies': of 'sourced' often bought water; aquifer water; and other groundwater are used (SKM, 2001, 2009, 2011; Arrow Energy, 2012; SKM, 2012, 2012*a*, 2012*b*; IESC, 2014*c*; *Davies et al.,* 2015).

A range of organic compounds (including hydrocarbons) and radionuclides may also be present in co-produced water (Golding *et al*., 2010; Shaw, 2010; Volk *et al*., 2011; Arrow Energy, 2012; Moore, 2012; Hamawand, 2013; Davies *et al*., 2015; Ferrer and Thurman, 2015; Lester *et al*., 2015). Some associated CSG extraction compounds are naturally occurring in traces. Co-produced water can contain polycyclic aromatic hydrocarbons (PAHs), total petroleum hydrocarbons (TPHs), oxygen-bearing aromatic compounds such as phenols, aldehydes, ketones and various carboxyl-, hydroxyl- and methoxy- bearing compounds, monocyclic aromatic hydrocarbons such as benzene, toluene, ethylbenzene and xylenes (the *Environmental Protection Act 1994* was amended in October 2010 to regulate the use of BTEX chemicals in hydraulic fracturing processes) and various radioisotopes of uranium, radon, thallium and potassium. These compounds are generally only detected in very low concentrations, if at all, and although they may be 'naturally occurring', they can still pose risks to environmental and human health in high concentrations (ANZECC/ARMCANZ, 2000; Huxley, 1982; Worrall, 2002; Worrall and Kolpin, 2004; Shaw, 2010; Lloyd-Smith and Senjen, 2011; Arrow Energy, 2012; Batley and Kookana, 2012; Moore, 2012; Queensland Government, 2013*a*; IESC, 2014*c*; Davies *et al*., 2015; Ferrer and Thurman, 2015; Lester *et al*., 2015; Towler *et al*., 2016). Untreated co-produced water can also contain a range contaminant associated with bore construction and operation (Nghiem *et al*., 2011; SKM, 2011; Arrow Energy, 2012; Batley and Kookana, 2012; IESC, 2014*b, c, d*; Davies *et al*., 2015; Ferrer and Thurman, 2015; Lester *et al*., 2015; Queensland Government, 2015; Towler *et al*., 2016). Ferrer and Thurman 2015 noted the use of biocides; used to attempt to inhibit corrosion and maintain bore integrity. A more comprehensive list of CSG extraction related chemical constituents, fluids and particles are included in the Appendices 5, 6 and 7.

The chemical constituents of fracking fluids are still commercially sensitive (Lloyd-Smith and Senjen, 2011), however disclosure is becoming more transparent (SKM, 2011;

Arrow Energy, 2012; SKM, 2012, 2012*a*, 2012*b*; IESC, 2014*c*). See Appendix 8 for comprehensive typical quality and data guidelines, ARMZECC/ARMCANZ.

It may take up to 3 to 5 years to lower the pressure drawing water to the level for gas production (Arrow Energy, 2012; QWC, 2012*d*). With the quality of the co-produced water varying significantly (Shaw, 2010; Karacran *et al*., 2011; Nghiem *et al.*, 2011; SKM, 2011; Arrow Energy, 2012; Moore, 2012; Hamawand and Hamawand, 2013, 2014; Queensland Government (DIP), 2013; Taulis and Milke, 2013; IESC, 2014*c*, Davies *et al*., 2015; Ferrer and Thurman, 2015; Lester *et al.*, 2015; Towler *et al*., 2016; Nelson, 2019).

Co-produced water management will be a major problem for the CSG industry, communities, and managers due to its massive volumes (RPS, 2011; Arrow Energy, 2012; Hamawand, 2013; Queensland Government (DIP), 2013; Huth *et al*., 2014; IESC, 2014*c*; Davies *et al*., 2015; Ferrer and Thurman, 2015; Lester *et al.*, 2015; Towler *et al*., 2016; Nelson, 2019). In Australia co-produced water in 2010 was ~33 GL/year with ~40% from CSG and ~60% from conventional gas and oil (RPS, 2011; Arrow Energy, 2012). During ~25 to ~35 years co-produced water production will increase, due to development of CSG resources in Queensland, subject to model projections (Arrow Energy, 2012; NWC, 2012; Davies *et al*., 2015). In the Surat Basin alone, QWC 2012*d* estimated that water production would be around 125 GL/year until 2015, reducing to around 95 GL/year for the next 50 years. QWC 2012*c, d*, recognised that CSG extraction may lower water levels in ~528 bores over the water trigger and occur on ~71 spring ecosystems and ~43 watercourses within the 180,000 km^2 area, with some 21,000 bores. With weak perennial and ephemeral streams and riparian vegetation most impacted. It is estimated that it will take 30-50 years before 50% of the groundwater, quality unknown, returns to CSG well areas in the Surat, Bowen, and Clarence-Moreton Basin regions (Queensland Government, March 2013, IESC, 2014*c*).

CSIRO 2011 found a paucity of research on the mobility of naturally occurring substances associated with CSG in Australia. Finding compounds: nitrophenol and chlorophenols, with no known biological, or coal basis (CSIRO, 2011; IESC, 2014*d*).

2.20.1. CSG Co-Produced Water Treatment

Several techniques are used for treatment of co-produced (IESC*c*, 2014 p.31):

- Membrane desalination reverse osmosis (RO), electrodialysis (ED), electrodialysis reversal (EDR) and thermal desalination; and

- Granular Activated Carbon (GAC), ion exchange, wetland, and advanced oxidation; and

Treatment processes are dependent on co-produced water (Table 2.2) (IESC, 2014*c* p. 31). In addition, see Appendices 8 and 9.

Table 2.2: Available Water Treatment Technologies

Process Technology	**Primary Contaminants Removed**				
	Suspended Solids or Turbidity	**Dissolved Solids (Salts)**	**Heavy Metals**	**Organic Contaminants**	**SAR (Sodium Adsorption Ratio)**
Membrane Desalination (Reverse Osmosis – RO)	No	Yes	Yes[1]	Yes[2]	Yes[3]
Electrodialysis & Electrodialysis Reversal	No	Yes	Yes	No	Yes[3]
Thermal Desalination	Yes	Yes	Yes	Yes	Yes[3]
Ion Exchange	No	Limited	Yes	No	No
Advanced Oxidation	No	No	No	Yes	No
Granular Activated Carbon	No	No	Yes	Yes	No
Sedimentation	Yes	No	No	Limited[4]	No
Filtration	Yes	No	No	Limited[4]	No
Wetland	Limited	No	Yes	Yes	No

[1] Removal of metals by RO depends on the chemical form of the metal.

[2] Some organics (e.g. methanol, ethanol, phenols, and ethylene glycol) may be poorly removed through RO depending on pH, temperature, and operating pressure. Some smaller organic contaminants may also pass through RO membranes.

[3] Chemical additions required to adjust SAR.

[4] Where chemical is added.

Source: IESC, (2014*c*) figure, retrieved from
https://www.environment.gov.au/about-us/publications/archive#water

One of the main sources of impacts to surface water receptors and the near-surface groundwater environment associated with the large volumes of co-produced water is the recovery of salts through the treatment process and the safe storage and disposal of this by-product. Landfilling of solid salts and injection of the brine reject from the treatment process are current disposal options. Leaks or spills from surface impoundments or waste management areas present potential hazards. Several hundred thousand metric tonnes of salt each year are possible assuming an average co-produced water extraction rate ~95,000 ML/a (QWC, 2012*d*), and an average salinity of co-produced water ~4000 mg/L, this amounts to ~400,000 metric tonnes of salt annually (assuming all of the salts are recovered and disposed accordingly) needed to be managed (Queensland Government, March 2013). Also, the everyday chemical and material used in the operation of CSG infrastructure, stored and handled in accordance with Best Management Practices (BMPs). Uncontrolled discharges of these chemicals may occur despite BMP. These may cause potential impact to the surrounding land and near-surface water environment (Queensland Government, March 2013). Current operations in this area include microfiltration and RO treatment with post-treatment mineralisation to match the receiving waters (Arrow Energy, 2012; IESC, 2014*c*). For each treatment process there will also be a number of by-product waste streams, such as brine from EDR, RO and thermal desalination. Often there are only limited options available for further treatment and disposal of waste streams, particularly brine in inland areas (Arrow Energy, 2012; IESC, 2014*c*).

The majority of the IESC report on fracking (IESC, 2014*d*) is taken from petroleum industry funded reports, exclusively. However, independent papers by Hamawand and Hamawand 2013, 2014, suggested that the expense of co-produced water treatment for irrigation purposes is too high: but did indicate that the treatment of co-produced water with acetic acid could be conducive with the growth of specific algae for possible biofuel harvesting; and with polystyrene for the potential production of a photo-bioreactor (Hamawand and Hamawand, 2013, 2014).

2.20.2 CSG Co-Produced Water Discharged into Waterways

Discharging co-produced water into waterways will increase change and increase flows. Reducing and changing the number, duration and magnitude of cease-to-flow and low flow patterns (Sheldon and Walker, 1997; Humphries *et al*., 1999, 2001, 2002; Arthington *et al*., 2000; Humphries and Lake, 2000; Neilson *et al.*, 2000; Puckridge *et al*., 2000; DNRE, 2002; Eamus *et al*., 2006; Humphreys, 2006; Nilsson and Renofait, 2008; Nevill, *et al*., 2010; McGregor *et al*., 2011; Nelson 2019). This will affect physical and ecological processes that rely on these flow regimes. Co-produced water discharge volumes will disrupt flow events by various levels and rates (Sheldon and Walker, 1997; Humphries *et al.,* 1999, 2001, 2002; Humphries and King, 2000; Neilson *et al.*, 2000; Puckridge *et al*., 2000; DNRE, 2002; Eamus *et al*., 2006; Humphreys, 2006; Nilsson and Renofait, 2008; Nevill, *et al*., 2010; McGregor *et al*., 2011, Rogers *et al*., 2011, Arrow Energy, 2012, CEWH *et al*., 2012; IESC, 2014*c*).

With flow stops resulting in partial or complete drying of a river channel, water of varying quality will remain in pools causing environmental stress. Biota that inhabits ephemeral streams have behavioural and/or physiological responses enabling survival in cease-to-flow events, and periodic drying can play an important role in carbon and nutrient cycling (Baldwin and Mitchell, 2000; Nielsen and Chick, 1997). Disrupting cease-to-flow periods will affect the ecosystems, *e.g*., ephemeral river systems. Though stable low flows are important for recruitment of some native fish (Humphries *et al.*, 1999, 2001, 2002; Humphries and Lake, 2000; Eamus *et al*., 2006; Nevill, *et al*., 2010; King *et al*., 2011) and for maintaining shallow riffle and run habitats and the range of biota that rely on those habitats (Humphries *et al.*, 1999, 2001, 2002; Arthington *et al*., 2000; Humphries and Lake, 2000; Eamus *et al*., 2006; Humphrey, 2006; Fensham *et al*., 2010; Nevill, *et al*., 2010; Rogers *et al*., 2011). Large differences between the magnitude of low summer and winter flows also influence vegetation zonation within the river channel (Christie and Clarke, 1999; Nevill, *et al*., 2010; IESC, 2014*c*).

Water held in remnant pools as rivers dry contributes to overall channel complexity (Bjornsson *et al*., 2003; Ryder *et al*., 2006; Reich *et al*., 2010; Nevill, *et al*., 2010; Rogers *et al*., 2011). A lack of wetting and drying events can also adversely affect biofilm production and nutrient dynamics (Boulton and Brook, 1999; Ryder *et al*., 2006; Nevill, *et al*., 2010; Rogers *et al*., 2011; IESC, 2014*c*).

A shift from an ephemeral to a perennial system may allow larger-bodied, flow-dependent fish species to colonise and out-compete or prey upon smaller endemic species that are adapted to ephemeral systems and normally survive cease-to-flow periods by retreating to refuge pools (Humphries *et al.*, 1999, 2001, 2002; Humphries and Lake, 2000; Eamus *et al*., 2006; Humphreys, 2006; Bond *et al*., 2010; Nevill, *et al*., 2010; Reich *et al*., 2010; King *el al*., 2011; Rogers *et al*., 2011; IESC, 2014*c*).

Macroinvertebrate assemblages in ephemeral streams are often dominated by highly mobile taxa and with desiccation-resistant eggs capable of rapidly colonizing habitats when water is present (Nevill, *et al*., 2010; Reich *et al*., 2010). A shift to more permanent flow is likely to increase macroinvertebrate abundance and diversity as conditions become more suitable for flow-dependent taxa, such as filter feeding caddisflies, *Simuliids* and *Baetid* mayflies (Humphries *et al.*, 1999, 2001, 2002; Humphries and Lake, 2000; Humphreys, 2006; Nevill, *et al*., 2010; Reich *et al*., 2010; King *et al*., 2011; Rogers *et al*., 2011; IESC, 2014*c*).

A shift from ephemeral to perennial flow is also likely to result in significant changes to the abundance and composition of littoral vegetation and aquatic macrophytes. Reich *et al.* 2010 reported that streams that had artificial perennial flow had more diverse and more extensive macrophyte assemblages than nearby streams that were ephemeral and unregulated. (IESC, 2014*c*).

Some native fish, such as Macquarie perch, deposit eggs in gravel substrates in shallow riffle or run habitats in late spring and early summer, changing flow regimes will interfere with egg-laying and consequently fish recruitment (Humphries *et al.*, 1999, 2001, 2002; Humphries and Lake, 2000; Eamus *et al*., 2006; Humphreys, 2006; Nevill, *et al*., 2010; King *et al.*, 2011; IESC, 2014*c*).

The larvae and juveniles of other native fish such as Crimson-spotted rainbowfish, Australian smelt and Carp gudgeon rely on shallow backwater and slackwater habitats for food and protection (Humphries *et al*., 1999, 2001, 2002; Humphries and Lake, 2000; King, 2000; Humphreys, 2006; Nevill, *et al*., 2010; King *et al*., 2011). These backwaters are characterized by warm temperatures, abundant food sources, such as zooplankton and small macroinvertebrates, and are a refuge from large-bodied predators that are unable to access these shallow habitats (Humphries *et al*., 1999, 2001, 2002; King, 2004; Eamus *et al*., 2006; Humphreys, 2006; King *et al*., 2011). Abundance and distribution of backwater habitats and could adversely affect the recruitment of native fish that rely on those habitats (Humphries *et al*., 1999, 2001, 2002; Humphries and Lake, 2000; King, 2004; Nielson *et al*., 2005; Humphreys, 2006; Nevill, *et al*., 2010; King *et al*., 2011; IESC, 2014*c*).

Substantial increases in the minimum flow can drown riffle and run habitats and either reduce the range of hydraulic environments or create a prolonged disturbance that flushes away or scours resident biota and organic material (Humphries *et al*., 1999, 2001, 2002; Humphries and Lake, 2000; King, 2004; Nielson *et al*., 2005; Eamus *et al*., 2006; Humphreys, 2006; Nevill, *et al*., 2010; King *et al*., 2011; McGregor *et al*., 2011; Rogers *et al*., 2011; IESC, 2014*c*).

Mackay *et al.* 2012 suggests that small changes in discharge would have the greatest effect on streams that were weakly ephemeral or weakly perennial. They have developed a simple four-level system to classify streams according to their susceptibility to a changed low flow regime. See Table 2.3. (IESC, 2014*c* p. 47). The effects and cumulative effects of discharging co-produced water into waterways on biota cannot be under estimated (Hart *et al*., 1990; Oliver, 1990; Williams and Smith, 1996; Nielsen and Chick, 1997; Puckridge *et al*., 1998, 2000; Humphries, 1999; ANZECC/ARMCANZ, 2000; Humphries, 2000; Neilsen *et al*., 2000, 2005; Schiller and Harris, 2001; SKM, 2001; Humphries and King, 2002; King, 2004; Eamus *et al*., 2006; Humphreys, 2006; Nilsson and Renofait, 2008; Tomlinson and Boulton, 2008; Fensham *et al*., 2010; Griffith and Biddulph, 2010; Nevill *et al*., 2010; Shaw, 2010; King *et al*., 2011; McGregor *et al*., 2011; Rogers *et al*., 2011; Takahashi *et al*., 2011*a*; Batley and Kookana, 2012; Mackay *et al*., 2012; Marsh *et al*., 2012; Rolls *et al*., 2012; James and Barnes, 2012; IESC, 2014*c*; Hamawand, 2013; Davies *et al*., 2015; Lester *et al*., 2015; Towler *et al*., 2016; Nelson 2019).

Table 2.3: Simple Four Level Low Flow Classification System for Streams and the Ecological Risk Associated with Small Changes in Discharge.

Class	Description	Ecological risk associated with small change in discharge
1	Highly ephemeral	Significant but lower risk than Class 3 because greater volume of continuous discharge needed to change to perennial system
2	Ephemeral	Significant but lower risk than Class 3 because greater volume of continuous discharge needed to change to perennial system
3	Weakly ephemeral to weakly perennial	High risk of ecological change as a result of a small change in discharge
4	Strongly perennial	Lowest risk because increase in discharge will not change the flow state, although a proportionally large increase in flow magnitude may still represent an ecological risk

Source: Mackay *et al*., (2012) table, retrieved from
http://www.environment.gov.au/about-us/publications/archive#water
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Mackay *et al.* 2012 used the Normalised Vegetation Difference Index (NVDI) to spatially extrapolate the simple classification system across Australia. Moreover, most of the streams within the coal seam gas exploration areas are strongly to weakly ephemeral. If enough co-produced water is continually discharged to these streams to make them perennial, then the ecological risks may be very significant (IESC, 2014*c*).

Co-produced water has initial elevated temperatures compared to ambient temperatures in most Australian rivers (Nghiem *et al*., 2011). When temperature is outside the ‘normal’ range it can influence the physiology of biota, alter ecosystem functioning and exacerbate susceptibility to chemical stress, *Australian & New Zealand Guidelines for Freshwater and Marine Quality* (ANZECC/ARMCANZ, 2000). *E.g*., some toxicants such as heavy metals, ammonia, pesticides, and PAHs are more toxic at elevated temperatures than low temperatures.

The volume of the thermal discharge; the amount of thermal elevation relative to the receiving water; and the amount of mixing of the receiving waters; are factors which influence any ecological impacts associated from temperature variations in the discharge water (ANZECC/ARMCANZ, 2000; Batley and Kookana, 2012; Hamawand and Hamawand, 2013, 2014; IESC, 2014*c*; Davies *et al*., 2015).

There can be additive effects or in some rare cases a synergistic effect may take place where the presence of one chemical increases the biological activity of others (IESC, 2014*c*, 2017).

The Queensland Government *Healthy HeadWaters Coal Seam Gas Water Feasibility Study* March 2013 developed specific guidelines for managing flow regimes (McGregor *et al*., 2011). Those guidelines can be used to assess the specific risk of co-produced water discharge and develop appropriate release plans for each project. Moreover, the release plans should be accompanied by robust monitoring programs to assess their effectiveness at reducing environmental risk and to allow adaptive management to further reduce environmental risks and improve the guidelines. These are essential if negative impacts on GDEs and dangers caused by changes to waterway ecosystems are to be minimised (Humphries *et al*., 1999, 2001, 2002; Humphries and Lake, 2000; King, 2004; Nielson *et al*., 2005; Eamus *et al*., 2006; Humphreys, 2006; Nevill, *et al*., 2010; King *et al*., 2011; McGregor *et al*., 2011; Rogers *et al*., 2011; Arrow Energy, 2012; Batley and Kookana, 2012; IESC, 2014*c*; Davies *et al*., 2015; Towler *et al*., 2016; Nelson, 2019).

2.20.3 Monitoring Hydraulic Fracking Impacts.

A determination of a baseline should be undertaken before fracking. Monitoring should be an ongoing process through to CSG well decommissioning (Arrow Energy, 2012; IESC, 2014*d*).

2.20.3.1 Flowback

The Queensland Government suggests monitoring a removed volume of 150% of the fracking fluid (DEHP, 2013*a*). This flowback fluid containing many constituents must be managed (Arrow Energy, 2012; IESC, 2014*c*, *d*).

Limited to no flowback volumes in Australia or estimates of the percentage of chemical additives remaining in coal seams after production. The IESC, 2014*c*, states: '*this would be a suitable topic for further research.'*

2.21 Well Integrity

Incorrect well construction can result in well failure. Incorrectly sealed wells, deterioration due to pressure, stresses, and corrosion. Correct construction of a well, is critical in containing contaminants and protecting groundwater by confining the coal seam formation from overlying aquifers (Arrow Energy, 2012; IESC, 2014*b*, *d*).

Wells are constructed and decommissioned based on international standards such as the API standards or guidelines *e.g*. Queensland *Code of practice for constructing and abandoning coal seam gas wells* (API, 2002; API, 2009*a*, *b*; DEEDI, 2011; Arrow Energy, 2012) setting minimum standards for well integrity followed by CSG proponents in Australia, which if not adhered to may cause major groundwater and surface water system impacts (ADITC, 1992; McLaughlan *et al*., 1993, 1996; Bourgoyne *et al*., 1999; Nuccio, 2000; API, 2002; McLean and Beveridge, 2002; Bennett *et al*., 2005; Corneliussen *et al*., 2007; Economides and Martin, 2007; Bellabarba *et al*., 2008, 2009*a*, *b*; Houben, 2008; Schlumberger, 2008; SKM, 2009; DEHP, 2009*a*; Gasda *et al*., 2010; GHD, 2010; Manifold, 2010; Nygaard, 2010, 2012*a*; Beckworth, 2010; DERM, 2010; Geosciences Australia and BREE, 2010; Green *et al*., 2012; URS, 2010*a*; USQ, 2010; ADITC, 2011; APLING, 2011*a*, 2013*b*; Ecological Australia, 2011, 2012; Batley and Kookana, 2012; CSIRO, 2012*a*; DEEDI, 2012; DEHP, 2012*b*; Penny, 2012; DEHP, 2013*a*, *b, d*; DIP, 2013; FracFocus, 2013; Hamawand and Hamawand, 2013; Queensland Government, 2013*a*, 2015; SANTOS, 2013*a*, *b*; Taulis and Milke, 2013; IESC, 2014*b*, *c*, *d*; Davies *et al*., 2015; DNRM, 2015*c*; Ferrer and Thurman, 2015; Lester *et al*., 2015; Alloway, 2017; Geosciences Australia, 2018).

The public disclosure of the results of these inspections would improve the community's understanding and confidence in CSG well design and construction. The role of well integrity is paramount in this (IESC, 2014*d*).

2.22 A Risk Analysis of Well Bore Integrity and 'Legacy Wells'

Well bores can experience gas leaks. Research is needed into well integrity and leakage: the depletion; reduction in flow; pressure; the contamination of groundwater; bores; and water sources and systems by CSG extraction. Which is judged to affect groundwater one kilometre away from the CSG wells (Clark *et al*., 2011; Karacran *et al.,* 2011; Lloyd-Smith and Senjen, 2011; Day *et al.,* 2012, 2014, 2015; Hardesty *et al.,* 2012; Hamawand, 2013; Davies *et al*., 2015; Ferrer and Thurman, 2015; Lester *et al*., 2015):

At the time of writing there was no published literature reviewing the adequacy of the MCRWBA (*Minimum Construction Requirements for Water Bores in Australia*). Water industry accepts the third edition of the MCRWBA, NUDLC, 2012 as sound design for water bores (Fitzgerald (ADIA), 2012). However, there are no regulations at a national and state level for monitoring the integrity of water bores, either upon completion, during operation, or decommissioning (NSW Government (T&I), 2012*a, c, d*; IESC, 2014*b*; NSW Government, 2014*e*; Queensland Government, 2015).

The level of compliance by drillers within the guidelines is largely unknown: and or unpublished. The *National framework for compliance and enforcement systems for water resource management,* outlines offences that regulators must endeavour to prevent (SEWPaC, 2012): water driller unauthorised; unlicensed non-compliance; and faulty bore failure (SEWPaC, 2012). Regulators in all jurisdictions have compliance officers to ensure that bores are drilled and constructed in accordance with guidelines (SRW, 2011; Arrow Energy, 2012). The number of bore inspections that are undertaken is not published (NSW Government (T&I), 2012*a, c, d*; IESC, 2014*b*; NSW Government 2014*e*; Queensland Government, 2015). Figure 2.10 demonstrates possible leakage pathways from a cased and abandoned bore (Gasda *et al*., 2004; IESC, 2014*b*, p. 13)

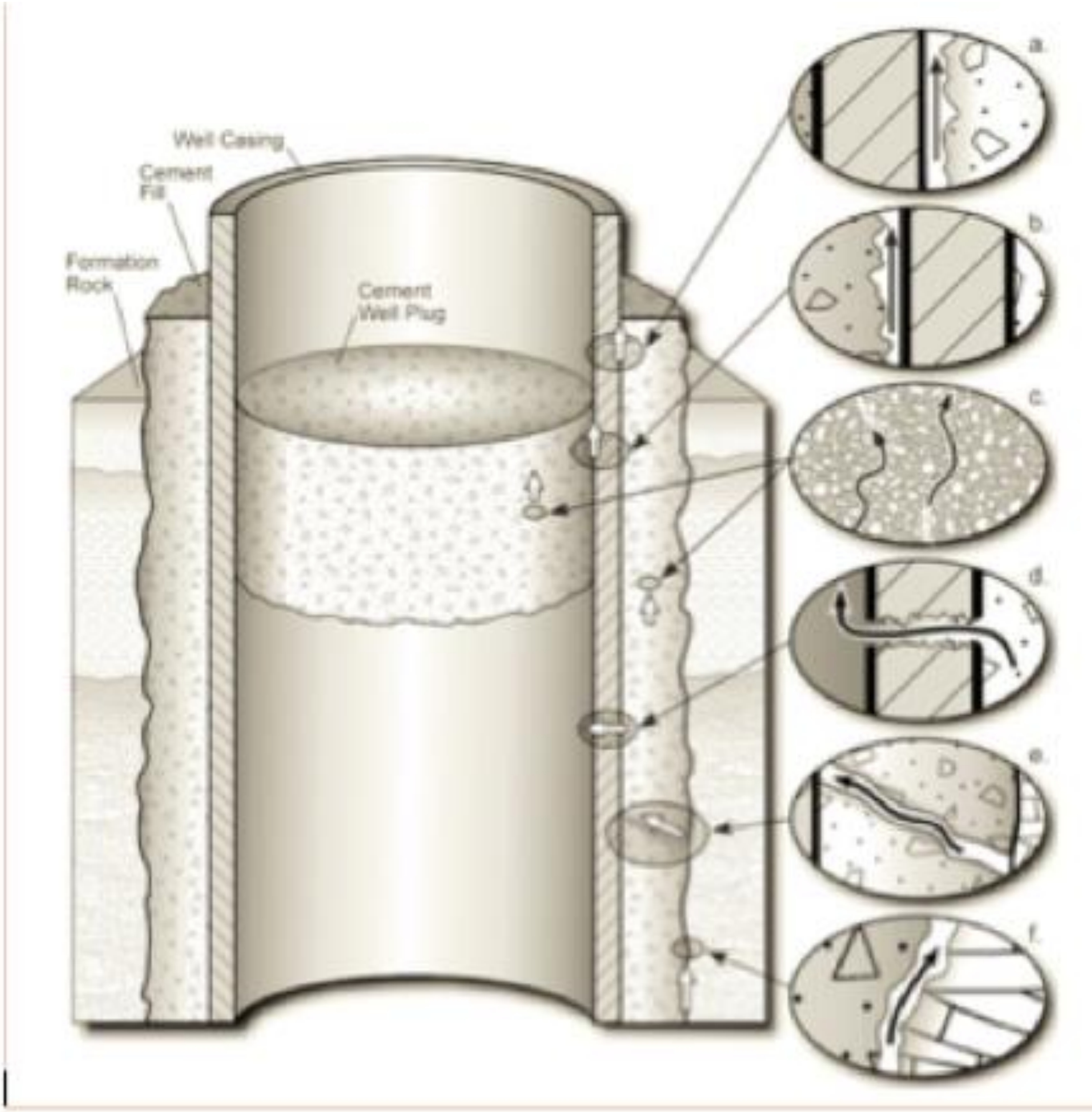

Figure 2.10: Diagrammatic Representation of Possible Leakage Pathways from a Cased and Abandoned Bore or Well. (a) Between Casing and Cement; (b) Between Cement Plug and Casing; (c) Through the Cement Pore Space as a Result of Degradation; (d) Through Casing as a Result of Corrosion; (e) Through Fractures in Cement; and (f) Between Cement and Rock

Source: Gasda *et al*., (2004) figure, retrieved from
https://www.environment.gov.au/about-us/publications/archive#water

Bores that are not decommissioned appropriately are often referred to as 'legacy bores' and their number in Australia is not known but likely to be substantial. Legacy bores can be any type of bore, although the most common types are (IESC, 2014*b,* p.43):

- *Oil and CSG wells;*
- *Water supply bores;*

- *Coal exploration wells;*
- *State government owned bores; and*
- *Government exploration bores.*

There are several significant implications of legacy bores, including (IESC, 2014*b,* p. 43):

- *Localised connectivity of aquifers, which can have further detrimental implications on local groundwater quality;*
- *Potential direct access between the ground surface and the aquifer, which is therefore a potential source of aquifer contamination; and*
- *Potential to release fugitive gas emissions as potential coal seam gas bearing layers are depressurised and release gas, which can ignite.*

At the time of writing there was little or no information available in the public domain on legacy wells. However, Queensland Government (DNRM) highlighted this data may be available in company reports and paper-based bore log records (IESC, 2014*b*; Queensland Government, 2015).

In Queensland, legacy wells are likely to exist from all types of bores: however, CSG wells are prominent in Queensland: abundant; probably inappropriately decommissioned; and unquantified. ~30,000 CSG wells drilled in the Surat Basin, and ~100,000 in the Bowen Basin. With unknown nature of bores decommissioning (IESC, 2014*b*; Queensland Government, 2015).

The Queensland Government *Code of environmental compliance for exploration and mineral development projects* (DEHP, 2013), allows for capping of non-artesian exploration holes at an appropriate depth for future land use, and backfilling above the cap. Exploration bores decommissioned may not have a cement plug and could be considered as legacy bores (IESC, 2014*b,* pp. 44-45).

An example of a CSG related exploration bore not appropriately decommissioned was reported August 2012 (Kennedy, 2012). The media report stated that the exploration bore was found after it caught on fire and started a local bushfire (Figure 2.11). The exploration bore, located 25 km west of Dalby in Queensland within Arrow Energy's Daandine gas field, but not installed or used by Arrow Energy, was at least one km from any CSG activity and the leaking gas, which caught fire (Kennedy, 2012). The well was presumed to have been drilled at least 20 years ago (IESC*b* p. 44).

Figure 2.11: Photo of a coal mining bore burning 25 km. west of Dalby, Queensland
Source: Kennedy, (2012) figure, retrieved from https://www.environment.gov.au/about-us/publications/archive#water Creative Common Licence CC BY 4.0

Jordan and Hare (2002) outline several methods that can be used to locate abandoned wells such as (IESC, 2014*b*, p. 45):

- *Remote sensing or geophysical methods - the thermal band in remote sensing data, such as Landsat images, can be used to detect temperature changes between the cool land surface and a warmer leaking abandoned well;*
- *A range of geophysical methods; and*
- *Methods such as transient electromagnetic sounding techniques can detect subsurface plumes of brine or borehole leakages.*

"*Bores with poor integrity have the potential to provide pathways for gases and liquids to migrate into and between aquifers, causing contamination of the groundwater*" (IESC, 2014*b*, p.45). Bore integrity is highly significant. The bulk of recent international research on bore integrity relates to wells for long-term storage of CO_2; however, much of this information can be extrapolated to other industries in different countries. A key difference between wells used for CO_2 storage and other wells is that CO_2 causes degradation to Portland-based cements, which are commonly used in well construction (Pearce, 2005; IESC, 2014*b*).

There are many factors that can impact on the integrity of a bore: some of which involve the breakdown of the physical barriers; while others involve the professional integrity of the engineers and technicians engaged to design; drill and construct the bore; or the regulatory regime, which depends on the intended purpose of the bore (Manifold, 2010; Arrow Energy, 2012; IESC, 2014*b*).

A main conclusion of the well integrity workshop for long term storage of CO_2 suggested that 'a leak-free' well is not possible. However, state-of-the-art technologies in well construction will reduce risks associated with poor well integrity (Pearce, 2005). Minimising leakage pathways in the annulus of the bore requires good cementing practices (GHD, 2010; Nygaard 2010,). These include: appropriate cement; quality and weight; waiting time; hole size; mud properties; pipe centralisation; and pre-cementing circulation procedures (Bourgoyne *et al*., 1999).

The majority of bore integrity research used by the IESC in their report on bore integrity (IESC, 2014*b*) is international and may or may not be relevant to Australian bores and wells due to Australian gas industry 'best practice' techniques employed, and Australia's unique geology. Whether the results achieved elsewhere are directly transferable to Australia is an important consideration.

2.23 Implications of Literature Review

The review of the extensive body of research relating to perceived CSG impacts in the Western Downs, Queensland, Australia, has been undertaken to gain an understanding of the extent of existing research and its importance and significance to this area of study. It confirms the relevance and the need for further research into this multi-billion-dollar CSG industry which has a far-reaching capacity to impact on many facets of everyday life affecting: human health, well-being and many parametres socioeconomic quality of life; environmental health and biodiversity; economic values and financial markets; energy supply; and water quality and quantity, locally and globally.

The social impacts and resultant conflicts have been highlighted as a sensitive, active ongoing area of research undertaken initially in the SIA of the EIS, *e.g.*, social dynamics and the concept of community from the Queensland Government guideline for SIAs and the SIA. Though this has been noted to appear of less concern by De Rijke 2013 p. 15. De Rijke also notes the degree of suspicion regarding Queensland University researchers and possibly non independent motives. De Rijke states that Dalby, Darling (Western) Downs highlights CSG developments and the substantial conflict and the emergence of the anti-CSG movement.

Paragreen and Woodley 2013 pp 48-49, views interpretations of social licence in the gas industry studying existing mining operations as concerning procedural justice. The definition of social license remains founded in interpretation, the progress towards an encompassing definition appears to be challenging.

Curran 2017 p. 427 states the importance of accountability in a more transparent world. Even hidden from view impacts making CSR effective, threatening corporate legitimacy and their reputation. Curran 2017 pp. 429-431 sees social licence as a response to ‘past disasters, conflicts and challenges’. Curran explores the contestation dynamics underlying conflict and polarisation ‘through the prism to operate’. Where ‘Framing’ - how the social movements actors and their values (anti-and pro-CSG protagonists) create and communicate meaning in their narratives in resource mobilisation and politics.

A novel approach of an underlying environmental peacebuilding theoretical framework based on the work of Conca and Dabelko 2002 has been developed and integrated by Dresse *et al*., 2018 and Lucas and Warman, 2018 to assist in avoiding conflict scenarios with no positive outcomes and replace them with incentives towards cooperation (Dresse *et al*., 2018, Lucas, 2018, Lucas and Warman 2018). Dresse *et al*., 2018 believe that ‘environmental peacebuilding represents a paradigm shift from a nexus of environmental scarcity to one of environmental peace.’

The social impacts and conflict will be studied and interpreted in chapters 5 and 6. The social impacts and conflicts and the effectiveness of SIAs and concepts of SL and the theoretical environmental peacebuilding framework will be discussed in chapter 7 and concluded in chapter 8.

This presents human and environmental challenges that cannot be ignored. Further research is an imperative on the safety of using unconventional CSG extraction, particularly fracking. Significant deficiencies have been noted on the accuracy and validity of most previous research (IESC, 2014*a, b, c,* and *d*). The IESC and state government scientists are aware of many of these deficiencies and with help will endeavour to provide detailed analysis and understanding of these shortcomings in CSG research. IESC, 2014*a, b, c,* and *d,* specify many areas of research gaps regarding CSG activities and CSG fracking based extraction on water systems applicable to the Western Downs. IESC, 2014*a* pp.186-188 on aquifer connectivity within the GAB, Surat, Bowen, and Galilee Basins list of 22 major knowledge gaps including:

- '*Cumulative impacts of CSG water extraction and understanding potential environmental and socio-economic impacts;*

- *The presence and importance of faults in controlling groundwater flow and inter-aquifer leakage to reduce uncertainty in the prediction of inter-aquifer leakage responses to CSG water extraction;*

- *Methods to model groundwater flow accounting for mechanical deformation of aquifers/aquitards to reduce uncertainty in the prediction of inter-aquifer leakage responses to CSG water extraction and re-injection; and*

- *Direction and magnitude of principle stress field for improved uncertainty in the prediction of inter-aquifer leakage responses to CSG water extraction and re-injection;*

In addition, CSG well dewatering, CSG '*depressurisation and co-produced water re-injection are some examples of anthropogenic changes to the natural hydraulic gradients which will result in changed aquifer connectivity. A better understanding is needed on how aquifer connectivity will be affected by the interplay of changing gradients, in situ stress, mechanical deformation, fluid properties and hydrogeological characteristics*' (IESC, 2014*a*). IESC, 2014*b* on bore integrity p. 48 on CSG well bore failures including:

- *Consequences of failure: the consequences of bore integrity failure for water resources, both in terms of terms of quantity and quality, are dependent on a variety of factors including the location of the bores, their depth, the surrounding groundwater resources, the purpose of the bore, its age and construction materials, and the rigour of its monitoring and maintenance program. However, detailed consequence assessments for water resources could not be readily identified in the literature;*

- *In the context of CSG extraction, investigations of cumulative issues associated with multiple incidents of bore failure could not be readily identified in the literature; and*

- *In addition, there is little or no information available in the public domain on CSG wells that are not decommissioned appropriately, called 'legacy bores' (IESCb, p 43, 2014).*

IESC, 2014*c* pp. 23, 27, 30, 35, 37, 39, 41-53, on co-produced water stresses there are many water system impacts related to co-produced water, the major issues including:

- *Untreated co-produced water can contain a range of contaminants associated with bore construction and operation. Furthermore in 10% of bores, hydraulic fracturing fluids are injected to aid in gas extraction, consisting of around 99% water and sand. The precise chemical composition of hydraulic fracturing fluids is generally a trade secret, the effects of which are not well understood, with many not having water quality guidelines. The interaction of these may result in greater toxicity;*

- *Unlimited water quantity usage; and*

- *Cumulative water quality and quantity impacts are not well understood with many gaps in knowledge.*'

IESC, 2014*d* pp. 32-42, on fracking techniques focussed on the environmental concerns raised by the NSW Inquiry into CSG and the Senate of Rural Affairs and Transport References Committee report concerning: '*the impacts of chemicals on human health and environmental impacts; lack of disclosure; absence of baseline monitoring; inadequate testing of chemical additives; and the recovery and disposal of used hydraulic fracturing fluids*'. In general, surface, and subsurface contamination, chemical additive toxicity regarding water supply.

Further, after comprehensive review of IESC literature there is very little information available in the public domain on CSG drilling and fracking techniques other than a basic diagram in IESC*d*, 2014 p.19. The CSG literature that is available is referenced from studies commissioned by the Commonwealth of Australia and is: conducted by external agencies; and partly funded or funded by gas industry or gas industry related sources; and from international sources in IESC, 2014*a, b, c*, and *d*. The IESC, 2014*a, b, c* and *d* reviews may or may not be entirely independent and admit to having major gaps in research in almost all CSG activities

(IESC, 2014*a*, *b c*, and *d*,). The international guidelines and data may or may not be appropriate to Australia. Most IESC data tends to have been completed pre-2012.

To study the perceived research gaps that are relevant to the thesis aims 1, 2, 3 and 4 and research questions 1, 2, 3 and 4 an interpretive mixed research methodology has been adopted (Bernard, 2011; Creswell and Plano-Clark, 2011; Creswell, 2013; Williamson and Johanson, 2013; Mercer *et al*., 2014; Creswell, 2017). Consisting firstly, of research data obtained from the computer tool NVivo derived from an anonymous participant questionnaire (chapter 5). Secondly, a Factiva, reported media based, text context study (chapter 6) (Creswell, 2013; Denscombe, 2014). Bearing in mind that many previous research questionnaires carried out by CSIRO, GISERA, QGFC, and UQ-CCSG (OCE, 2015) in the Western Downs, Queensland have resulted in a degree of survey saturation, (OCE, 2015) and community mistrust due to perceived gas industry bias (expressed in section 1.2) of the use the surveys are put toward. A pilot study has been carried out to ensure the veracity and clarity of the thesis research questionnaire questions (Denscombe, 2014). Secondly, research based on media content analysis (MCA) of Factiva, a computer-based search engine, providing 1270 comprehensive international, national, and local traditional media data entries (newspaper articles), on the Western Downs, Queensland dating from 1982 to 31st December 2018 on CSG/CBM and possible CSG fracking based extraction (Bernard, 2011; Creswell, 2013, 2017). Chapter 3 of the thesis focusses on ethical dilemmas and centres around sections 1 and 2 section of the *National Statement on Ethical Conduct in Human Research 2007 (Updated 2015*) on the risks and benefits of the research, Bond University's Ethics Committee manuals (BUREM) 09 and 24 and the Human Research Ethics Application (HREA). Research participant safety and confidentially cannot be understated, especially when the questions concern a contentious driver of controversial, community conflict such as CSG fracking. Lacy and Lamont 2014 discussed this sensitivity. Curran 2015 on social licence and corporate social responsibility (CSR)Cockery *et al* 2015 study on CSR are relevant with regard to the gas industry's responsibilities.

2.14 Conclusion

Chapter two has encompassed an extensive literature base of the potential social impacts of CSG and possible CSG fracking based extraction impacts on water systems and the resultant ramifications. The extensive research gaps have been broached and their implications briefly explored. As explained, choices and decisions need to be made and answers must be found if present and future, potentially irreparable damage is to be averted. Most government and independent researchers have found short-falls and gaps in potential social and CSG, and potential CSG water system impact research. This chapter provided the established groundwork and research. Chapter three concentrates on the ethical dilemmas faced by the researcher and the reasons which limited and in effect determined the research methodology adopted in chapter four.

CHAPTER 3: Ethical Dilemmas

3.1 Introduction

This chapter discusses the complicated and controversial facts of CSG research and the ethical dilemmas implicit in devising research methods to cope with and explore potential CSG impacts. The previous chapter reviewed the existing relevant literature and introduced the concept of CSG extraction impacts. It demonstrated the importance and implications of the propensity for potential CSG extraction impacts to spread from local to global impacts leading to the research questions. This chapter is concerned with the ethical dilemmas inherent in CSG extraction research and helps formulate the research methodology in the next chapter.

3.2 The Ethical Dilemmas

Ethical conduct that places participant safety and security above research goals is paramount in the research practiced and methodology that is instituted. Participant safety protocol prioritisation is essential over what might be considered preferred direct investigation. The thesis foundation is not to be compromised by the breach of privacy of participants, or researcher, due to the latent danger inherent in this study. A current example of the inherent dangers of ethical dilemma and the precarious nature of even governmental scientific research is the controversial cautionary example of the attempted release of sensitive health data prematurely, as in the ongoing case of the wild and farmed captive salmon at British Columbia, Canada, and the reasons for extremely high mortality events in wild salmon and links with salmon farming at the Fraser River and tributaries in salmon migratory pathways. Although concern regarding salmon declines had been noted as early as the late 1980s (Kent, 1990, Newbound and Kent, 1991, Eaton and Kent, 1992, Miller, 2009), a paper by Miller *et al*., 2011 published in Science, January 2011 potentially linking the decline to fish farming resulted in a 'muzzling' of Canadian federal government Department of Fisheries and Ocean (DFO) scientists talking to press agencies. This initiated the 'Streisand Effect' phenomenon. Where information and misinformation release suppression stimulated viral media backfire, after journalists became frustrated with no communication from the DFO resulting in the reported loss of public trust of government science. The media ban was lifted two days after a change of Canadian government in 2015 (Miller, 2017). New viruses were discovered in dead and dying chinook salmon and endangered wild Pacific salmon populations (Miller *et al*., 2017, Mordecai *et al*., 2019).

A CSG whistleblower was forced to give her testimony in private at the Palmer United-led Senate inquiry 2014[1] into the Queensland Government. Senior bureaucrat Ms. Simone Marsh has claimed in the media she was forced to rush through CSG approvals in Western Queensland. She repeated these claims at the enquiry behind closed doors, despite being ready to testify in public. Liberal Senator Ian Macdonald said Ms. Marsh had made unsubstantiated claims against individuals, and it would be inappropriate to hear them publicly.

Her claims had previously been referred to the Crime and Misconduct Commission which took no action. Speaking to media after the session, Ms. Marsh said the CMC decided her claims were "outside their jurisdiction".

"I have gone to the CMC with environment and health matters, and it took them several months to tell us it was outside their jurisdiction" she said.

She said she believed the inquiry was worthwhile, despite not being able to go through all the documents presented. But Senator Macdonald said it was "a wasted day."

"Unfortunately, we can't talk about what one of the witnesses said" he said.

"Although some of the issues she raised cast real doubt on the attitudes and actions of the previous Bligh government in Queensland." - APN NEWSDESK (Sunshine Coast Daily, 29th November 2014).

An online comment by an anonymous whistleblower (MICRODOT-Casino) attached to the article in '*CSG whistle-blower testifies behind closed doors at inquiry*', STAR (Gatton, Lockyer & Brisbane Valley), Politics section, by Geoff Egan, 29th Nov 2014 5.00am, dated 5 years ago. Retrieved 14/01/2020 5. 30am, claimed:

"That Ms. Marsh had, "substantiated her claims with copious and detailed documentation. I have seen some of it…But he can tell a lie and get away with it, because it appears someone connected with the LNP tricked the chairman, Senator Lazarus, into

1. Palmer United-led Inquiry 2014 into Queensland Government CSG whistleblower Ms Simone Marsh – http:www.gt.com.au/csg-whistle-blower-behind-closed-doors-at-inquiry/news-story/79df9b086617ea8e6163e1036c256

believing that Ms Marsh had asked for the session to be held 'in camera'. Then McDonald (sic) stole the media cycle by claiming the senate had made the decision based on the evidence. Not only that, but one of the LNP Senator (McGrath) works for the gas company Santos, and he failed to inform the witness of the committee of his conflict of interest".

Online Politics, 7th January 2016, 7.00am, Ms Simone Marsh released, '*Whistle-blower Simone Marsh's new expose: the corrupt birth of the Queensland gas industry'*, (Thesis Annex Document, pp. 269-272).

The following transcript has been included due to the perceived global impact that some of the content contains regarding CSG extraction impact activities, in particular, how far a 'single' CSG drill hole can reach, or extend, and perceivably its negative impact ramifications. CSG industry employee personal communication with the researcher on CSG fracking 04/04/2019. Which focuses on gas industry practices which have not been found in the literature and may cause perceived severe potential CSG extraction impacts:

"*I feel like Australian CSG grew as a kind of backyard industry, that was constrained with conventional technology…The first CSG wells were drilled using water boring rigs. There is a real trade off, the higher tech drilling rigs have a much larger footprint and cost millions to run. But a big rig could drill horizontals along a coal seam for kilometres. A water boring rig may only get 30 metres off the vertical.*

There is a method of fracking where water and sand are injected at high pressure into a newly drilled well. The pressure tends to create fractures that grow from the well. The 700-1000 metre centres are amazing. I don't really understand how they get the benefit of multi well pads if they only have 30 metre horizontal range off the vertical well (that doesn't make much sense because the deeper you go at an angle, the further you get away from the centre). Their success is based on physics. Once the head pressure of the water is removed, the gas will find the path of least resistance to an area of low pressure. Once the movement gets going the gas will rocket through the pipes, and that creates a suction on the gas in the coal seam, which accounts for the draw from up to a kilometre away.

Well spacing is of course dependent on the qualities of the coal seam, but 700-1,000 metre centres seem reasonable. Traditional CSG wells just went straight down so their effectiveness drove the drill patterns.

I have seen drill patterns (non- conventional, author) that approximated 1200 metre grid (600 metres from the drilled well head hub epicentre, author). I also know that pattern can be adjusted around infrastructure or sensitive land (on the surface, author).

The most recent design I saw involved a well head hub with multiple longer directional drill holes all heading out from a single location.

The longest well I know of was about 16 kilometres (from well head, author) at Wytch Farm Oilfield in the UK, but that was some time ago, someone will have broken that record by now.

The last wells I worked on in the UK had a mother bore and multilateral bores heading out from that central bore. 16 kilometres is extreme, but kilometres are routinely achievable.

In conventional oil and gas wells there is a real focus on the geology. The precision measurement is a key component to the design of the well (including which bits are cased, sealed, or perforated – open to let the gas / oil in). In CSG work I saw much more focus on the hydrogeology (how much water they were going to have to remove and handle to get the gas to flow).

Fracking really is a precision task. The design will be entirely dependent on the geology. The important things are size and shape. Too much fracking in the wrong place is likely to fracture the wrong rock which would cause too much water to enter the well, or cross contamination between aquifers, or escape of gas to strata.

Remembering the objective is to maximise gas to the well. I think the scare around fracking is justified, but when real science is applied, it should be able to be done safely. The work I was doing in CSG required no fracking. There was sufficient natural fracking in the coal (seam, author) to allow gas to flow without artificially fracturing.

To be honest, everything comes down to $$$. The gas coming out needs to cover the cost of getting it out (+ profit) and that fact will drive decisions around geological monitoring and modelling, drilling technology, and fracking design and application. A lot comes down to geologists, drillers, expertise, and preferences. If corners need to be cut, the risk of the worst impacts being realised goes up. On hydraulic fracturing the risks are real because it is not possible to 'know' the rock will fracture once the pressure is applied. I tend to think with

Queensland CSG there is less continuity in the confining strata, and more chance of causing some impact to a non-target stratum, but again that would be contingent on how much knowledge exists of the localised geology."

One of the original objectives of this thesis was the possibility of establishing baseline measurements of unaffected groundwater and surface water and CSG fracking affected groundwater and surface water mono and polycyclic aromatic hydrocarbon levels by taking water measurements above and below the CSG production areas, based on the findings of the Queensland Government, March 2013. The findings were that the directional water flows were north east to south west. The findings have been considered questionable by Professor Underschultz *et al*. of the UQ-CCSG and the OGIA, but not yet demonstrated by peer references at the time of writing **(**Balonne Beacon 14/12/2017, Factiva) (Appendix 12 and Thesis Annex Document). The flow in the Surat Basin may be southwestern to north eastern. Further studies are being carried out in conjunction with the CSIRO and the CSG Compliance unit. This further negates the veracity of establishing the original thesis water sampling objective and does not justify placing participants in jeopardy and is in conflict with the original BUREM and Australian Government ethical approval (see Appendix 1) for HREA Question M1.2 response for clarification:

'M1.2 details about technique/s for measuring hydrocarbons in groundwater and surface water systems. No prior baseline measurements carried before CSG exploration and production.'

The researcher's answer to Question M1.2:

"*For elucidation and confirmation of the lack of prior measurement of pre-existing, background environmental background or 'baseline' levels of hydrocarbons, please refer to references QWC, 2012a, b, Queensland Government, March 2014, and Commonwealth Government IESC, 2014a, b, c, d in PhD Confirmation Document, 31st August 2017. With respect to the veracity of proposed water samples: General groundwater flow in the Western Downs, Queensland is southwestern (Queensland Government, March 2014 p.16). I propose to take measurements northeast of the CSG production sites to gain an estimation of non-affected water systems hydrocarbon levels and compare them to measurements of hydrocarbons in water systems within the CSG well affected site areas (or south west of the affected CSG well sites if not possible) in the Western Downs*."

Consequently, the research method used avoids direct investigation, that is: the use of traditional participant interview methods, such as, 'one on one'; questionnaires where the participant's identities and their locations are known; and, for the same reasons, water sampling techniques on their landholdings. The water sampling exposes affected landholders to breaches in the privacy protocol and conduct potentially conflicting with their confidential, non-disclosure arrangements - Conduct and Compensation Agreements (CCAs) signed with gas companies (5,000 signed in Queensland, APPEA, 2015, OCE, 2015) (Lacey and Lamont, 2014, Cockery, *et al*., 2015). To a similar extent, interviewing the participants could be in breach of the signed agreements with regard to their identity and location, compromising and exposing the participants and their family to possible negative legal and socioeconomic ramifications. Also, the range of gas company leased tenement areas in the Western Downs is well established (CSG exploration began in the 1970-80s and CSG production began in 1995) and very extensive. Similarly, the researcher is also compromised when using direct investigation. It is unethical, unwise, and unsafe to conduct research methodology techniques that presume the researcher and participants, and their landholdings can be studied by the simplistic personal approach. To presume that the permission to investigate has been granted by the researcher's returned, signed, and ratified letter and explanatory note extends to clear and release the researcher of moral and ethical obligations and somehow makes research safe and ethical is absurd, dangerous and fraught with ethical and legal loopholes (Lacey and Lamont, 2014, Tan *et al*., 2015, Dresse, *et al*., 2018, Lucas, 2018, Lucas and Warman 2018).

The Queensland mining legislative framework permits exploratory and productive access by the petroleum industry to occupied, residential and farmed landholder leased land. This particular peculiarity of Australian legislative misfeasance underlines and defines a major source of the perceived polarisation of opinion on CSG extraction and is probably the major source of the ethical dilemma for the study of CSG extraction. The legislature is potentially biased in favour of the CSG mining industry against the affected landholder (Lacey and Lamont, 2014, Tan *et al*., 2015). Figure 3.1 illustrates the ongoing controversy of the Condamine River, Western Downs, and the 'debateable' cause of the flammable gas percolating to the river's surface. Figure 3.2 drives home what is at stake for Australia's economy and the multi-billion-dollar gas industry.

Figure 3.1: Controversial Condamine River, Western Downs.

Source: Canberra Times, (©2016) figure, retrieved from canberratimes.com.au 22nd April 2016 'Reproduced with permission'

Figure 3.2: $200 Billion Spent on LNG, 2015

Source: APLNG, (2015) figure, retrieved from http://www.aplng.com./topics/transporting-lng-.html

Due to the polarisation of opinion and community conflict regarding CSG extraction, it is a controversial topic - there are advocates and activists on both sides of the debate. Natural resource management frequently requires the addressing of controversial topics (Lacey and Lamont, 2014, Tan *et al*., 2015, Dresse, *et al*., 2018, Lucas, 2018, Lucas and Warman 2018).

On balance it is best to avoid involving family members of participants. The initial rationale was to have the family's approval of questionnaire participation. Overall, the anonymous questionnaire is not compromised by not including them. The Bond University Ethics Committee finding that: Participants will no longer discuss the interview with family members or employers consistent with Q3.9 Human Research Ethics Application (HREA). This is now no longer applicable due to the anonymisation strategy, which is discussed and introduced in this section.

3.3 Potential Risks Associated with the Thesis Research

There is the potential for participant distress or even threat resulting from taking part in the CSG research and expressing concern on CSG extraction, particularly fracking, due to the polarisation of public opinion and community conflict on CSG extraction:

- Socioeconomic, CSG related adverse effects resulting in: job loss and farm loss (pressured off land, per. comm), family break ups, forced to leave area (per. comm.), political bias (Chapter 6), controversy, corruption, victimisation (ostracised and marginalised) and violence (Chapters 5, 6 and per. comm.);
- Possible CSG related health problems: cancer, nose bleeds, sore eyes, respiratory problems, toxic contamination from various sources, mental health problems, *e.g.*, stress, suicide (Chapters 5, 6 and per. comm.);
- Legal ramifications: from denying access to farmland and organised rallies resulting in arrests, fines and in some cases imprisonment (Chapter 6), breaches of non-disclosure and conduct in Conduct and Compensation Agreements (CCAs) signed with gas companies; and
- Possible extensive CSG related 'whistleblower' consequences (Chapter 6 and per. comm.): for participants and researchers, resulting from revealing CSG gas industry related commercially sensitive information, trade secrets, photographing, entering, and sampling on CSG active properties or CSG tenement held land and communicating with informed, potentially affected, Western Downs residents.

This is elucidated further in the Human Research Ethic's Approval process. A potential risk of social and economic harm as described by the *National Statement on Ethical Conduct in Human Research 2007*, chapter 2.1. Further, Bond University Human Research Ethics Manual (BUREM), Booklets 09 and 24. Principally regarding confidentiality of the information concerning their opinions that the participants share; and the knowledge of their taking part in the research on CSG extraction. This potential risk extends to the participant's family who are excluded from any knowledge of participation in the anonymous questionnaire. The correct identification of the risks and benefits associated with the proposed human research, must ensure that participants have a clear and accurate understanding of the benefits and risks to verify a truly informed decision about their participation in the project.

There are potential participant risks of social and financial harm associated with access to the water sampling sites and associated with obtaining the appropriate authorisation to collect water samples on landholder's properties, though many landholders in the affected area have suggested they would be happy to have their water sources tested (personal communication, 2017). The potential risks may extend to the participant's family, friends, and associates.

In accordance with the BUREM and *National Statement* the balancing of benefits (participants and reviewers must be supplied with a reasonable, balanced assessment of potential benefits, as per BUREM Booklet 2) and the potential for described risks/burdens must be minimised using the guidelines in BUREM Booklets 02 and 09 and section 1 of the *National Statement* of value and principles of ethical conduct: research merit; justice: beneficence; respect; and the application of these values and principles regarding this research.

In accordance with the BUREM and the *National Statement*, the two themes of the risks and benefits of this research and the participant's consent must be brought together and balanced: with specific ethical consideration with respect to research methods and the participants. BUREM Booklet 09 and chapter 2.1 of the *National Statement* outlines the guidelines for risk minimisation and management that must be adhered to regarding this research. BUREM Booklet 09 and chapter 2.2 outlines the guidelines of the general requirements for participant consent that must be adhered to regarding this research.

In accordance with the BUREM Booklets 09 and 24, and the *National statement*, section 3: chapters 3.1, qualitative research; and 3.2, databanks: ethical considerations specific to these research methods must be adhered to regarding this research.

In accordance with the BUREM and the *National Statement*, section 5 of which sets out the institutional governance for the ethical review and management regarding this research.

3.3.1 Anonymisation Strategy

Ethics Application no: JS000398, Appendix 1

Research Title: '*The Impact of Coal Seam Gas (CSG) Extraction on Groundwater and Surface Water Systems in the Western Downs, Queensland, Australia'*.

Due to controversial nature of the research topic, a postal survey/questionnaire has been deemed to be the safest, and most confidential approach to safely obtaining participant participation and their data on the polarisation of opinion and community conflict on CSG extraction by fracking wells. Prospective participants will be least exposed to possible breaches in confidentiality of their participation in the research area, and the likelihood of the protection and security of their data therefore maximised.

In terms of anonymisation of the survey itself, survey / questionnaire forms will be numbered. There are four groups to be surveyed: community group members; farmers and other landholders; Australian government officials; and gas industry employees. The number of participants involved in the anonymous questionnaire will be deliberately limited to ten (10) participants per group, to minimise the risks of the breach of participant confidentiality and to maximise their privacy and security. Within each group questionnaire forms will be allocated randomly to potential participants. This will be done by a third party with no knowledge of the project, and it will be their job to randomly place a numbered survey in a labelled envelope.

An anonymisation strategy will be designed in accordance with the BUREM Booklets 09 and 24 and *National Statement on Ethical Conduct in Human Research* establishing the participants as non-identifiable: for the balancing of risk/burden and benefits; the minimisation of risk; the protection of the participants; and the security of the confidentiality of their collected data.

3.4 Conclusion

These findings further justify the importance and relevance of research into to CSG impacts in the Western Downs. The fact that CSG impact research is so dangerous and fraught with many ethical dilemmas regarding the safety of participants, their families and friends, and the researcher drives home the point of this thesis. It demands further investigation into perceived potential human and environmental health impact issues; potential social licence, corporate social responsibility, and economic impact ramifications; and potential legal impacts

(Wester-Herber, 2004, Lacey and Lamont, 2014, Corkery *et al*., 2015 Tan *et al*., 2015, Adger, 2016, Dresse, *et al*., 2018, Lucas, 2018, Lucas and Warman 2018).

Recent amendments to the Commonwealth *Corporations Act 2001* and the *Taxation Administration Act 1953* which commenced on 1 July 2019 provide for an expansion of the corporate whistleblowing scheme and a new tax affairs whistleblowing scheme reflect the seriousness that the Commonwealth of Australia are taking this extremely sensitive issue, with corporate body civil penalty fines of greater than $10,500,000 and individual fines of greater than $1,050,000 for breaching a whistleblower's anonymity and engaging in (or threatening to engage in) detrimental conduct towards a whistleblower or potential whistleblower. Failure to comply with the confidentiality and detrimental conduct provisions will also be criminal offences, punishable by imprisonment and / or fines. Corporate entities are also responsible for their employee's engagement in detrimental conduct based on a belief or suspicion that a person is an actual or potential whistleblower, and the corporation fails to fulfil any duty they have to prevent this, or take reasonable steps to ensure the detrimental conduct was not engaged in. Public companies and large proprietary companies have until 1st January 2020 to implement a compliant whistleblowing policy (McGregor and Cross, 2019).

This chapter has outlined the research methodology restrictions that have dictated the research strategy in next chapter. The next chapter specifies the anonymisation strategy and the social scientific inquiry research methodology.

CHAPTER 4: Research Methodology

4.1 Introduction

This research studies potential CSG extraction impacts in the Western Downs, Queensland. The previous chapter explained the ethical dilemmas that constrained the research methods and have guided the construction of the aims and research questions in this chapter and established the conceptualisation of participant risks and CSG fracking based extraction impacts in the Western Downs. Chapter two outlined the previous studies in this field of research in primarily Queensland, Australia to establish the value and significance of this research. This chapter introduces the aims and research questions extensively. The inherent requirements and techniques which are involved to establish the aims and objectives, and possible outcomes to the questions which are fundamental to this research. An interpretive social scientific inquiry, mixed methodology of media content methods strategies will be employed to elucidate and explore the nature of the study.

In this research the use of an anonymous questionnaire is employed to help gather sensitive data on this controversial study area. Selective sampling protocols are practiced ensuring that the participants are representative of their groups, so the outcomes given for the data set are meaningful and applicable to the research questions. As stressed in the previous chapter on ethical dilemmas, ethical protocol and adherence is paramount to conducting, and the success of this study.

4.1.1 Aims and Research Questions

The implications of the literature review elucidate the gaps in the literature ascertained in chapter 2. The research aim of this study is to formulate strategies and study potential CSG fracking based extraction impacts in the Western Downs, Queensland, with recommendations to mitigate any impacts. To realise these aims this chapter has developed the research aim and questions:

Research Thesis Aim

The key aim of this study to conduct an independent interpretive research into the perceived and potential impact of the CSG extraction and related activities and identify possible mitigation of impacts. To accomplish the aim, the thesis has four key research objectives:

1)To ascertain the current state of knowledge about the possible nature and extent of the impacts on groundwater and surface water systems in the Western Downs, Queensland, Australia;

2)To examine the CSG stakeholder's perceived perspectives on impacts of CSG activities on groundwater and surface water systems in the Western Downs, Queensland, Australia;

3)To study CSG stakeholder's perceptions and interpretations of the causes of conflict and community polarisation relating to CSG extraction; and

4)To develop conflict mitigation strategies to reduce the perceived community conflict about CSG extraction.

Research Thesis Questions

1)What is the current state of knowledge about the possible nature and extent of the impacts on groundwater and surface water systems from unconventional coal seam gas (CSG) extraction in the Western Downs, Queensland?

2)How have these impacts been perceived and experienced by different stakeholders and represented in the traditional media?

3)What is the nature and extent of the perceived community conflict and polarisation of opinion over CSG extraction in the Western Downs, Queensland? and

4)What is the potential for the perceived community conflict over CSG to be resolved and what strategies could contribute to this?

An interpretive social scientific inquiry, mixed methodology of media and text content analysis research are used to achieve the principle aims of the research questions (Bernard, 2011, Creswell, 2013, Williamson, 2013). First, the computer text content analysis tool NVivo will study the questionnaires and will be the basis of the research data. Second, comprehensive media content study of traditional media article sources, will be used to highlight potential impacts of CSG in the Western Downs, Queensland focusing on general CSG articles that have CSG industry activity relevance (Creswell, 2017), assisting in the development of the strategy to suggest outcomes for the thesis research questions and objectives.

This chapter outlines the data collection protocols and procedures to protect the anonymity of the participants, and data base used to develop and extrapolate the variables to interpret the participant's opinions and the general themes extracted (Appendix 18).

4.2 Research Methods Design

Ethical dilemmas have constrained the researcher's choice of methods, influencing methods of data collection, and data interpretations. This section, under the constraints of the last chapter, explains these choices and how they were made.

The initial identification of the research area to formulate the research questions is based on the gaps in the data, drawn from the literature review. This has dictated the strategy chosen along with the method of data collection. Analysing and interpreting the data, has led to the research findings (Bernard, 2011, Creswell, 2013, Williamson, 2013). This chapter establishes how the selection process was made for this research and the method of collection and collation of the dataset.

4.3 Interpretive Social Scientific Inquiry: Anonymous Questionnaire and Factiva

The thesis epistemological approach is grounded in a mixed methodology of an interpretive social scientific inquiry. The interpretive mixed research methodology is the foundation for the environmental conflict and peacebuilding based theoretical framework (Conca and Dabelko, 2002, Dresse *et al*. 2018) and practical research framework. The social scientific inquiry based mixed methods strategy was selected because it enables researchers to answer questions that could not be answered using other methodologies, especially controversial questions with a greater range of viewpoints (Bernard, 2011, Creswell and

Plano-Clark, 2011, Creswell, 2013, Williamson, 2013, Mercer *et al*., 2014.). An anonymous questionnaire has provided the data for the text and media content-based research. An anonymous questionnaire sent to key stakeholders, has been found to be appropriate, to preserve anonymity and protect participants and their family's identity, to extract a representative '*pool of people*' to study the extremely risk burdened, controversial study of the CSG extraction in the Western Downs and the "polarisation of opinion" on CSG extraction, in particular fracking. To help study the causal relationship, or chain of causality leading to my human 'dependent' variable data input (Neuman, 2011).

Denscombe, 2014 and McPhee, 2017 describe criteria that was applicable to questionnaire construction:

- Use simple and clear vocabulary;
- Avoid sensitive questions;
- Avoid leading questions;
- Maintain the logical flow; and
- Ensure each question is related to the topic.

A pilot study of the draft anonymous participant questionnaire was carried out on fellow Ph.D. Candidates in May 2017, to test that the questionnaire's questions have clarity and are understandable (Denscombe, 2014). Bearing in mind that communities in the Western Downs have been saturated with gas industry funded and partly funded surveys (CSIRO, GISERA, GasFields Commission, UQ-CCSG, etc.) which has led to a reported large degree of mistrust and survey sensitivity (de Rijke, 2013, Witt *et al*., 2014, OCE, 2015). This will be discussed in chapters 5 and 7.

Ensuring that there is no possibility of endangering participants by compromising their identity (and the researcher), exposing them to community conflict, ostracising, victimisation, workplace marginalisation, or potential violence. The researcher is aware that 'whistleblower' labelling and academic consequential ramifications may result from this 'sensitive' research topic if it is not studied with discretion and impartiality.

Firstly, the two straightforward closed ended questions have been manually studied using Word Excel and interpreted (Creswell, 2013, Williamson, 2013)). The twelve opened ended questions have been studied with the well trialled, used for some twenty years, NVivo (now NVivo 12) software tool and interpreted (Creswell, 2013, Williamson, 2013, Creswell, 2017).

Secondly, in Chapter 6, Factiva a traditional media software search engine has been employed, which contains comprehensive international, national and local newspaper articles. CSG data from the early 1980s to 31st December 2018. The research emphasis is on subjectivity and impartiality with a narrative to highlight potential CSG impact research in the Western Downs, Queensland and articles of relevance, such as, gas industry development and anti- and pro-CSG article content. We must also be aware that there may well be media information bias, depending on the sources of information and agendas that may not always be impartial, such as media newspaper articles (Bernard, 2011, Creswell, 2013, Williamson, 2013, Creswell, 2017). The Factiva data by NVivo software is used for media content study (MCS). The researcher is mindful that there may be media bias as stated (Data Appendix 10).

4.3.1 Computer Data Generated Media Content Study Approach

The rationale for the media content study is that it is: employed to study and group comparative similarities in the large amounts of data obtained from the anonymous survey data.

4.3.1.1 Microsoft Word Excel

In Question 1, Microsoft Word Excel uses a straightforward manual data input approach for 'closed ended questions', based on Microsoft software and is used for MCS and the anonymous participant survey. The data input program studies the data and generates pictorial, computer numerical based tables interpretively studied research outcomes and findings. Macnamara, 2005, pp. 1-34 notes the benefits and best practice of this methodology (Macnamara, 2005, Bernard, 2011, Williamson, 2013).

In Question 3 similarly, Word Excel is used with a slightly more complicated manual data input approach, based on Microsoft software, for this multiple-choice question. Generating pictorial, computer numerical based tables to be interpretively studied for research outcomes and findings (Bernard, 2011, Williamson, 2013). Question 3 leads in to Question 4. This data and results have supported the NVivo 12 data for the anonymous questionnaire research study (See Appendices 10, 16, and 18 for data).

4.3.1.2 NVivo 12

NVivo is a computer software tool which uses formal content and thematic methods to study the qualitative data (Creswell, 2013, Mercer *et al*., 2014, Creswell, 2017). This provides large amounts of data from multiple sources and searches for common content and themes. In this study it interprets over 11,000 words from the 4 groups, A, B, C, and D of 10 participants, and their sum, or total, answer data from the 12 Questions. It does this by encoding the 4 participant groups into 'nodes' and the individual participants within the groups into 'children', or sub nodes. These nodes and sub nodes are populated with their respective data, the answers, from the 12 Questions.

The 12 Questions are encoded into 'cases' and the answers of the 4 groups A, B, C and D and the sum, or total of the groups, are populated with their respective answer data into 'children' cases.

These nodes and sub nodes, and cases and children cases act as storage containers to be interpreted and compared using text content or content themes. In this way the graphic illustrations of text content, and word clouds are representative of the 4 groups, their participants, and their answers (the nodes and sub nodes and the cases and children cases are shown in Appendix 15). In this thesis NVivo 12 is used to interpret data imported from the anonymous questionnaire in Questions 2, 4, 5, 6, 7, 8, 9, 10. 11. 12, 13 and 14. This data and its outcomes have been studied to provide possible outcomes towards the thesis research questions 1, 2 3, and 4 and thesis research objectives 1, 2 3 and 4 of possible mitigating, resolving solutions, in combination with the literature review, and interpretations from Factiva in chapter 6, brought together in chapter 7.

4.3.2 Factiva: Media Content Study (MCS) Interpretive Approach

Due to the comprehensively large amount of the data collated from the international, national, and local traditional media (*e.g.,* newspaper articles) software search engine Factiva from 1982 to December 2018, a 'condensed' representation of the data, with accompanying NVivo media content study data visualisation using 'word clouds' is found in chapter 6 and has been chosen for its interpretive mixed methodological research approach (Bernard, 2011, Creswell, 2013, 2017). Focusing on CSG and CSG fracking based extraction in the Western Downs, Queensland and related CSG article data pertaining to water systems, economic development, history, and evolution of Australian CSG industry and its potential human and environmental health, and social impacts. In addition, the issues of social licence and corporate social responsibility. Due to the enormous number of media data, unfortunately, only a small fraction of the potential research content of the Factiva data base collected daily over four years is used. It has been condensed to give CSG information specific to this thesis. However, the researcher believes that there is sufficient CSG data for multiple topics concerning CSG extraction and other CSG related topics for post-doctoral research. The comprehensive 'Thesis Annex Document' is provided to accompany the Factiva research data used in chapter 6 (Appendix 11).

4.4 Potential Research Participants

Due to the ethical sensitivity of the research study area (see chapter 3), four (4) relatively small groups of ten (10) participants were randomly obtained to ensure their confidentiality and safety in participating in this controversial research study. The only knowledge of the person is which group they are included in.

Group A and Group B participants have been randomly obtained from a Facebook social media base 'pool of people' of 200, by allocating numbers 1 to 100 to each group participating and an impartial fellow Bond University Ph.D. Candidate selecting the sequence of personal message contact order from anonymous number lists for groups A and B

Similarly, Group C and Group D participants have been randomly obtained from a Linkedin social media base 'pool of people' of 200, by allocating numbers 1 to 100 to each group participating and an impartial fellow Bond University Ph.D. Candidate selecting the sequence of personal message contact order from anonymous number lists for groups C and D.

(These lists, consisting of 400 people in total, were subsequently disposed of securely as the greater number of individuals at this stage were not deemed to be potential participants and it was felt there was no ethical reason to risk their breach of confidentiality). The stakeholders concerned are:

- Group A, community group members;
- Group B, ten community individual participants;
- Group C ten Commonwealth or Queensland Government officials; and
- Group D, ten gas industry employees.

These particular stakeholder group participants are selected for their awareness, experience, and knowledge of CSG fracking based extraction and their possible anti-CSG and pro-CSG opinions on the research study area. Thus, helping to provide possible views to explain and rationalise potential community conflict and polarisation of opinion on CSG fracking based extraction; with the view of identifying and suggesting perceived methods of resolution. The recruitment of participants has endeavoured to provide a 'balanced' choice and number of focus groups and individuals to gather representative points of view on CSG fracking based extraction's possible impacts on groundwater and surface water systems and the apparent community conflict and polarisation of opinion concerning CSG providing perceived outcomes to the thesis research questions 1, 2, and 3 and thesis objectives 1, 2 and 3.

4.4.1 Anonymisation of Participant Process

Due to controversial nature of the research topic, a postal questionnaire has been deemed to be the safest, and most confidential approach to safely obtaining participant participation and their data on the polarisation of opinion on coal seam gas extraction by fracking wells. Prospective participants will be least exposed to possible breaches in confidentiality of their participation in the research area, and the likelihood of the protection and security of their data therefore maximised. See previous chapter for more information.

The anonymity strategy has been developed with the assistance of the supervising researchers, in accordance with Bond University's Ethics Committee guidelines and the Commonwealth of Australia's National Statement on Ethical Conduct (*National Statement (NHMRC)*, 2015, *BUREM Booklet 09*, 2018). The strategy is initiated with contact established through Facebook and Linkedin, with randomly obtained, known social media contacts, with personal messages to persons: living, have lived; working or have worked (including retired); or who have visited; or have friends and family in the Western Downs with awareness or experience of CSG fracking based extraction. The personal message explains the anonymous nature of the CSG fracking research questionnaire and invites the prospective participant to give their informed opinion on CSG fracking issues by their participation. The messages were sent during May-July 2018:

"*Hi (name), I am conducting an anonymous Postal Questionnaire on CSG fracking in the Western Downs, Queensland as part of my Ph.D. thesis research and would greatly appreciate your confidential, informed opinions and participation. All that is required at this* *stage if you wish to participate, is your postal address for the questionnaire's participant consent form and information sheet, to comply with Bond University's ethical guidelines. Many thanks in advance, the researcher*".

The participant consent form (Appendix 2) and participant information sheet (Appendix 3) are developed in accordance with Bond University's Ethics Committee guidelines and the *National Statement on Ethical Conduct in Human Research*. Random personal contacts are 400 persons in total who may have met the questionnaire's participant criteria (overall combined social media 'pool of people' base is in excess of 30,000, approximately 10% of which possibly meet participant criteria). 100 are obtained from each of the four stakeholder groups of participants involved in the questionnaire survey.

From the initial personal message concerning the invitation to participate in the CSG fracking based extraction questionnaire: of Group A - 34 potential participants responded favourably; of Group B - 20 potential participants responded favourably; of Group C - 17 potential participants responded favourably; and of Group D - 22 potential participants responded favourably. In total 93 potential participants responded favourably.

On the receipt of a favourable response *i.e.*, a return message from the person expressing their interest to participate and their postal address, a thank you message is sent to the replying person, explaining the anonymous questionnaire consent procedure:

"*Hi (name), thank you for your interest in the anonymous postal questionnaire. I will be posting the questionnaire consent form and information sheet today for your consideration. Please read the information sheet and if you are happy to participate, please sign the consent form and return it to me in the reply-paid envelope. My best wishes, the researcher*".

On the receipt of the signed consent form from the potential participant, the anonymity strategy is again employed to confidentially send them the anonymous participant questionnaire (Appendix 3). From this stage on their identity is no longer known.

Group A potential participants are allocated an anonymously numbered participant questionnaire with a number between 1-50 by an impartial Ph.D. Candidate, who then seals the participant questionnaire in an envelope with a reply-paid envelope, addressed back to the researcher at Bond University. Similarly, Group B potential participants are allocated numbers between 51-100. Group C potential participants are allocated numbers between 101-150. And Group D potential participants are allocated numbers between 151-200.

The final stage of the participant process is the postal receipt of the filled out anonymous questionnaire (Appendix 4) from the potential participant by the researcher. As of September 30th, 2018: Group A's potential participation was 11; Group B's potential participation was 11; Group C's potential participation as 11; Group D's participation was 10 (See Appendices 16 and 18 for participant data).

As Group A had an additional potential participant a qualitative judgement was made to exclude the last received questionnaire. Group B's additional potential participant had compromised their anonymous questionnaire by revealing their name and address. Consequently, they were excluded, and their questionnaire disposed of securely. Group C, as with Group A's additional potential participant, was excluded due to late arrival. Group D had the required 10 participants.

To protect and preserve the participant data the practice of keeping three (3) copies of the data is always being fulfilled securely in locked storage and locked rooms. Maintaining and assuring participants compliance to the adherence to Bond University's ethical guidelines are duly considered at all times. All data collection has only been shared with my supervisors and it will be saved on my Bond One drive for five (5) years (Appendix 17).

4.5 Methodological Limitations

In this chapter the formulated interpretive social scientific inquiry research strategy attempts to overcome the constraints placed on it. An anonymous participant approach which has been explained fully in chapter three and expanded upon in this chapter. The research limitations appear to have been successfully overcome and the research successfully adapted to fulfil the ethical guidelines and protected the anonymity of participant ensuring their safety, while still participating in the thesis research. By studying the data obtained from the anonymous participant survey combined with Factiva MCS and interpreting them together we may get a clear understanding of the thesis research questions and their outcomes during the research time period. The anonymous survey was conducted during June 2018 through to September 2018. The Factiva media content data was collected from its first relevant appearance on CSG in Australia in 1982 to the end of the thesis research period December 31st, 2018. Further limitations on the thesis research are: only being able to focus on perceptions of impacts, due to the challenges involved in accessing and interpreting technical data on water quality and use, properties of aquifers, etc.; not being able to spend time in ‘the field’(due as much to resource constraints, as possible perceived changes in the direction of groundwater flow; participant and researcher safety concerns; the low response rate inherent in questionnaire surveys; and the challenges of working with publicly available media sources of varying degrees of reliability. The researcher is critically aware of these limitations and has endeavoured to deal with these often common, research compromising challenges.

4.6 Conclusion

The thesis aims and research questions have been studied using an interpretive social scientific inquiry grounded approach with mixed methods research strategy employed in this chapter. The methodology has provided comprehensive research findings to be interpreted and discussed in the following chapters to confirm this.

Chapter 5: Results and Discussion (Anonymous Questionnaire)

5.1 Introduction

Chapter four on research methods has explained interpretive social scientific inquiry mixed methods strategy employed, and detailed in depth the anonymisation strategy devised to confidentially investigate and explore the perceived outcomes from the four groups: Group A - community group members; Group B -community individual participants; Group C - Australian government officials; and Group D – gas industry employees , participating in the anonymous questionnaire on possible CSG fracking based extraction impacts. Chapter five studies and discusses the qualitative responses to the questions in the anonymous questionnaire (See Appendix 10 for Word cloud and tree data).

5.2 Question 1 In your personal view has CSG extraction affected water quality in your area?

Community group members participants, Group A have results of 80% of participants suggesting no impact. Participant 9 having suggested perceived significant negative impact and Participant 30 having perceived very significant perceived negative impact.

No participant responses suggest positive impacts.

Community individual participants, Group B have findings of half the participants suggest very negatively impacted. With a further 20% of participants suggested being significantly negatively affected. 30 % of participants were not impacted.

No participant responses suggest positive impacts.

Australian government official participants, Group C, have findings of 40% suggest very significantly negatively impact. 60% response suggest not impacted.

No participant responses suggest positive impacts

Gas industry employee participants, Group D have finding of 100% suggest no impact, negatively or positively. None lived in an area where water quality is impacted by CSG extraction.

Question 1 - In your personal view has CSG extraction affected water quality in your area?

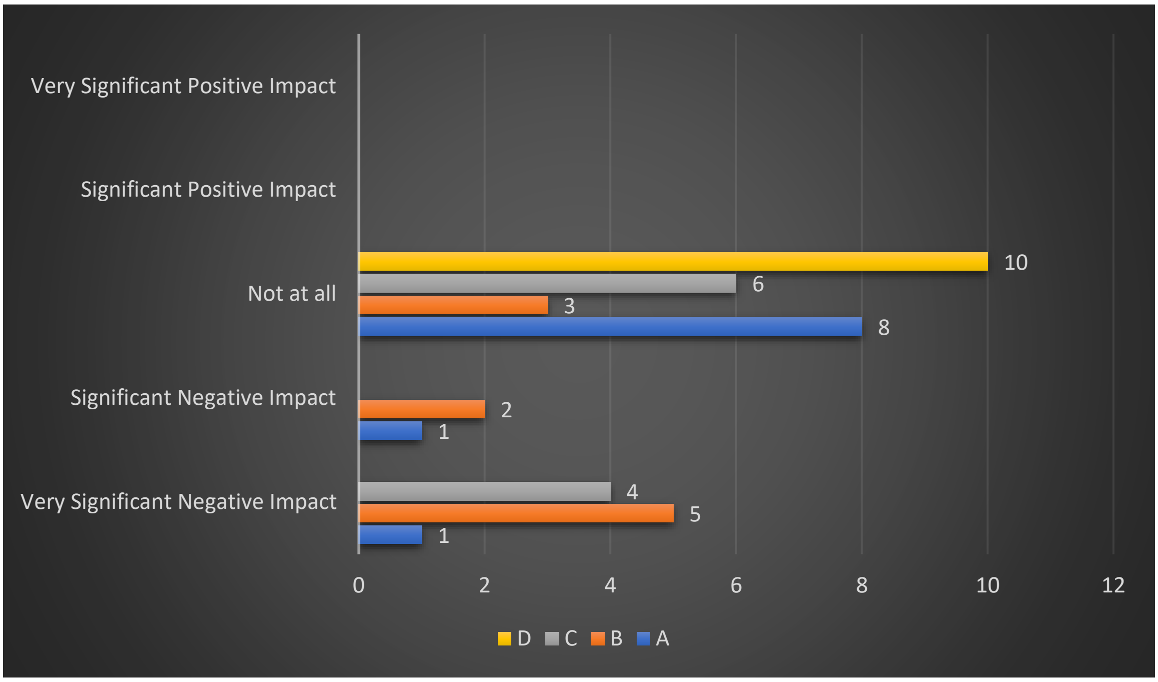

Figure 5.1: Question 1 Result

Table 5.1: Response Groups: A, B, C and D to Q1.

#		Response	%	Count
1		Very significant negative impact	25.00%	10
2		Significant negative impact	7.50%	3
3		Not at all	67.50%	27
4		Significant positive impact	0.00%	0
5		Very significant positive impact	0.00%	0
		Total	100%	40

Participant Groups A, B, C and D have findings of 67.5% that are not impacted. 25% suggested they are very significantly negatively impacted, 7.5% suggested they are significantly negatively impacted (Figure 5.1 and Table 5.1).

No participant responses suggest positive impacts.

5.3 Question 2 There appears to be a polarisation of opinion on CSG extraction methods, particularly fracking. Do you believe this is true? If not, why?

80% of Group A participants gave an affirmative answer to Question 2, there appears to be polarisation of opinion on CSG extraction, particularly fracking. Representative responses of this from Group A participants:

Participant 6 "*Agree, a combination of misleading information from fracking supporters and public apathy to investigate*.";

Participant 8 "*Yes. Those for CSG extraction:*

a- work for the industry;
b- stand to gain financially;
c- and are unaware of the negative impacts.

Those against CSG extraction:

a- are directly impacted;
b- have witnessed the negative impacts;
c- are ethically sound scientists; and
d- and do not stand to gain financially or may have changed their minds.";

Participant 9 "*Yes, there is significant polarisation. Mainly due to the facts. 1. The majority of people who research this industry realise it is an environmental and financial disaster and are total opposers. 2. Those that know little about it and either stand to gain wondrous financial rewards or believe the hype and promises from the Fracking Corporations and are for it. Fortunately, they are in the minority, even though the heavily biased media quote significant amount of people are for it, generally unsubstantiated*.";

Participant 29 "*It seems to me that the CSG companies are in favour of fracking and most others are against it – scientist, farmers*…"and

Participant 42 "*No. Just trying to create it*."

The NVivo word tree for Group A (Figure 5.2 in appendix 10) appears consistent with the responses.

100% of Group B participants gave affirmative answers to Question 2, there appears to be polarisation of opinion on CSG extraction, particularly fracking. Representative responses of this from Group B:

Participant 54 "*True amongst people who know about the process. But not true amongst general public. Think this is because the whole conversation is in the public arena (newspapers, TV, etc.) is gas industry propaganda or government propaganda designed to win votes. Also, most people don't realise that approvals for conventional drilling have 'will only frack if necessary' in the fine print. Don't realise that as gas starts to run out it becomes necessary! People have opinions formed on the basis of half-truths propagated by self-interest of those being paid by the gas companies*.";

Participant 69 "*Yes. I believe this is part of a wider polarization in society around mining and other potentially environmentally harmful industries in general. Jobs vs. environment. Money (shares) vs clean land and water*.";

Participant 72 "*Yes. Industry workers and representatives maintain that unconventional gas and fracking techniques are safe; despite the growing body of evidence to the contrary. Industry cannot cite the full suite of chemicals used in fracking. Nor do they cite the 'norm' (naturally occurring radioactive materials) that are brought to the surface during drilling operations. Residents are expected to accept industry media releases, despite convincing scientific evidence, to back claims by industry*.";

Participant 73 "*The polarisation in opinion is obvious. Supporters of CSG extraction are generally uneducated, climate science deniers. They are interested in short term gain like jobs in the CSG industry rather than their children's future which is dependent on the survival of the agricultural industry, fresh water, biodiversity and a liveable climate*"; and

Participant 77 "*Yes, some people will only ever think about money with little regard on what CSG is doing to this country*."

The NVivo word tree for Group B (Figure 5.3 in appendix 10) appears consistent with the responses.

The majority of Group C participants gave an affirmative answer to Question 2 there appears to be polarisation of opinion on CSG extraction, particularly fracking. Representative responses of this from Group C:

Participant 101 "*Community members are concerned of impacts of fracking. The concern relates to mis information and outright lies by lobby groups. Fracking if conducted properly is not a concern Any fracked well will be pumped for many years which means all water and fluids surrounding the well be removed to surface with no chance of fluids moving away from the fracked well*.";

Participant 102 "*Yes. Those in favour of fossil fuels and those promised jobs and growth are in favour and those who are against fossil fuels or understand how little job and growth is involved are against fracking due to impacts*.";

Participant 114 "*I believe the polarisation is driven by a perception that successive Queensland Governments have shut down debate and information flow to ensure the projected economic benefits can be achieved. My understanding is that the government and CSG companies are ignoring or playing down the environmental risks and associated costs but are stifling objective information that might allow the community to arrive at a balanced perspective based on fasts*.";

Participant 125 **"***When AGL started fracking in Gloucester, the community was very divided, and violence was very close. Someone unscrewed my son's 4WD wheel bolts, and face book messages from pro CSG group talked of violence. As a teacher I was told to step back, as CSG was regarded as a controversial issue, and I had to fear for my job, because I continued to protest and be pro-active*.'; and

Participant 138 "*The only "polarisation" is between those profiting from CSG and those impacted by it, that is, between CSG executives and politicians receiving royalties and job offers from the mining industry; and the communities forced to allow their land, water, air and businesses to be polluted sand destroyed by this toxic industry and the bullies who force landholders into allowing access*."

The NVivo word tree for Group C (Figure 5.4 in appendix 10) appears consistent with the responses.

100% of Group D participants gave an affirmative answer to Question 2 there appears to be a polarisation of opinion on CSG extraction, particularly fracking. Representative responses of this from Group D:

Participant 152 "*Yes. I believe there is a significant polarising of opinion on extraction methods, particularly fracking. The reasons for the polarisation are many, but are also interlinked with polarisation over CSG with some of the positives including:*

- *Access to CSG income for farmers;*
- *Access to CSG based services for regional people;*
- *Access to CSG employment for regional workers; and*
- *Enhanced development in regional areas, injection of funding into regional areas.*

And the negatives including:

- *Unsustainable use of water resources;*
- *Non-agricultural use of water;*
- *Non-agricultural uses of water resources;*
- *Potential impact to water resources volume and quality;*
- *The polarisation is exacerbated by the fact that CSG became an emotive issue before the science could be understood*."

Participant 153 "*I do believe there is a polarisation of opinion. I feel a lack of knowledge on the methodology associated with fracking is one cause of this. The other is misinformation*.";

Participant 155 "*Yes, I certainly believe there a polarisation of opinion re: CSG in general, particularly when it comes to fracking. I think this can be attributed in part, to a number of factors. 1. The prevalence of misinformation that is available on the internet 2. The transposition of the un-regulated nature a fracking in the USA (real or perceived) 3. Most importantly, the science behind assessing CSG being an ever-changing field 4. The lack of resources available to adequately assess condition and then enforce CSG project approvals*.";

Participant 158 "*Yes, it's true. I believe that this is the case because chemicals are put into ground to extract the gas. The chemicals used are a source of concern for many people (in my experience)*."; and

Participant 171 "*It seems to be true, primarily because of either a lack of information, or mis-information. For mine, the most important issue / factor is constructing of CSG extraction wells to ensure no connection between aquifers and aquitards*."

The NVivo word tree for Group D (Figure 5.5) appears consistent with the responses.

In Groups B and D, the majority gave confirmation of the opinion of there appearing to be polarisation on CSG extraction, particularly fracking.

The majority (one ‘no answer’) of Group A participants also agreed. With Participant 42 feeling it was “*created*”.

The majority of Group C agreed. Participant 101 believing that Group C members ‘lobbyists’ are concerned about fracking, but with ‘misinformation and lies’, feeling that fracking “*if done properly*” was not a concern.

The NVivo word tree for Groups A, B, C and D (Figure 5.6 in appendix 10) appears consistent with the responses.

5.4 Question 3 Multiple Choice. Where do you obtain information on CSG extraction (you may answer more than one)? (See Appendix 10 for data)

Group A participants obtain some of their information on CSG extraction from online sites and social media. A similar amount obtained information from traditional media (*e.g.*, newspapers, radio, television, etc.). Again, a similar number obtain information from public meetings, and a slightly smaller number of participants obtain information from word of mouth in the community and other sources.

Group B participants obtain some of their information on CSG extraction from online sites and social media. A similar number obtain information from traditional media and word of mouth in the Community. Again, a similar number of participants obtain information from public meetings. A small amount of Group B participants obtain information from other sources.

Group C participants obtain some CSG extraction from online sites. A similar amount obtain information from traditional media. Slightly less obtain information from other sources and word of mouth in the community. Slightly less, also obtain information from social media and, a smaller number of Group C participants from public meetings.

A third of Group D participants obtain some of their information on CSG extraction from online sites. Slightly less obtain information from traditional media. Less again, obtain information from other sources. Fewer obtain information from word of mouth in the community. With the least of Group D Participants obtaining information from social media and from public meetings.

Question 3 – **Where do you obtain information on CSG extraction (you may answer more than one)?**

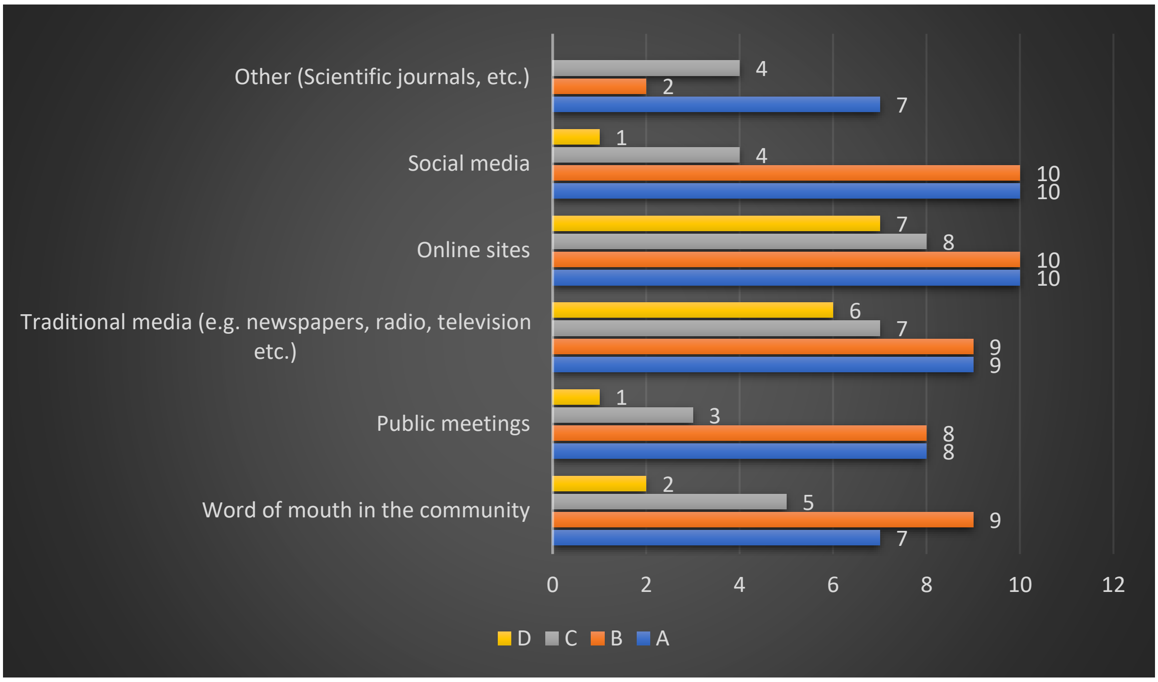

Figure 5.7: Question 3 Results

Table 5.2: Response 3 Groups: A, B, C and D to Q3

#	Response	%	Count
1	Word of mouth in the community	15.33%	23
2	Public meetings	12.67%	19
3	Traditional media (*e.g.*, newspapers, radio, television, etc.)	20.67%	31
4	Online sites	24.00%	36
5	Social media	16.00%	24
6	Other	11.33%	17
	Total	100%	150

Approximately a quarter of Groups A, B, C and D participants obtain some of their information on CSG extraction from online sites. A slightly less amount obtain information from traditional media. Fewer again appear to obtain information from social media. A similar number of participants obtain information from Word of mouth in the community. And the least number of total participants obtain information from public meetings and from other sources, respectively (Figure 5.7 and Table 5.2).

5.5 Question 4 Of the sources identified in question 3 what is the most important source of CSG extraction information?

Response 4 stems from Question 3 answers, with respect to the participant's most important source(s) of CSG extraction information. The following responses are representative of Group A, community group members:

Participant 2 "*On the internet and at rallies against fracking and listening to people who are opposed to fracking*.";

Participant 6 "*Online searches, Social media, and interaction with those in affected areas*."

Participant8 "*Social media – many organisations, media outlets, private citizens, NGOs, universities, etc. can add their information directly to social media*.";

Participant 9 "*1. Public meetings with speakers who have lived in fracking areas. Speakers who have worked in the financial markets, etc.*

2. Internet sites, such as Pennsylvania Environment research Centre.

3. Social media. Keeps you up to date on current personal information that is hard to find on the commercial news-they rarely say anything against it e.g., Murdock has large conflict of interest!"; and

Participant 30 "*All are very important, but peer reviewed scientific reports, Dr's reports, impacted residents abound and are beyond question*."

The word tree for Group A (Figure 5.8 in appendix 10) appears consistent with the responses.

Response 4 stems from Question 3 answers, with respect to the participant's most important source(s) of CSG extraction information. The following responses are representative of Group B, community individual participants:

Participant 51 "*Word of mouth is most important. I have friends who live in and nearby Queensland gasfields whose lives have been directly affected adversely in numerous ways; their firsthand stories are what I regard as the most accurate source of information*.";

Participant 54 "*To me word of mouth and social media are most important. The people who actually live in gasfields who are not paid by the industry*.";

Participant 69 "*Non-mainstream media sites online and documentaries circulated in the community*.";

Participant 72 "*Scientific papers or actual drill logs. Some are found online*."; and

Participant 77 "*Scientists. People living in the gasfields. Social Media, e.g., Lock the Gate*."

The word tree for Group B (Figure 5.9) appears to be consistent with participant responses.

Response 4 stems from Question 3 answers, with respect to the participant's most important source(s) of CSG extraction information. The following responses are representative of Group C, Australian government officials:

Participant 101 "*I identified 'other' as part of Government. I have access to all relevant shareholder information, as well as O.G.I.A., DNRM and EHP data*.";

Participant 102 "*Scientific publications; mainly because traditional media is measurably biased, social media is mainly opinion and online sites have agendas one way or the other*.";

Participant 103 "*Most important source of information for me as an EHO is the Queensland Health website.www.health.qld.gov.au/research-reports/environmental-health*."

Participant 110 "*EIS, Journal papers and; Technical reports*."; and

Participant 114 "*The most important source is online information. But the internet also provides a great deal of incorrect and misleading information. I favour scientific reports that I can access online from which I can synthesise my own, hopefully objective, assessment*."

The word tree for Group C (Figure 5.10) appears consistent with the responses.

Response 4 stems from Question 3 answers, with respect to the participant's most important source(s) of CSG extraction information. The following responses are representative of Group D, gas industry employees:

Participant 151 "*Professionals in the gas industry*.";

Participant 152 "*I find it essential to obtain information from multiple sources, and assess the reliability, robustness, and defensibility of the information and reporting within the context of the set of available information. All media has the potential to be: biased, sensational, emotive, ill informed, misleading, and funded or supported by commercial or political interests*.";

Participant 155 "*Project proponent EIS's as they be made available on-line. This is another source of polarisation. There is no regulatory requirement within QLD for the technical information contained within an EIS to be presented in a more user friendly and easily understandable format. Contributing to the assessment process being out of touch for the people who should really be understanding it.*";

Participant 158 "*Australian Government web pages. I worked for Origin Energy for a period of one year as an Environmental Advisor, Origin would conduct training days to educate their staff on gas extraction technology / methodology*."; and

Participant 165 "*CSG company and Government data / information is the most important to me*."

The word tree for Group D (Figure 5.11) appears consistent with the participant responses.

Response 4 stems from Question 3 answers, with respect to the participants most important source(s) of CSG extraction information.

The word trees and the responses for Group A and B suggest participants appear to obtain their most important information from word of mouth in the community and CSG gasfields, and other sources, such as, scientific journals and public forums and speakers.

Group C seems to prefer Australian government sources and EISs and the gas industry employees Group D seems to prefer gas industry reports and company supplied information. This appears consistent with the word tree Figures 5.10 and 5.11

The word tree for Groups A, B, C and D (Figure 5.12) appears consistent with the participant responses.

5.6 Question 5 How do you perceive, or view the CSG benefits compared to the possible impacts on water systems?

Group A the community group members, have been comprehensive in answering Question 5 on their perceived or viewed CSG benefits compared to their perceived possible impacts on water systems. The responses which are provided are representative of Group A:

Participant 8 "*Short term financial benefits are NOT worth the loss of a water supply for future generations. Tara / Chinchilla communities have experienced lowering of the water table preventing access to water. Sick or dead domestic and wild fauna and flora; and children with burns and rashes from sitting in water contaminated by chemicals and gas in the water. When there are other methods of energy sources, willingly poisoning water supplies is preposterous*.";

Participant 9 "*The benefits to communities in the longer term are mostly totally negative, the fracking corporations are highly immoral, have little integrity and exaggerate benefits and generally leave communities in a poor state, with the corporations using large amounts of public infrastructure to take their profits and leave communities with huge health problems as well as many water problems, ranging from discolouration to varying degrees of toxic pollutants and diminished pressure*.";

Participant 22 "*In times of drought the gas companies promised the farmers water, but those farmers who signed up, found that their water was contaminated with heavy metals, and was sometimes inflammable. These metals have been making farmers, their families and their stock sick.*";

Participant 30 "*Quite frankly I do not perceive any benefits compared to the damage to families, workers, the environment, wildlife, water, air, soil, all life on earth, our very existence as a species*."; and

Participant 49 "*I do not see any benefits from CSG that could not be achieved by comparable investment in renewable alternatives whereas the potential impacts on water are devasting*."

The word tree for Group A (Figure 5.13) appears consistent with the responses.

Group B the community individual participants, have been comprehensive in answering Question 5 on their perceived or viewed CSG benefits compared to the possible impacts on water systems. The responses which are provided are representative of Group B:

Participant 51 *"When you look at the big picture, I see no benefits for CSG. The risks to our water, land and air are way too high. It has already happened that the bores are contaminated by gas, the rivers are bubbling, and the toxins in the air are finding their way into rainwater tanks*.";

Participant 69 "*Fresh clean water is too precious and already too contested to waste carelessly. There are cleaner ways to produce gas for households (e.g., from landfill) Gas is not necessary for industry*.";

Participant 72 "*No comparison! CSG benefits are mostly economic benefits to corporations and a small number of individuals who do not live with their families in impacted areas. The impacts to our water systems are already evident. Many impacts will compound and increase in the coming years. This is unconscionable given that water security is vital for agriculture and indeed, for all life*.";

Participant 73 "*I consider that CSG has no possible benefits compared to probable impacts on water systems, climate, the culture of rural communities, the health impacts on both workers and people living in the vicinity and the toxic residue and dead zones created on farms, forests, rivers and roadside plant and animal communities*."; and

Participant 78 "*I don't perceive any CSG benefits. There are no benefits at all when the water has been poisoned, where creeks and dams etc bubble with gas fires. No poisoning of our water tables and thus our food and health is worth any big corp. profit in CSG*."

The word tree for Group B (Figure 5.14) appears consistent with the responses.

Group C Australian government officials have been comprehensive in answering Question 5 on their perceived or viewed CSG benefits compared to their perceived possible impacts on water systems. The responses which are provided are representative of Group C:

Participant 101 "*Very little long-term benefits for communities apart from improved road infrastructure. Most landholders benefit financially but would rather not be associated with CSG. Water systems (WCM in Surat) will be mostly de pressurised and rendered useless for centuries as viable water supplies for LH's*.";

Participant 102 "*Given the improving efficiencies with renewables, the short-term benefit of CSG cannot outweigh the risks to groundwater*.";

Participant 110 "*CSG is not worth the risk to our surface waters, which we understand reasonably well, much less our groundwater which we understand poorly*.";

Participant 114 "*I believe the economic benefits of CSG are enormous. But the cost of responsible environmental management of impacts on water potentially risks profitability. So successive governments have adopted a level of acceptance of environmental impacts to reap the economic benefits. Water legislation did not originally capture CSG water, and this gap has been used to advantage by CSG companies and governments*."; and

Participant 138 "*There is no benefit that can outweigh the pollution of our artesian water and catchments. No short-term royalties can make up for the destruction of our sustainable agriculture caused by poisoning our clean water sources.*"

The word tree for Group C (Figure 5.15) appears consistent with the responses.

Group D the gas industry employees have also been comprehensive in answering Question 5 on their perceived or viewed CSG benefits compared to their perceived possible impacts on water systems. The responses which are provided are representative of Group D:

Participant 151 "*The CSG benefits are equal to impacts on water systems. We need water to survive. But our economy must prosper also. It is important to be able to manage or mitigate impacts on water quality as part of CSG operations*.";

Participant 152 "*The potential benefits of CSG were (in hindsight) greatly overstated. The LNG industry has not contributed as significantly to the economic development of Queensland, as was predicted. The loss of gas from the domestic market has caused pressure on energy prices in Australia, that were not anticipated, or were understated in comparison to the benefits. At present some of the impacts of CSG cannot be cost effectively and practically mitigated. The precautionary principle should be applied. Solutions should be researched. UNTIL solutions are found, coal seam gas extraction be limited to avoid the severe impacts*.";

Participant 153 "*The impacts of CSG on groundwater resources are comparable to the impacts that the agricultural sector has impacted on the groundwater systems over the last 100 years. The CSG industry can co-exist, the impacts I believe are limited to marginal aquifers*.";

Participant 170 "*There seems to be a large economic benefit to the entire community, whilst impacts on water systems should be able to be easily managed (e.g., correct well construction, no drawdown / take from productive aquifers)*."; and

Participant 174 "*I believe the impacts to water systems to be potentially significant and very difficult / expensive to remediate if impacts occur*."

The word tree for Group D (Figure 5.16) appears consistent with the responses.

The findings of Response 5 Groups A, B, C and D to Question 5 are so comprehensive that a word cloud (Figure 5.17 in appendix 10) has been used to illustrate the data provided by NVivo. The word tree was too large and unintelligible.

Groups A, B and C appear consistent with their perceived views on CSG extraction impacts on water systems. They are perceived to be negative with regard to their perception of possible CSG water impacts. Only Group C Participant 114 perceived "*enormous CSG benefits*".

Group D perceived that the CSG benefits far outweighed their perceived impacts to water systems and that any perceived CSG impacts on water systems are manageable.

The word cloud for Groups A, B, C and D (Figure 5.17 in appendix 10) appears consistent with the participant responses.

5.7 Question 6 What are your personal, or first-hand experiences of CSG fracking?

Group A community group member's responses to Question 6 have been representatively provided:

Participant 2 "*I have met X / Affected Concerned Citizen whose father committed suicide because of the bullying by the gas companies*.";

Participant 8 "*METGASCO fracked a well near the airport and pipes underground shot out of the well under pressure and rained down from the air. People could have been killed. I have watched the Condamine River on fire from fracking. I have friends directly affected by the effects of fracking who have described, firsthand, the rumbling underground at Tara when METGASCO fracked on their property. METGASCO couldn't reseal the well after fracking before they left the area. The owners (who have now sold) believe that the well [sic] to still be leaking coal seam gas*.";

Participant 9 "*The benefits to communities in the longer term are mostly totally negative, the fracking corporations are highly immoral, have little integrity and exaggerate benefits and generally leave communities in a poor state, with the corporations using large amounts of public infrastructure to take their profits and leave communities with huge health problems as well as many water problems, ranging from discolouration to varying degrees of toxic pollutants and diminished pressure*.";

Participant 29 "*I studied geology at University, and I understand the impact of breaking an aquifer*."; and

Participant 42 "*I have visited sites and seen the damage caused up to 20 years later. I have read tests completed both in the past and today and compared results*."

The word tree for Group A (Figure 5.18) appears consistent with the responses.

Group B community individual participant's responses to Question 6 have been representatively provided:

Participant 54 "*I had relatives in Chinchilla. Saw the whole boom-bust cycle. I now see a sick looking environment driving from Condamine / Tara to Chinchilla. I have a friend whose kids experience unexplained nose bleeds their property is surrounded by wells and* *infrastructure. I remember hearing that they've done something, gas is out of control in the Condamine River. People are terrified of bushfires caused by flaring*.";

Participant 69 "*I have family in Chinchilla (I have never lived there) and I've seen the boom and bust in property values. I also personally know people who have experienced acute health issues and loss of livestock and livelihood*.";

Participant 71 "*Friends forced off land and suicides*.";

Participant 72 "*I have witnessed the huge environmental and social impact that came with the rollout of the industry. I have witnessed the spraying of roads (bitumen, ash, etc.) of 'produced' water. I have seen drill rigs operating in the vicinity of family homes – noise and light pollution impacting those households (they operate on a 24/7 basis)*."; and

Participant 73 "*I have researched the effects of CSG, and the fugitive methane emissions produced by CSG extraction, particularly fracking. I have been arrested during an incident where I was fighting the expansion of the CSG industry along with my community in peaceful civil – disobedience. Santos employees lied about this incident and their own violent behaviour in court*."

The word tree for Group B (Figure 5.19) appears consistent with their responses.

Group C Australian government official's responses to Question 6 have been representatively provided:

Participant 101 "*Aware of fracks that have not been confined to the coal seams targeted. However remedial action was implemented. Not aware of Any contamination arising from fracking*.";

Participant 114 "*I conducted a review of CSG practices and impacts on water, based on Australian, Canadian and US experience, to help advise the Commonwealth Government in developing its environmental policies on CSG product water*.";

Participant 125 "*There is a coal mine near Strafford, and we fought there and at first thought that Gas would be a cleaner option, but once we started to educate ourselves, we formed Groundswell and organised meetings and daily protests at the fracking sites. We also held a fundraising party to spread the word, and lobbied ministers, the govt, students at school* *etc. The police were also pushing the wrong way and had to be educated by the fabulous "Knitting Nannas"*;

Participant 128 "*Water reform discussions with farmers NFF and CSG companies*.";

Participant 138 "*My neighbour had his farm bore polluted with benzene after CSG bores were put down on his farm. Previously he was a keen CSG supporter. Now he just wants to sell his land, but no-one will buy it or his neighbour's properties. The Chinchilla water supply has been contaminated with water releases from Sunwater. I now cannot use town water for my cattle in case of contamination*."

The word tree for Group C (Figure 5.20) appears consistent with the responses.

Group D gas industry employees participant's responses to Question 6 have been representatively provided:

Participant 152 "*I have worked on conventional oil and gas sites where fracking was undertaken without environmental harm. I have researched fracking on CSG. I have concluded that fracking is entirely inappropriate where:*

- *The geology is not understood.*
- *The hydrological models are constructed with too many assumptions.*
- *There is uncertainty about the robustness and continuity of confining strata.*
- *There are high quality exploitable water resources that would be impacted*.";

Participant 155 "*I am an environmental professional and have been involved in a number of CSG projects in QLD. I also have family connections with areas of the Bowen and Surat Basins*."; and

Participant 171 "*I have been involved in land clearing activities to open up well sites for Drill rigs and associated right of ways (ROW's)*."

The word tree for Group D (Figure 5.21) appears consistent with the responses.

Both Groups A and B (or their families and friends), suggest they have experienced perceived very negative impacts from CSG fracking. This appears reflected by their responses and the Figures 5.18 and 5.19 (in appendix 10).

Group C responses are mixed, with responses suggesting negative CSG fracking affects being experienced by some participants, or their families and friends, such as Participant 138 "*My neighbour had his farm bore polluted with benzene after CSG bores were put down on his farm. Previously he was a keen CSG supporter. Now he just wants to sell his land, but no-one will buy it or his neighbour's properties. The Chinchilla water supply has been contaminated with water releases from Sunwater. I now cannot use town water for my cattle in case of contamination*." Some of the participants responded that they have little or no experience. The Figure 5.20 would suggest that overall, the CSG fracking affects are perceived as negative for Group C, particularly concerning water.

Group D gas industry employees:

Participant 152 response "*I have worked on conventional oil and gas sites where fracking was undertaken without environmental harm. I have researched fracking on CSG. I have concluded that fracking is entirely inappropriate where:*

- *The geology is not understood.*
- *The hydrological models are constructed with too many assumptions.*
- *There is uncertainty about the robustness and continuity of confining strata.*
- *There are high quality exploitable water resources that would be impacted*."

Most Group D participants appear to believe that there are few perceived negative impacts. Most participants have no firsthand experiences. Participant 158 appears adamant that there have been no perceived negative impacts.

The Group D NVivo Figure 5.21 appears consistent with these responses. The word tree A, B, C and D (Figure 5.22) appears consistent with the Groups A, B, C and D responses.

5.8 Question 7 Are you personally affected adversely, or positively by CSG extraction? How? By whom?

The following Group A, community group member's Question 7 responses are representative of the answers they have provided:

Participant 2 "*Long term everyone is affected by releasing gas into the atmosphere. And like the other thousands of abandoned mines across Australia who will clean up the mess*.";

Participant 8 "*Adversely. I am forced to step up to try and protest our nation for our and our children's futures and the future generations due to an unwilling government that not only ignores the threat but enables gas companies to destroy farmland, water and wilderness areas and poison our air. It costs lots of money to do what I do! I am a peaceful protestor with Knitting Nannies Against Gas*.";

Participant 9 "*Not directly at this point. However, it appears that more cases of toxic substances are being allowed to get into our food chains because of the universally poor imposing of regulations of this industry, e.g., Nugrow who are disposing of toxic waste into garden fertilisers etc. and many cases of out livestock eating and drinking toxic feed and water – their does not appear to be any identification of this continuous contamination*.";

Participant 30 "*I am adversely affected by time I have devoted to fighting the insane concept of this insane so-called industry. I could have been doing productive happy things with my life, not having to fight to protect my grandkids health and future wellbeing*."; and

Participant 42 "*Yes personally. Adversely. Stress for one, devalue of property, time being used up on research.*"

The word tree for Group A (Figure 5.23) appears consistent with the Group A responses.

The following Group B, community individual participant's Question 7 responses are representative of the answers they have provided:

Participant 51 "*Not directly. Other than being distressed about the situation, and the high possibility that a lot of the food produced in our "food bowl" which is now a "gas bowl" could well be contaminated*.";

Participant 54 "*I live downstream from current gasfields, but they are getting closer. My house value has dropped significantly. I live one street back from a beautiful river, my house should be going up in value. It was worth over $350,000 ten years ago, now probably be lucky to get $200,000*.";

Participant 56 "*We were heavily impacted by CSG extraction carried out by QGC and Origin Energy to the point where we paid to relocate because of the past, present and future impacts that would be caused by the CSG in our area*.";

Participant 69 "*I'm not living in the gasfields, but I am impacted by severe effects on rural industries and rural communities. The high cost of living Australia and current disdain for anyone who speaks out against fracking and mining is destructive*."; and

Participant 72 "*Yes. I have lived in town, but the rollout of the industry has decimated all real estate markets in the area. The property that I purchased pre-boom is now virtually unsaleable. As a pensioner with my home representing my only asset, this puts me in a position with few options to resolve. Cost of living rose by near 100% in just 3 years. Even our medical centre stopped bulk billing of pensioners.*"

The word tree for Group B (Figure 5.24) appears consistent with the Group B responses.

The following Group C, Australian government official's Question 7 responses are representative of the answers they have provided:

Participant 104 "*I have no personal experience of CSG extraction*.";

Participant 110 "*Yes. The wells and access roads fragment the landscape. No monitoring of gas leaks occurs on better than an ad-hoc basis*.";

Participant 114 "*I am not personally affected, other than by benefitting from the economic outcomes for QLD. Some environments in which I previously conducted research now lie within regions from which CSG is being extracted*.";

Participant 125 "*As a vocal protester, I had to appeal to the principal at Coffs, as the Dept. of Ed. Sees the issue of CSG as a controversial one (surprise?). the pro-frackers were very noisy and threatening with violence at times. The prospect of having a gas field nearby nearly sent me mad and I thought I had to move from my beautiful, self-renewable paradise as I am aware of the industry's respect of everything.*"; and

Participant 138 "*I am a beef cattle grazier who depends on water flowing from the Baralcula State Forest both in Stockyard ck and overland in floods into my dams. Most recent floods in Dec 2011, Jan 2011 and Jan 2013. Exploratory gas wells are being put in upstream in the Baralcula. I am legally liable for my any contaminants in the beef I produce. CSG wells are in our artesian water also. My business is directly threatened and extremely vulnerable*."

The word tree for Group C (Figure 5.25) appears consistent with the Group C responses.

The following Group D, gas industry employees Question 7 responses are representative of the answers they have provided:

Participant 158 "*I guess financially I have benefited by the CSG industry (I have worked in this industry for Approx. 5 years)*."; and

Participant 171 "*Positively, due to opening up work opportunities which otherwise would not be available by major Gas Companies (Origin, Santos, Arrow).*"

The word tree for Group D (Figure 5.26) appears consistent with the Group D responses.

Consistent with the figures 5.23. 5.24 and 5.27 Groups A and B responses indicate mostly perceived negative CSG extraction impacts. Group A Participant 42 "*Yes personally. Adversely. Stress for one, devalue of property, time being used up on research.*" Group B Participant 54 "*I live downstream from current gasfields, but they are getting closer. My house value has dropped significantly. I live one street back from a beautiful river, my house should be going up in value. It was worth over $350,000 ten years ago, now probably be lucky to get $200,000*."

Group C Australian government officials, responses were interpreted as reflective of the figure 5.25. Participant 138 "*I am a beef cattle grazier who depends on water flowing from the Baralcula State Forest both in Stockyard ck and overland in floods into my dams. Most recent floods in Dec 2011, Jan 2011 and Jan 2013. Exploratory gas wells are being put in upstream in the Baralcula. I am legally liable for my any contaminants in the beef I produce. CSG wells are in our artesian water also. My business is directly threatened and extremely vulnerable*."

Group D, gas industry employees, were mostly interpreted as positively affected by CSG extraction. Participant 152 is perceived to have some reservation, "*I am not currently* *affected negatively or positively by CSG extraction. I was positively affected from 2009 to 2013, where income was fully supported by the CSG industry, but the bottom fell out of that. The effects of the deterioration of the CSG industry were significant on Qld and many hundreds maybe thousands of individuals (engineers, scientists, and other specialists) lost their employment. But no-one talks about that*." However, of Group D, no one lives in a perceived negatively affected water quality area (Question1). This may be coincidence or choice.

The word tree for Groups A, B, C and D (Figure 5.27 in appendix 10) appears consistent with the Groups A, B, C and D responses.

5.9 Question 8 What challenges do you think we face due to CSG fracking based extraction regarding water systems (groundwater and surface water); for example, quantity use, or water quality impacts?

Group A the community group members have been comprehensive in answering Question 8 concerning the challenges that we face due to CSG fracking based extraction regarding water systems. The responses which are provided are representative of Group A:

Participant 2 "*How can you frack the rock and shale and not have major challenges to our water to our water tables? It is insane*.";

Participant 8 "*Many! Mining companies have access to UNLIMITED quantities of water for FREE so have no motivation to preserve water or care for the quality as they HAVE to as much as they can to get the gas out. They THEN have no plan to know what to do with the water so waste it by: spraying on roads; evaporating in the air; and feeding stock that humans eat. Farmers PAY for their water license and are restricted on the quantity they use yet feed the nation. I could go on…*";

Participant 9 "*From my 10 plus years of looking into this generally flawed industry, the challenge we have is to convince the public to force the corrupt politicians to ban this business! It is an industry that fails to have answers to many basic scientific outcomes, the method is not controllable – the fractures leach into the groundwater, the toxic waste is not able to be cleaned up properly. It is expensive and corporations will always take profits before community well-being*.";

Participant 30 "*To destroy the most important components of life on this earth is beyond insanity, first to satisfy the greed of corporations, shareholders and corrupt politicians. This is* *the driest nation on earth, our rainfall is decreasing dramatically, and our beautiful country is being destroyed by mainly foreign corporations*."; and

Participant 49 "*CSG fracking destroys the structure of the rocks and can potentially disrupt the water table. It also produces vast quantities of toxic wastewater with no adequate disposal method to date."*

The word tree (Figure 5.28) appears consistent with the Group A responses.

Group B the community individual participants have been comprehensive in answering Question 8 concerning the challenges that we face due to CSG fracking based extraction regarding water systems. The responses which are provided are representative of Group B:

Participant 54 "*It is all a game of Russian Roulette. Fracking is not an exact science. They crack the ground, the gas rises, but the pathways are unknown. This puts our water at significant risk. They have already contaminated the aquifer with gas. Oh gee…they must be connected to another aquifer. My god!! It (fracking) has the potential to leave vast areas of Australia (51% NT) as a wasteland. It's like some mad scientist from a Spiderman movie has bedazzled government – fracking and conventional drilling is madness!!*";

Participant 69 "*Water allocated to fracking leaves rural industries depleted of water, and it leaves them with contaminated water. Santos sprays frack wastewater on rural roads, further contamination*.";

Participant 71 "

1. *Fracking uses huge amounts of groundwater, drawing it down so it is unavailable to farmers.*
2. *Fracking introduces dangerous chemicals into groundwater systems.*
3. *Fracking brings salt to the surface where it can contaminate rivers, creek systems*.";

Participant 72 "*Loss of water will / is impacting farm and household sustainability. Pollutants, both sprayed on roads and land - spraying enter watercourses. Water quality cannot be guaranteed or even compared as a lack of baseline testing of both water and air favours industry claims that there is no harm being done. Also, altering the overland flow through construction on localised roads, pipeline corridors, etc., has a big impact on localised flooding, erosion, etc*."; and

Participant 73 "*Any wastage, pollution or theft of water sources is devastating for the environment, farmers and rural communities, especially in this age of prolonged and severe droughts caused by AGW. The problems of toxic, saline wastewater storage are not able to be overcome by available funds and technology. The brine is stored in unsafe conditions or sprayed on roads*."

The word tree (Figure 5.29) appears consistent with the Group B responses.

Group C the Australian government officials have all been comprehensive in answering Question 8 concerning the challenges that we face due to CSG fracking based extraction regarding water systems. The responses which are provided are representative of Group C:

Participant 104 "*Long term rehabilitation of ecosystem on a holistic approach as water is only one part of the system. This shouldn't be isolated. Needs to be a more holistic approach*.";

Participant 110 "*Contaminating of aquifers with CSG construction / production chemicals.*";
Fracturing the strata that previously confined aquifers, resulting in mixing and possible cross contamination. Dealing with saline wastewater.";

Participant 114 "*1. Water quality (groundwater) effects from chemicals injected during fracking. Underground dispersion, fate and impacts not adequately known to manage risks. 2. Surface water flows of treated water product returned to streams has significant affects. But QLD Government has blocked investigations.3. Storage of saline product water in above ground ponds can be managed better to use the water rather than allowing it to evaporate or infiltrate*.";

Participant 125 "*Aquifers will be poisoned, groundwater made toxic, even radio-active, and farmers out west will be suffering the consequences. Look at what happens in Queensland, or the USA, where whole regions are virtually no longer inhabitable, and the water no longer useful to drink or irrigate*."; and

Participant 138 "*Govt hydrology reports presented locally report drops of 200m. Local bores have dropped along with water pressure from bores. If we need to put in a water bore it* *will now cost us over $350,000 to access the only aquifer left for farm use, and we will have no recourse if the aquifer is polluted by bore casing failures in other bores*."

The word tree (Figure 5.30) appears consistent with the Group C responses.

Group D the gas industry employees appear to have also been comprehensive in answering Question 8 concerning the challenges that we face due to CSG fracking based extraction regarding water systems. The responses which are provided are representative of Group D:

Participant 151 "*Water quality is the biggest challenge. The use of chemicals in the fracking process must be monitored and there should be no adverse impact on water systems above and below ground. Groundwater dependent (The QLD government should rely on reliable data rather than speculation.) ecosystems must not be adversely impacted*."; Participant 152 "*Potential damage to confining strata between aquifers of different quality. Potential impacts to groundwater systems because of limited knowledge of the geological strata (lower quality historical geological mapping, gross generalisations regarding the interbedding layers of sandstone and coal). Unsustainable use of groundwater resources. Use of water resources that should be reserved for agriculture – Australia must continue to have food security and locally grown food is essential. Potential impact to water volume and quality. The unknown effects of removing water from the coal bearing strata. The potential of mixing of lower quality groundwater in the Condamine alluvium. The potential of contamination of groundwater in the Condamine alluvium. The potential depressurisation of the great artesian basin. The salination of agricultural land. The unknown and subsequent impacts of any of the above happening, on agriculture, natural, and water systems.*";

Participant 156 "*Consumption – personal experience in the resource industry and water infrastructure management leads me to believe consumption will be poorly managed and recorded. Quality – pressure to maximise profits will result in 'cutting' corners and result in failures and impacts. Community. Little respect shown by operators and their contractors when accessing private properties*.";

Participant 170 "*My understanding is that the primary issue is correct well construction to ensure no leakage between water-bearing units, and ensuring aquifers are not depressurised by de-gassing / de-pressurising saturated coal seams*."; and

Participant 174 "*Making sure impacts from extraction are localised (very localised), so water quality, volume and water pressure are not compromised, for other water users or the environment. Making use of extracted water in a way to benefit the environment and water users*."

The word tree (Figure 5.31) appears consistent with the Group D responses.

The responses for Groups A, B and C are interpreted as consistent with respect to their common perception of perceived significant CSG fracking based extraction impacts on water systems:

Group A Participant 8 "*Many! Mining companies have access to UNLIMITED quantities of water for FREE so have no motivation to preserve water or care for the quality as they HAVE to as much as they can to get the gas out. They THEN have no plan to know what to do with the water so waste it by: spraying on roads; evaporating in the air; and feeding stock that humans eat. Farmers PAY for their water license and are restricted on the quantity they use yet feed the nation. I could go on…*";

Group A Participant 30 "*To destroy the most important components of life on this earth is beyond insanity, first to satisfy the greed of corporations, shareholders and corrupt politicians. This is the driest nation on earth, our rainfall is decreasing dramatically, and our beautiful country is being destroyed by mainly foreign corporations*.";

Group B Participant 54 "*It is all a game of Russian Roulette. Fracking is not an exact science. They crack the ground, the gas rises, but the pathways are unknown. This puts our water at significant risk. They have already contaminated the aquifer with gas. Oh gee…they must be connected to another aquifer. My god!! It (fracking) has the potential to leave vast areas of Australia (51% NT) as a wasteland. It's like some mad scientist from a Spiderman movie has bedazzled government – fracking and conventional drilling is madness!!*"; and

Group B Participant 72 "*Loss of water will / is impacting farm and household sustainability. Pollutants, both sprayed on roads and land - spraying enter watercourses. Water quality cannot be guaranteed or even compared as a lack of baseline testing of both water and air favours industry claims that there is no harm being done. Also, altering the overland flow through construction on localised roads, pipeline corridors, etc., has a big impact on localised flooding, erosion, etc*.

Group C the Australian government official's responses are perceived to be more consistently aligned with Groups A and B:

Participant 110 "*Contaminating of aquifers with CSG construction / production chemicals*;

Fracturing the strata that previously confined aquifers, resulting in mixing and possible cross contamination. Dealing with saline wastewater."; and

Participant 125 "*Aquifers will be poisoned, groundwater made toxic, even radio-active, and farmers out west will be suffering the consequences. Look at what happens in Queensland, or the USA, where whole regions are virtually no longer inhabitable, and the water no longer useful to drink or irrigate*."

These findings appear to be reflected in Figures 5.28, 5.29 and 5.30 (in appendix10). The gas industry practice of apparent 'dispersal' of co-produced water on to local Western Downs roads in the vicinity of CSG activity has been perceived as expressed in some responses by both Group A and Group B participants.

Group D the gas industry employees participant responses are also perceived to express concern over suggested potentially significant and significant CSG fracking based extraction impacts and appears to be illustrated in Figure 5.31:

Participant 152 "*Potential damage to confining strata between aquifers of different quality. Potential impacts to groundwater systems because of limited knowledge of the geological strata (lower quality historical geological mapping, gross generalisations regarding the interbedding layers of sandstone and coal). Unsustainable use of groundwater resources. Use of water resources that should be reserved for agriculture – Australia must continue to have food security and locally grown food is essential. Potential impact to water volume and quality. The unknown effects of removing water from the coal bearing strata. The potential of mixing of lower quality groundwater in the Condamine alluvium. The potential of contamination of groundwater in the Condamine alluvium. The potential depressurisation of the great artesian basin. The salination of agricultural land. The unknown and subsequent impacts of any of the above happening, on agriculture, natural, and water systems*."; and

Participant 156 "*Consumption – personal experience in the resource industry and water infrastructure management leads me to believe consumption will be poorly managed and recorded. Quality – pressure to maximise profits will result in 'cutting' corners and result in failures and impacts. Community. Little respect shown by operators and their contractors when accessing private properties*."

The word tree and word cloud (Figures 5.32*a* and 5.32*b*) appear consistent with the Groups A, B, C and D responses.

Question 8 Groups A, B, C and D responses indicate that the polarisation of opinion on the matter of perceived challenges faced due to CSG fracking based extraction on water systems impacts is not apparent. All groups expressing similar, though varying degrees of perceived concern, regarding either: suggested perceived potentially significant, and significant impacts on water systems.

5.10 Question 9 Can you think of any possible solutions to mitigate or reduce negative impacts, or increase the benefits of CSG fracking based extraction?

The following Group A, community group member's Question 9 responses on possible solutions to mitigate or reduce negative impacts, or increase the benefits of CSG fracking based extraction are representative of the answers they have provided:

Participant 2 "*Ban fracking. Most gas is sold cheaply to overseas markets for a pittance anyway*.";

Participant 8 "*No. To be viable the entire process is dependent upon chemicals that are carcinogenic remain below ground (who knows where…the companies don't) and filter into the GAB through cracks caused by fracturing the rock systems below ground. The only 'solution' is to BAN it and the government immediately work towards renewable energy systems as other leading countries already are*.";

Participant 9 "*Yes. Have it banned as it is in 20 out of 30 countries where shale and coal seam gas are able to be mined. Even in the very best-case scenario, eventually a certain percentage of CSG wells leak and as time goes by that percentage gets higher. The main problems with possible solutions are that any mitigation comes at a cost and if the full regulation was imposed the industry could not exist. It only exists because of the "Ponzi" nature of the finances and the taking of cost cutting "short cuts*.";

Participant 30 "*There are no positive solutions. Companies are given tax holidays. They are able to write off expenses to avoid taxes. They are given subsidies they are given infrastructure from our taxes. In return our way of life, our land and water, our very existence is destroyed. The corrupt politicians are given millions to sustain their psychopathic lust for power. The whole process is a poisoned and poisonous process. It is a lose concept and the few winners will be losers eventually*."; and

Participant 42 "*Only solution is to not do it*."

The word tree (Figure 5.33) appears consistent with the Group A responses.

The following Group B, community individual participant's Question 9 responses on possible solutions to mitigate or reduce negative impacts, or increase the benefits of CSG fracking based extraction are representative of the answers they have provided:

Participant 51 "*NO! It should be stopped NOW. Ban all unconventional onshore gas extraction. The only way to reduce the negative impacts is to stop it now*.";

Participant 51 "*NO! It should be stopped NOW. Ban all unconventional onshore gas extraction. The only way to reduce the negative impacts is to stop it now*."; Participant 54 "*Just don't do it. We can't eat or drink money or gas. We (and future generations) need water. Mitigate impacts – don't drill for gas anywhere there is underground water (e.g. Great Artesian Basin) or where there is overland water flows (flood plains, channel country). It's not safe anywhere else in the world. It's not going to be safe here*."

Participant 72 "*The problems are unable to be overcome. Air emissions, loss of water, fugitive emissions, pipeline subsidence, salt disposal, loss of social cohesion, health and environmental impacts are each, on their own, immense. Not just immediately, but for all time into the future*.";

Participant 73 "*The only solution to reduce negative impacts of the CSG industry is to stop all expansion and to wind back current production as safely as possible. The only benefits possible are to make the corrupt CSG corporations pay tax and to close down the export industry, reserving gas currently under production for the use of local homes and industry*."; and

Participant 78 "*NOT TO FRACK. To seek alternative energy sources and start implementing into future practices*."

The word tree (Figure 5.34) appears consistent with the Group B responses.

The following Group C, Australian government official's Question 9 responses on possible solutions to mitigate or reduce negative impacts, or increase the benefits of CSG fracking based extraction are representative of the answers they have provided:

Participant 110 "*Better utilisation of solar, wind and other renewables to remove the need for any CSG extraction. This is mitigation by avoidance*.";

Participant 114 "*There needs to be a greater big-picture strategy to investigating and communicating negative and positive impacts and solutions. The regulatory Environmental Impact Assessment process is not suitable for this purpose, as it focusses only on achieving compliance with legislation, rather than actually identifying and understanding impacts so that real solutions can be developed. So, the real solution is more research, better research, and effective communication and knowledge transfer of results*.";

Participant 120 "*Severely restrict access. Onus should be on protecting groundwater NOT CSG extraction. Onus should be reversed. CSG subservient*.";

Participant 125 "*All CSG wells eventually leak. There is no safe CSG extraction, and we don't need it. Renewable energy is the answer*."; and

Participant 138 "*There needs to be an immediate moratorium on the CSG industry. Nothing is worth the destruction of our most valuable natural resource, our clean water, on which our agriculture and tourism industries depend. The waste salt from CSG mining is also an immediate threat to our soils and catchments, with a 15 million tonne salt dump approved near Chinchilla in the floodplains and catchments of the Murry Darling Basin.*"

The word tree (Figure 5.35) appears consistent with the Group C responses.

The following Group D, gas industry employees Question 9 responses on possible solutions to mitigate or reduce negative impacts, or increase the benefits of CSG fracking based extraction are representative of the answers they have provided:

Participant 151 "*No use of chemicals, if they present a risk to water quality or impact groundwater levels.*";

Participant 152 "*Increasing use of solar power, increasing use of wind power, legislated transition away from fossil fuels, legislated protection of domestic gas supply, legislated protection of agricultural land for current and future food production, Legislated and enforcement of requirements for geological / hydrological research prior to allowing CSG extraction to progress, Location specific legislated bans on fracking where high quality water resources and groundwater dependent ecosystems exist, and could be threatened, location specific legislated support for fracking where robust understanding of the hard rock geology indicates that fracking could occur without impacting water resources*.";

Participant 156 "*Heavy penalties for breaching and appropriately resourced Regulators*.";

Participant 170 "*Better public education, along with the obvious solution of ensuring quality control in well construction and water quantity / quality monitoring associated with CSG projects*."; and

Participant 171 "*Further studies to determine if fracking is more efficient than other drilling methods and potential effects on salinity and groundwater contamination*."

The word tree (Figure 5.36) appears consistent with the Group D responses.

Groups A and B are consistent in their responses with regard to their perceived possible mitigating and the reduction of perceived negative CSG fracking based extraction impacts. Both groups expressing their perceived views that CSG extraction has potentially significant negative impacts to human health and water systems and are of the interpreted opinion that it should be banned or stopped. Groups A and B express no positive benefit perceptions of CSG fracking based extraction:

Group A Participant 8 "*No. To be viable the entire process is dependent upon chemicals that are carcinogenic remain below ground (who knows where…the companies don't) and filter into the GAB through cracks caused by fracturing the rock systems below ground. The only 'solution' is to BAN it and the government immediately work towards renewable energy systems as other leading countries already are*."; and

Group B Participant 72 "*The problems are unable to be overcome. Air emissions, loss of water, fugitive emissions, pipeline subsidence, salt disposal, loss of social cohesion, health and environmental impacts are each, on their own, immense. Not just immediately, but for all time into the future*.

The word trees (Figures 5.33 and 5.34 in appendix 10) appear consistent with these responses.

Group C Australian government official's responses are interpreted as similar to Groups A and B and do not suggest any interpreted perceived positive benefits from CSG fracking based extraction, only perceived significant negative impacts and more research on their perceived impacts. There are interpreted significant responses appearing to favour renewable energy sources. The Figure 5.35 appears consistent with these responses:

Participant 110 "*Better utilisation of solar, wind and other renewables to remove the need for any CSG extraction. This is mitigation by avoidance*."; and

Group C Participant 138 "*There needs to be an immediate moratorium on the CSG industry. Nothing is worth the destruction of our most valuable natural resource, our clean water, on which our agriculture and tourism industries depend. The waste salt from CSG mining is also an immediate threat to our soils and catchments, with a 15 million tonne salt dump approved near Chinchilla in the floodplains and catchments of the Murry Darling Basin.*"

Group D responses regarding possible solutions to mitigate or reduce negative impacts or increase the benefits of CSG fracking are not positive. They are interpreted as focusing on education and further research into better CSG extraction methods, enforcement of existing penalties and control mechanisms.

The Figure 5.36 appears consistent with these responses:

Group D Participant 152 "*Increasing use of solar power, increasing use of wind power, legislated transition away from fossil fuels, legislated protection of domestic gas supply, legislated protection of agricultural land for current and future food production, Legislated and enforcement of requirements for geological / hydrological research prior to allowing CSG extraction to progress, Location specific legislated bans on fracking where high quality water* *resources and groundwater dependent ecosystems exist, and could be threatened, location specific legislated support for fracking where robust understanding of the hard rock geology indicates that fracking could occur without impacting water resources*."; and Group D Participant 170 "*Better public education, along with the obvious solution of ensuring quality control in well construction and water quantity / quality monitoring associated with CSG projects*."

Question 9 responses for Groups A, B, C and D, were interpreted as similar to Question 8 responses and were not interpreted as being polarised in opinion on CSG fracking based extraction. Groups A, B, C and D responses indicated perceived negative concern regarding CSG fracking based extraction. Groups Ds were interpreted as perceivably negative from a different perspective.

The word tree (Figure 5.37) appears consistent with the Groups A, B, C and D responses.

5.11 Question 10 Do you think the present government guidelines are fair for all stakeholders, those with interests, positive or negative, in CSG fracking based extraction?

The Group A, community group member's responses on the present government guidelines on CSG fracking based extraction and the stakeholders involved are representative of the answers they have provided:

Participant 8 "*ABSOLUTELY NOT! The government openly facilitates the industry and accepts large donations from them corrupting the decision-making process from the outset. The government CHANGES LAWS in favour of gas mining to prevent the average citizen from defending the environment. The guidelines are skewed totally towards fracking*.";

Participant 9 "*Government guidelines for this industry are a joke! The industry operates basically under the "Haliburton Clause". Where they have almost free reign environmentally, the fines for breaches are, compared to the general population, pathetic. The "useful" resources regulations are a scam to use toxic waste disposed of throughout the community in a disgraceful manner. Self-regulation for this industry have failed everywhere they operate*."

Participant 22 "*Definitely not fair for the farmers and their communities. The companies employ standover tactics to grind farmers down*.";

Participant 29 "*No. I think the government guidelines are too loose and allow the CSG companies too much freedom to frack wherever, and the clean-up is minimal. (Too many loop-holes).*"; and

Participant 30 "*Of course not. Self-regulation for a high-cost concept for a company that has to satisfy shareholders is a certain concept for failure and corruption*."

The word tree (Figure 5.36) appears consistent with the Group A responses.

The Group B, community individual participant's responses on the present government guidelines on CSG fracking based extraction and the stakeholders involved are representative of the answers they have provided:

Participant 51 "*NO! It's heavily weighted to the gas companies. The landholders who are in favour of it are just interested in short term financial gains and not the long-term preservation of farmland and water conservation and quality*.";

Participant 54 "*No. Landholders can be taken to the Land Court (though none have). Government guidelines are composed in conjunction with the CSG industry. Government research (CSIRO) is funded by the gas industry. The worst-case scenario is not put forward. Landholders are not given all the information. Landholders are not told they can't get insurance for example*.";

Participant 69 "*No. Mining companies and their shareholders and politicians who receive mining company donations are favoured over small rural industries and communities – who are lied to and manipulated*.";

Participant 73 "*Farmers and rural communities are bullied and exploited by a CSG industry that comes into their community like a plague, despoiling, poisoning and destroying all in its way. There is often no recourse for affected communities other than to move away from their homes or commit suicide. The only 'winners' are the managers and* shareholders *of the CSG industry and the politicians they corrupt"*; and

Participant 77 "*No, they seem to favour the companies wanting to make the most amount of money out of our resources, with little regard on the legacy they leave for future generations*."

The word tree (Figure 5.39) appears consistent with the Group B responses.

The Group C, Australian government official's responses on the present government guidelines on CSG fracking based extraction and the stakeholders involved are representative of the answers they have provided:

Participant 102 "*Depends on which level of government in which state. Governments have the fracking switch mainly on because of potential jobs otherwise, the science would urge much more care and caution*.";

Participant 104 "*Self-regulation doesn't work. Business will always use the method which cost less, this may not lead to the desired result.* ";

Participant 114 "*Not at all. My understanding is that existing QLD government guidelines are heavily focused on allowing the CSG industry interests in order to receive the economic and social benefits, with only a minimum level of compliance on environmental impacts. The government has engaged in suppressing information and selective communication to create a more favourable public perception of benefits, impacts and risks*.";

Participant 120 "*No. They are biased toward facilitating extraction*"; and

Participant 125 "*The present LNP govt does not govern. It abuses the environment, and fossil fuel extracting companies have all the rights, and those opposing it can be arrested for peacefully protesting. It's a disgrace and very dangerous*.";

The word tree (Figure 5.40) appears consistent with the Group C responses.

The Group D, gas industry employees responses on the present government guidelines on CSG fracking based extraction and the stakeholders involved are representative of the answers they have provided:

Participant 151 "*No. Landholder consent to activity on freehold land should be compulsory. Govt. should not use CSG industry as a mechanism to fill research gaps or require / regulate outcomes that are higher than the pre-CSG environment situation*.";

Participant 155 "*The regulatory framework is robust. However, depending on your position could be considered too much 'green tape' or conversely not rigorous enough. Environment laws can only be enforced to the degree that the law is written. Unfortunately, we rarely see in QLD the application of full penalties beneath the law. Accordingly, I don't see env. Regulation as being as strong as it should / could be*";

Participant 165 "*No. Landholders need greater compensation and beneficial use of CSG water*.";

Participant 171 "*No, because though the guidelines state will be done legally, I don't believe they are actually followed or monitored, and that interests are biased toward those that benefit from CSG fracking*."; and

Participant 174 "*I think so. The policy and guidelines must be dynamic, so they are modified to reflect recent experience, research and new technology. Modification of guidelines must be done in a clear and transparent manner*."

The word tree (Figure 5.41) appears consistent with the Group D responses.

Groups A and B responses are not interpreted as indicating that the present government guidelines are fair for all perceived stakeholders with interests in CSG fracking extraction, there appears to be a perceived bias of the government guidelines perceived by the Group A and B participants in favour of the gas industry. Their interpreted responses may be suggested in Figures 5.38 and 5.39:

Group A Participant 9 "*Government guidelines for this industry are a joke! The industry operates basically under the "Haliburton Clause". Where they have almost free reign environmentally, the fines for breaches are, compared to the general population, pathetic. The "useful" resources regulations are a scam to use toxic waste disposed of throughout the community in a disgraceful manner. Self-regulation for this industry has failed everywhere they operate*."; and

Group A Participant 29 "*No. I think the government guidelines are too loose and allow the CSG companies too much freedom to frack wherever, and the clean-up is minimal. (too many loop-holes)*."

Group B Participant 54 "*No. Landholders can be taken to the Land Court (though none have). Government guidelines are composed in conjunction with the CSG industry. Government research (CSIRO) is funded by the gas industry. The worst-case scenario is not put forward. Landholders are not given all the information. Landholders are not told they can't get insurance for example*."; and

Group B Participant 73 "*Farmers and rural communities are bullied and exploited by a CSG industry that comes into their community like a plague, despoiling, poisoning and* *destroying all in its way. There is often no recourse for affected communities other than to move away from their homes or commit suicide. The only 'winners' are the managers and shareholders of the CSG industry and the politicians they corrupt*."

Group C has six (6) responses interpreted as being consistent with Groups A and B. These responses suggest the participants perceive there may be a bias in favour of the gas industry and their perception that present government regulations may not be fair for all perceived stakeholders with interests in CSG fracking extraction. Also, Participant 101 "*Guidelines Are very prescriptive for operators and designed to protect L.H. interests*". And Participant 103, "*I think communities affected by CSG fracking should be treated more fairly by providing them with sufficient information to make an informed decision as to whether or not they agree with it taking place*". Other responses:

Group C Participant 114 "*Not at all. My understanding is that existing QLD government guidelines are heavily focused on allowing the CSG industry interests in order to receive the economic and social benefits, with only a minimum level of compliance on environmental impacts. The government has engaged in suppressing information and selective communication to create a more favourable public perception of benefits, impacts and risks*."; and

Group C Participant 125 "*The present LNP govt does not govern. It abuses the environment, and fossil fuel extracting companies have all the rights, and those opposing it can be arrested for peacefully protesting. It's a disgrace and very dangerous*."

However, two Group C responses were simply "no"

Word tree Figure 5.40 may reflect Group C's responses.

Group D responses non-indicative interpretations. Four responses were interpreted as suggesting they were not fair to all stakeholders, with a further three participants being unsure. Three Group D gas industry employees perceived the present government guidelines were fair to all stakeholders:

Group D Participant 155 "*The regulatory framework is robust. However, depending on your position could be considered too much 'green tape' or conversely not rigorous enough. Environment laws can only be enforced to the degree that the law is written. Unfortunately, we* *rarely see in QLD the application of full penalties beneath the law. Accordingly, I don't see env. Regulation as being as strong as it should / could be*."; and

Group D Participant 171 "*No, because though the guidelines state will be done legally, I don't believe they are actually followed or monitored, and that interests are biased toward those that benefit from CSG fracking*."

The Question 10 Group A, B, C and D responses on their perceived fairness of present government guidelines are not interpreted as polarised. Groups A and B indicate they believe there is a perceived bias toward the gas industry. The Group C response indicates there may be a perceived bias and Group D is non-indicative.

The word tree (Figure 5.42 in appendix 10) appears consistent with the Groups A, B, C and D responses.

5.12 Question 11 How do you believe decisions on CSG fracking based extraction should be decided regarding present and future activities involving CSG fracking based extraction?

The Group A, community group member's responses to how decisions on the CSG fracking based extraction should be made regarding present and future activities CSG extraction are representative of their answers:

Participant 6 "*Clear information made available and either clear policy by political parties or a plebiscite.*";

Participant 8 "*By listening to those impacted. By NOT corrupting the environmental watchdogs like the EPA, CSIRO, etc. By RETURNING FUNDING to ethical scientists to thoroughly research the industry. By formulating an EXIT strategy to kick the industry out once and for all and properly fund renewables*.";

Participant 9 "*Any decisions regarding fracking should be decided by the people voting directly and individual communities should be allowed to have a direct say to whether their water, air and land are turned into an industrial area and their health put at risk. Governments have failed totally in their duty of care and decision should be taken from them*.";

Participant 30 "*The only solution is to ban extraction and fracking from this country entirely. Other countries have done it and the sky did not fall in*."; and

Participant 34 "*Social license, health and environmental considerations and moving away from fossil fuels to renewables*."

Figure 5.43 appears consistent with the Group A responses.

The Group B, community individual participant's responses to how decisions on the CSG fracking based extraction should be made regarding present and future activities CSG extraction are representative of their answers:

Participant 51 "*Baseline testing. If it was done it would show numerous reasons why it is unsafe and should be stopped. The future must be considered – health effects are paramount considerations; health of people, animals, water, air and soil*.";

Participant 54 "*Water, Land, Air and Health Should be Number 1. If the gas industry cannot 100% say that none of these will be negatively affected it should not go ahead. Since we need a healthy planet to live on, maybe the most committed environmentalists should have a say…but even they could become corrupted by bribery / political donations*.";

Participant 56 "*Using real independent scientists and community representatives to investigate that it is carried out to the highest standard if it is deemed it can be done without damage to underground water, the environment and any living thing in the environment*.";

Participant 69 "*I think we should ban it completely for its toxic effects. Other countries have done so. We need to cap at a low level all political donations to end the corruption*."; and

Participant 72 "*An independent (truly independent, unlike GISERA or the Gasfields Commission) Commissioner is required, backed by the government to enforce regulations and penalise non-compliance. Self-regulation by the industry has shown to be a failure*."

The word tree (Figure 5.44) appears consistent with the Group B responses.

The Group C, Australian government official's responses to how decisions on the CSG fracking based extraction should be made regarding present and future activities CSG extraction are representative of their answers:

Participant 102 "*These decisions should be made by an informed local / regional community along with the stakeholders. It is being done in their country and they have to live with long term outcomes*.";

Participant 103 "*All stakeholders, including affected communities should be consulted. Future decisions on where fracking may take place must ensure that it will not impact on the environment including natural ecosystems and habitats*.";

Participant 114 "*I strongly support knowledge – based decision making, based on rigorous scientific information. The science needs to be demonstrably objective and independent of industry interests. I have not seen how effective the Commonwealth Expert Committee is in ensuring objectivity in current decision process*."

Participant 128 "*Strong government involvement and environmental regulation*."; and

Participant 138 "*There should be a plebiscite of all residents, and our Federal Government needs to act to protect our water and close down the CSG industry along with any other industry that pollutes our water resources*."

The word tree (Figure 5.45) appears consistent with the Group C responses.

The Group D, gas industry employee's responses to how decisions on the CSG fracking based extraction should be made regarding present and future activities CSG extraction are representative of their answers:

Participant 151 "*Need to consider fracking ACROSS ALL CSG operations, not just one company independent of others, i.e., cumulative impact*.";

Participant 152 "*Decisions on CSG fracking based extraction should be determined on the basis of robust and defensible independent scientific research. Industry should be required to fund research, but not pay directly for it. The government should have the senior personnel who are sufficiently qualified and skilled to understand the scientific research and they should be afforded the authority to make decisions without bias or political influence*."; Participant 155 "*There is not enough focus on cumulative impacts in all forms of resource development. Additional scrutiny in terms of long-term cumulative effects would be beneficial, to better understand the impacts certain activities may or may not have in 10, 20, 30 – 50yrs time*."

Participant 171" *Community meetings and involvement. Discussions at a state government level. Stakeholder discussions*."; and

Participant 174 "*Decisions must be made using current knowledge of the local environment values and environmental risks. Cooperative working relationships, data / knowledge sharing protocols and community involvement mechanisms are needed to build confidence in the decisions that are made*."

The word tree (Figure 5.46) appears consistent with the Group D responses.

With respect to Question 11, how do you believe decisions on CSG Fracking based extraction should be made at present and in the future, of Groups A, B, C and D participants the majority responded with common perceptive themes. The need to involve those communities affected by CSG fracking based extraction for decision making on CSG extraction, in the present and the future is interpreted as a common theme. Further, the interpreted need for ethical, expert, independent scientists to research the gas industry and CSG activities similarly is a common theme amongst all groups. Also, the need to protect water and the environment appears frequently throughout the anonymous survey questionnaire for all groups. There appears no interpreted polarity of opinion on these issues, though there are 'bones of contention':

Group A Participant 8 "*By listening to those impacted. By NOT corrupting the environmental watchdogs like the EPA, CSIRO, etc. By RETURNING FUNDING to ethical scientists to thoroughly research the industry. By formulating an EXIT strategy to kick the industry out once and for all and properly fund renewables*."; and

Group A Participant 9 "*Any decisions regarding fracking should be decided by the people voting directly and individual communities should be allowed to have a direct say to whether their water, air and land are turned into an industrial area and their health put at risk. Governments have failed totally in their duty of care and decision should be taken from them*."

Group B Participant 54 "*Water, Land, Air and Health Should be Number 1. If the gas industry cannot 100% say that none of these will be negatively affected it should not go ahead. Since we need a healthy planet to live on, maybe the most committed environmentalists should have a say…but even they could become corrupted by bribery / political donations*."; and

Group B Participant 56 "*Using real independent scientists and community representatives to investigate that it is carried out to the highest standard if it is deemed it can* *be done without damage to underground water, the environment and any living thing in the environment*."

Group C Participant 103 "*All stakeholders, including affected communities should be consulted. Future decisions on where fracking may take place must ensure that it will not impact on the environment including natural ecosystems and habitats*."; and

Group C Participant 114 "*I strongly support knowledge – based decision making, based on rigorous scientific information. The science needs to be demonstrably objective and independent of industry interests. I have not seen how effective the Commonwealth Expert Committee is in ensuring objectivity in current decision process*."

Group D Participant 152 "*Decisions on CSG fracking based extraction should be determined on the basis of robust and defensible independent scientific research. Industry should be required to fund research, but not pay directly for it. The government should have the senior personnel who are sufficiently qualified and skilled to understand the scientific research and they should be afforded the authority to make decisions without bias or political influence*."; and

Group D Participant 174 "*Decisions must be made using current knowledge of the local environment values and environmental risks. Cooperative working relationships, data / knowledge sharing protocols and community involvement mechanisms are needed to build confidence in the decisions that are made*."

The word tree (Figure 5.47) appears consistent with the Groups A, B, C and D responses in answer to Question11.

5.13 Question 12 Are the existing control mechanisms for CSG extraction sufficient? For example: Australian Petroleum Production and Exploration Association's 'best practice' approach; and the Commonwealth Government and State Government laws and guidelines governing CSG fracking based extraction. If so, how, and why? If not, how, and why?

The responses of Group A the community group members, to whether the existing control mechanisms for CSG extraction are sufficient? For example: Australian Petroleum Production and Exploration Association's 'best practice' approach; and the Commonwealth Government and State Government laws and guidelines governing CSG fracking based extraction are consistent with the following:

Participant 6 "*No. Impacts on those in areas affected are unreasonable, if not banned operations need stricter regulation, governance and enforcement*.";

Participant 8 "*NO.* "*Best practice" "Robust". These terms no longer have ANY meaning as again and again the industry lets down people who put their trust in them. Insurance companies want no bar of properties in gasfields, so they become unsellable, and their values drop. HOW CAN this be good for Australia? Large swathes of once valuable real estate is being rendered worthless every day by this industry"*;

Participant 9 "*No, the mechanisms are failing daily, breaches occur daily, many breaches are not reported. Whistle blowers are treated as criminals. As time goes on governments realize how expensive funding the supervision of these so called "best practices" is, funding is always cut, and self-regulation is a joke. Many of the results of breaches do not become an issue until years after the extraction has finished. Then there is the problem that is never mentioned in reports done prior to implementing regulations – corruption. Corruption, bullying and untruths are a trademark of this industry*.";

Participant 22 "*How can they be sufficient when the chemicals in fracking fluid contain up to: 40% endocrine disrupters; 30% suspected carcinogens; 30% toxins that affect development; and a percentage harmful to brain and nervous systems. Plus, they use about 450kg sand per frack.*"; and

Participant 30 "*Best practice" is a myth. It is a lie perpetuated by politicians and companies. APPEA is a farce, a rubber stamp. It has been bought*."

The word tree (Figure 5.48) appears consistent with the Group A responses

The responses of Group B the community individual participants, to whether the existing control mechanisms for CSG extraction are sufficient? For example: Australian Petroleum Production and Exploration Association's 'best practice' approach; and the Commonwealth Government and State Government laws and guidelines governing CSG fracking based extraction are consistent with the following:

Participant 51 "*No, definitely not. It's a self-regulated industry. The "best practice" approach is an illusion. Go and speak to those who are directly affected and do baseline testing*.";

Participant 54 "*No – These guidelines are written to ensure that gas extraction goes ahead. The industry self regulates. They turn off flares etc. when inspections take place. They do not monitor health impacts on people living amongst their infrastructure. Waste is disposed of "beneficially". This cuts down the gas industry costs. Waste is not adequately tested nor monitored. Waste sprayed on the ground ends up in the water. APPEA has blocked me on social media, not the 'part-truths' that they put out. Without being able to have an open debate how are people supposed to make informed decisions. Federal environment minister blocked me too!! Maybe I'm on the right track*!!";

Participant 69 "*Obviously not. I am not familiar with the details, but unhappy communities and individuals give plenty of evidence that they are not – or they are not enforced*.";

Participant 71 "*No. Existing regulations do not protect the environment or the health and welfare of people or livestock*."; and

Participant 73 "*No way are the existing control mechanisms sufficient. APPEA is a corrupt association full of 'revolving door' politicians. The Commonwealth and State laws and guidelines governing CSG fracking extraction are from a past era and do not even take into account the climate impacts of CSG and Australia's signature to the IPCC agreement*."

The word tree (Figure 5.49) appears consistent with the Group B responses

The responses of Group C the Australian government officials, to whether the existing control mechanisms for CSG extraction are sufficient? For example: Australian Petroleum Production and Exploration Association's 'best practice' approach; and the Commonwealth Government and State Government laws and guidelines governing CSG fracking based extraction are consistent with the following:

Participant 102 "*There is a lot of research which brings industry best practice approaches into question for such impactful practice. Because the community becomes the piggy in the middle and vested interests control the processes, the outcomes are usually substandard*. ";

Participant 103 "*Without looking into this I would say no as they may hold a biased view due to the revenue being made from this extraction*.";

Participant 138 "*NO. The CSG has a proven track record of water pollution. Section 100 of our Constitution guarantees farm and environmental water use. Poisoned water kills farms and the environment. Uphold the Constitution and close down this toxic industry*."

Participant 104 "*They may be adequate but doubt they get the resourcing to ensure compliance. Self-regulation in extractive industries will not work as $ motivates business not best practise*.";

Participant 114 "*This question is a worthy topic for an entire Ph.D. thesis. I am sceptical of most "industry best practice" approaches because they often involve least expensive approaches to achieve minimum compliance, rather than actually seeking best outcomes. The process of reforming CSG fracking projects to the Commonwealth as a part of the State EIA process is worthwhile in principle, but I don't see the Queensland government as genuinely having concern for the environment in CSG Considerations. Current EIA legislation allows the Coordinator General considerable leeway in reaching a "balanced" decision on compliance requirements for projects of State significance*."; and

Participant 138 "*NO. The CSG has a proven track record of water pollution. Section 100 of our Constitution guarantees farm and environmental water use. Poisoned water kills farms and the environment. Uphold the Constitution and close down this toxic industry*."

The word tree (Figure 5.50) appears consistent with the Group C responses.

The responses of Group D gas industry employees, to whether the existing control mechanisms for CSG extraction are sufficient? For example: Australian Petroleum Production and Exploration Association's 'best practice' approach; and the Commonwealth Government and State Government laws and guidelines governing CSG fracking based extraction are consistent with the following:

Participant 152 "*Evidently not. It must be noted that APPEA is an industry organisation who are remarkably pro CSG extraction. When opposition to CSG started to build APPEA very quickly developed an exceptionally well-funded campaign. APPEA members are oil and gas companies who will benefit from maximum extraction. Their best practice will always be the best practice that supports the goals of their members. Oil and gas companies must contribute to the establishment of best practices, but it is the role of government to set the benchmark, and raise standards as necessary, above that which the industry considers best practice if needed.*

Sometimes resources just need to be left unexploited, for the benefit of communities, and other industries. The governing of those resources should not be left to self-determination by oil and gas companies and self-regulation by industry bodies.";

Participant 153 "*The govt legislation provide sufficient protection for all parties. I have seen first-hand how the legislation protect both landholders and CSG companies*.";

Participant 155 "*Current 'best practice' may well be considered extremely negligent in the future. When you are working with an industrial process that has only been around for less than 50 years then the science behind it is not set. Furthermore, the understanding of the environment being impacted is also very new and again evolving as more is understood*.";

Participant 158 "*I think in my experience that Australia has some of the strictest rules and reg's around CSG and fracking in the world. I haven't heard of any incidents around contamination of ground / surface water (in QLD). (I'm not familiar with other states in QLD)*."; and

Participant 165 "*Yes. Based on best available science and engineering*."

The word tree (Figure 5.51) appears consistent with the Group D responses**.**

Group A and B responses to Question 12 are interpreted as potentially significantly negative and indicate the participants in Groups A and B perceived a lack of confidence in the sufficiency of the existing control mechanisms for CSG extraction:

Group A Participant 8 "*NO.* "*Best practice" "Robust". These terms no longer have ANY meaning as again and again the industry lets down people who put their trust in them. Insurance companies want no bar of properties in gasfields, so they become unsellable, and their values drop. HOW CAN this be good for Australia? Large swathes of once valuable real estate is being rendered worthless every day by this industry*."; and

Group A Participant 9 "*No, the mechanisms are failing daily, breaches occur daily, many breaches are not reported. Whistle blowers are treated as criminals. As time goes on governments realize how expensive funding the supervision of these so called "best practices" is, funding is always cut, and self-regulation is a joke. Many of the results of breaches do not become an issue until years after the extraction has finished. Then there is the problem that is* *never mentioned in reports done prior to implementing regulations – corruption. Corruption, bullying and untruths are a trademark of this industry*."

Group B Participant 51 "*No, definitely not. It's a self-regulated industry. The "best practice" approach is an illusion. Go and speak to those who are directly affected and do baseline testing*."; and

Group B Participant 73 "*No way are the existing control mechanisms sufficient. APPEA is a corrupt association full of 'revolving door' politicians. The Commonwealth and State laws and guidelines governing CSG fracking extraction are from a past era and do not even take into account the climate impacts of CSG and Australia's signature to the IPCC agreement*."

The word trees of Figures 5.48 and 5.49 appear consistent with the Group A and B responses to Question 12.

Of Group C, the Australian government officials only Participant 101 responded that their perception of the existing CSG extraction control mechanisms are sufficient. The majority of participants appeared to respond with perceptions that are significantly negative. Similar to Groups A and B perceptions this would suggest indications of a lack of confidence in the existing CSG extraction control mechanisms sufficiency.

Group C Participant 114 "*This question is a worthy topic for an entire Ph.D. thesis. I am sceptical of most "industry best practice" approaches because they often involve least expensive approaches to achieve minimum compliance, rather than actually seeking best outcomes. The process of reforming CSG fracking projects to the Commonwealth as a part of the State EIA process is worthwhile in principle, but I don't see the Queensland government as genuinely having concern for the environment in CSG Considerations. Current EIA legislation allows the Coordinator General considerable leeway in reaching a "balanced" decision on compliance requirements for projects of State significance*."; and

Group C Participant 138 "*NO. The CSG has a proven track record of water pollution. Section 100 of our Constitution guarantees farm and environmental water use. Poisoned water kills farms and the environment. Uphold the Constitution and close down this toxic industry*.

The word tree of Figure 5.50 appears consistent with the Group C responses to Question 12.

Group D gas industry employee's responses to Question 12 indicate a perception that is polarised. An apparent positive attitude may be interpreted towards the existing CSG extraction control mechanisms sufficiency:

Group D Participant 153 "*The govt legislation provide sufficient protection for all parties. I have seen first-hand how the legislation protect both landholders and CSG companies*."; and

Group D Participant 158 "*I think in my experience that Australia has some of the strictest rules and reg's around CSG and fracking in the world. I haven't heard of any incidents around contamination of ground / surface water (in QLD). (I'm not familiar with other states in QLD)*."

The word tree of Figure 5.51 appears consistent with the Group D responses to Question 12. Group D is appearing polarised, suggesting an interpreted positive opinion of the sufficiency of the existing CSG extraction control mechanisms compared to Groups A, B, and C on its interpreted responses to Question 12.

The word tree (Figure 5.52) appears consistent with the Groups A, B, C and D responses.

5.14 Question 13 If changes to CSG extraction are required, what do you believe should be done, and by whom to protect water systems?

The Group A community group member's responses to Question 13 which follow are representative of their answers:

Participant 6 "*Should be banned. Government legislation to prohibit it*.";

Participant 8 "*BAN IT. All states, all governments*.";

Participant 9 "*CSG extraction, "unconventional" gas extraction is an industry that uses methods that are relying on "perfect" models for their system to work without damaging water systems – in the real world this does not exist! The inherent risk associated have no place near water source and should be banned as they are in most countries*."

Participant 34 "*The industry should not be allowed to have unlimited use of water. Evaporation ponds are a problem. Dilution is a solution – or so the industry thinks*."; and

Participant 42 "*Government should completely ban onshore gas extraction in all forms, this is the only way to protect our water systems*.

The word tree of Figure 5.53 appears consistent with the Group A responses to Question 13.

The Group B community individual participant's responses to Question 13 which follow are representative of their answers:

Participant 51 "*It needs to be stopped. You can't un-poison the aquifers and this is a point that is unquestionably vital*.";

Participant 54 "*Just don't have this industry at all in Australia. Especially near rivers (do we want more like the Condamine – on fire!!), especially on top of aquifers. Drilling through aquifers is crazy. We need that water to grow food now and in the future*.";

Participant 56 "*CSG should be banned. No if buts or maybes until they can 99.9% guarantee that there will be no negative impacts on water, soil, the environment or animal and people living in the environment to be mined*.";

Participant 70 "*I believe a full ban should be imposed on any new submissions, and that the respective state and Federal government agencies should have oversight of protection*."; and

Participant 77 "*CSG extraction should be banned in this country. The Federal and State Governments have a duty of care to future generations*."

The word tree of Figure 5.54 appears consistent with the Group B responses to Question 13.

The Group C Australian government official's responses to Question 13 which follow are representative of their answers:

Participant 101 "*When govt make a decision to allow for the development of a CSG industry in say the WC's in the Surat basin they are indirectly changing the status of the WCM's from a water resource to a hydrocarbon resource. So difficult to protect water systems in total*.";

Participant 102 "*The science and EIS process should be much more clearly organised and made available to the community and stakeholder groups right from the start so informed* *decisions can be made. The current approaches are not transparent and do not help understanding of the risks and / or benefits*.";

Participant 110 "*Government regulation on approach; based on best international science. Industry mandatory adoption. Government compliance and enforcement. Extraction license revoked for major and repeat breaches. Current compliance is too weak*.";

Participant 114 "*There is a pressing need to adopt a system-based approach to water systems which includes ecosystems understanding of interlinked processes, and the risks and likelihood of unforeseen outcomes. Ecosystem thinking needs to consider multiple spatial and temporal scales and these scales cannot be effectively addressed within the current EIA timeframes. Much more rigorous post construction monitoring is required to ensure industry monitoring actually foods (sic) into accumulated systems knowledge*."; and

Participant 138 "*The Federal Government needs to uphold Section 100 of our Constitution and close down this industry and make it fully responsible for all remediation expenses*."

The word tree of Figure 5.55 appears consistent with the Group C responses to Question 13.

The Group D gas industry employee's responses to Question 13 which follow are representative of their answers:

Participant 151 "*Extraction should be controlled at a "whole of industry" level. The CSG industry must be responsible for CSG impacts. The QLD and Australian governments must continue to regulate activities*.";

Participant 152 "*Water resources have been a political football for too long. It is the Commonwealth Government's job to protect water resources now and for future generations. The Commonwealth Government must commit to the protection of water resources through robust long term. Whole of resource, strategic pans that are based on scientific, rather than political criteria. The same can be said for fossil fuels, energy, and the environment. The political alignment of major parties as either climate change believers or climate change sceptics borders on ridiculous. The influence, of the extreme factions in pushing their agenda is unfathomable. The resourcing of government departments is subject to the same political influences, with resourcing waxing and waning based on the whims of whoever is in power.*

Long term strategy needs long term commitment to government department resourcing (not just numbers but also technical competence) and the establishment of truly independent arbiters. The quality people are more likely to end up employed by industry or an industry organisation, than a government department able to regulate the industry. The high-level strategy needs to be sorted out first. Then regulation of the industry can occur in line with the overarching strategy. Unfortunately, the factional fighting with our governments, the three / four-year political cycle, and the need for current popularity and votes in the short term, all mean that this is unlikely to happen (making the future unfortunately persistently uncertain for the industry, farmers, and other water users).";

Participant 155 "*As alluded to throughout these responses, addition resources being made available to: regulatory assessment, compliance and enforcement would be a good start. I consider the regulatory framework robust but its application to large and economically "important" projects is lacking*.";

Participant 158 "*Environmental monitoring of surface water / ground water in CSG areas. Monitoring by government project Environmental Advisors. External auditing of CSG activities to ensure compliance*."; and

Participant 171 "*A clearer and more concise reporting of potential / actual environmental effects, and easier access to guidelines, codes of practice, etc for the community. Local and state environmental bodies should be responsible for protecting water systems, not individual companies*."

The word tree of Figure 5.56 appears consistent with the Group D responses to Question 13.

Groups A and B have an interpreted 'consensus of opinion' in their responses to Question 13: Ban CSG fracking to protect water systems.

Group A:

Group A Participant 8 "*BAN IT. All states, all governments*."; and

Group A Participant 9 "*CSG extraction, "unconventional" gas extraction is an industry that uses methods that are relying on "perfect" models for their system to work without* *damaging water systems – in the real world this does not exist! The inherent risk associated have no place near water source and should be banned as they are in most countries*."

Group B:

Group B Participant 56 "*CSG should be banned. No if buts or maybes until they can 99.9% guarantee that there will be no negative impacts on water, soil, the environment or animal and people living in the environment to be mined*."; and

Group B Participant 70 "*I believe a full ban should be imposed on any new submissions, and that the respective state and Federal government agencies should have oversight of protection*.

Group C participant responses to Question 13 are interpreted as being perceived as being focused on mitigation through existing government regulation and the enforcement of laws and guidelines to protect water systems:

Group C Participant 110 "*Government regulation on approach; based on best international science. Industry mandatory adoption. Government compliance and enforcement. Extraction license revoked for major and repeat breaches. Current compliance is too weak*."; and

Group C Participant 114 "*There is a pressing need to adopt a system-based approach to water systems which includes ecosystems understanding of interlinked processes, and the risks and likelihood of unforeseen outcomes. Ecosystem thinking needs to consider multiple spatial and temporal scales and these scales cannot be effectively addressed within the current EIA timeframes. Much more rigorous post construction monitoring is required to ensure industry monitoring actually foods (sic) into accumulated systems knowledge*."

Group D gas industry employee's responses to Question 13 are similar to the Australian Government official's Group C responses. Their perceived concern is on the mitigation of CSG extraction impacts to protect water systems through the adhering to of existing government laws and guidelines. In particular, the monitoring and enforcement of existing laws and guidelines:

Group D Participant 155 "*As alluded to throughout these responses, addition resources being made available to: regulatory assessment, compliance and enforcement would be a good* *start. I consider the regulatory framework robust but its application to large and economically "important" projects is lacking*."; and

Group D Participant 158 "*Environmental monitoring of surface water / ground water in CSG areas. Monitoring by government project Environmental Advisors. External auditing of CSG activities to ensure compliance*."

The word tree (Figure 5.57) appears consistent with the Groups A, B, C and D responses

5.15 Question 14 Is there any further information, or comment you would like to provide?

The Group A responses provided are representative of Question 14 answers:

Participant 6 "*Water is our most valuable asset. Long term protection is vital to maintain food production, over short-term cash grab for resource dollars*.";

Participant 9 "*I have been looking at reports from various financial analysts regarding the fracking industry and they all come to the same conclusion. The industry is unviable. Many of the companies in the US where the gas is running out are involved now in drilling masses of unproductive wells to give their shareholders the impression of profitability ala Ponzi Schemes. This industry has a history of unscrupulous practices, psychologically bullying and covering up environmental and health disasters. It should have been banned world-wide years ago*."; Participant 29 "*The government has been too easily influenced by the CSG companies and not taken its responsibility for water, environment, flora, fauna, at all seriously*.";

Participant 30 "*I add that many universities have been contaminated, infected, compromised by huge donations for research which have to produce the desired outcome or donations cease. I hope your university is not one of these*.";

Participant 34 "*I have supported residents at Lara / Kogan gasfields for 8 years. I raised money for health tests and 17 tests came back positive to CSG chemicals in the urine*." and

Participant 42 "*Too much damage has already been recorded. There are better alternatives to energy production and gas is one of the worse pollutions, even worse than coal, when you account for fugitive emissions*."

The word tree of Figure 5.58 appears consistent with the Group A responses to Question 14.

The Group B responses provided are representative of Question 14 answers:

Participant 51 "*There are no jobs on a dead planet. There are massive jobs that will be long term in the renewable sector. Water is life. Coal Seam Gas is not the answer*.";

Participant 54 "*My friend's child has tested positive for heavy metals in her blood, and experiences unexplained bleeding noses. The gas industry and government ignore the evidence as it would affect their bottom line. The official response – we tested in 2011, 2013. Well, it's 2019!! This kid should be front and centre of their focus!! My other friend has gas in a bore that was drilled to 'make good'. They can't 'make good' all they can do is destroy our most precious resource – underground water. Indigenous friends have told me there's no fish where they've always has been, and fish have funny red eyes!!*";

Participant 56 "*I have seen impacts on the land from water extraction, suffered health problems. I asked industry and government for a written guarantee that CSG would not impact our health or environment, we were paid to relocate rather than rather than industry or government write a letter of guarantee. In my opinion. CSG is not and cannot be done safely anywhere with corruption or lies*.";

Participant 72 "*What is happening in the Queensland Gasfields is a breach of basic human rights. Any emphasis regarding the industry is ONLY from the POINT of VIEW of the INDUSTRY. There is NO consideration given to the humans who have a massive heavy industry plonked on top of them, their families, farms and businesses*."; and

Participant 73 "*This toxic, ecological industry goes ahead over the dead bodies of Australian farmers. We have children. We want a future for our children*." The word tree of Figure 5.59 appears consistent with the Group B responses to Question 14.

The Group C responses provided are representative of Question 14 answers:

Participant 101 "*The Elephant in the room Which No One is Addressing in the Accumulation of 100,000 Tons of Salt (Ex Water Treatment) and No Salt Management Strategy in Place and every Year More and More Salt Sitting in the Landscape Waiting for an environmental disaster to happen.!!!*";

Participant 102 "*Fracking is very emotive, and our groundwater resources poorly understood. It is the perfect storm for poor decision making*.";

Participant 110 "*CSG is an industry based around getting a select group of companies very wealthy with little (none?) flow on to the rest of Australia and no consideration of the environmental harm that it does*."

Participant 114 "*There is a confusion within industry, the community, and parts of Government that equates EIA processes with scientific best practice and rigour. This CAN be the case, but typically the two are poles apart. The QLD govt places too much emphasis on EIA processes that it can control to achieve economic and social outcomes, with less emphasis on the environmental protection outcomes*." and

Participant 138 "*We need to replace this toxic industry with renewable energy generators and storage to provide cheap energy for our communities and supplementary income for farmers struggling to survive droughts and climate disasters*."

The word tree of Figure 5.60 appears consistent with the Group C responses to Question 14.

The Group D responses provided are representative of Question 14 answers:

Participant 151 "*There should be greater information shared with the community about fracking*.";

Participant 155 "*An idealistic me would say apply the "precautionary principal" but I understand "progress" needs to be made. A moratorium similar to that applied to shale oil could be appropriate for fracking in areas located in areas highly dependent on g/water ecosystems (both for the environment and agriculture).*";

Participant 156 "*I believe CSG can be extracted without impacting water systems but doubt it would be in the current regulatory environment. The risk of non-compliance against the financial benefit is too attractive for resource operations*."; and

Participant 170 "*No, other than to say CSG should be able to be part of our energy delivery system, so long as infrastructure is installed and maintained correctly, and it ensured that overlying and underlying aquifers and / GDEs are not impacted*."

Only four (4) Group D participants Responded.

The word tree of Figure 5.61 appears consistent with the Group D responses to Question 14.

Group A and B's further information responses were interpreted as focussing on perceived negative CSG fracking based extraction impacts:

Group A Participant 6 "*Water is our most valuable asset. Long term protection is vital to maintain food production, over short-term cash grab for resource dollars*."; and

Group A Participant 34 "*I have supported residents at Lara / Kogan gasfields for 8 years. I raised money for health tests and 17 tests came back positive to CSG chemicals in the urine*."

Group B:

Group B Participant 54 "*My friend's child has tested positive for heavy metals in her blood, and experiences unexplained bleeding noses. The gas industry and government ignore the evidence as it would affect their bottom line. The official response – we tested in 2011, 2013. Well, it's 2019!! This kid should be front and centre of their focus!! My other friend has gas in a bore that was drilled to 'make good'. They can't 'make good' all they can do is destroy our most precious resource – underground water. Indigenous friends have told me there's no fish where they've always has been, and fish have funny red eyes!!*"; and

Group B Participant 72 "*What is happening in the Queensland Gasfields is a breach of basic human rights. Any emphasis regarding the industry is ONLY from the POINT of VIEW of the INDUSTRY. There is NO consideration given to the humans who have a massive heavy industry plonked on top of them, their families, farms and businesses*."

The Group C further response were varied. Some suggested there should be more shared information on CSG extraction. Others focussed on government laws and guidelines and their possible implications. Others on perceived negative CSG activity impacts:

Group C Participant 102 "*Fracking is very emotive, and our groundwater resources poorly understood. It is the perfect storm for poor decision making*."; and

Group C Participant 114 "*There is a confusion within industry, the community, and parts of Government that equates EIA processes with scientific best practice and rigour. This CAN be the case, but typically the two are poles apart. The QLD govt places too much emphasis* *on EIA processes that it can control to achieve economic and social outcomes, with less emphasis on the environmental protection outcomes*."

Group D provided limited further information. The information that was provided however is insightful and was interpreted as not polarised:

Group D Participant 155 "*An idealistic me would say apply the "precautionary principal" but I understand "progress" needs to be made. A moratorium similar to that applied to shale oil could be appropriate for fracking in areas located in areas highly dependent on g/water ecosystems (both for the environment and agriculture).*"; and

Group D Participant 156 "*I believe CSG can be extracted without impacting water systems but doubt it would be in the current regulatory environment. The risk of non-compliance against the financial benefit is too attractive for resource operations*."

The responses of groups A, B, C and D were often interpreted as commonly aligned expressing common frequent responses for perceived impacts of CSG fracking based extraction, and common frequent responses over the perceived effectiveness of existing CSG extraction control mechanisms (there is only a limited response from Group D). The responses were not interpreted as reflecting any polarisation of opinion.

The word tree (Figure 5.62) appears consistent with the Groups A, B, C and D responses to Question 14.

The following Figures 5.63, 5.64, 5.65 and 5.66 are individual word frequency-based word clouds for Group A, B, C and D and the word cloud Figure 5.67 which is representative of all participant groups combined. The word clouds feature the 50 most frequently used words by each group and the sum total of all groups. The larger, central and prominent words are those which each group have used most frequently, illustrated pictorially. The words which each group(s) are perceived to regard to be most important and frequent to that stakeholder group.

Group A community individual participants have 'fracking' as their central word. Group B community individuals, Group C Australian government officials and Group D gas industry employees have 'CSG', as did Groups A, B, C and D.

Figure 5.62 (appendix 10) the word cloud appears to highlight Group A's perceived focus on fracking, community change, CSG and current media information as their primary perceived concerns in the anonymous survey's questions.

Figure 6.4 (appendix 10) the word cloud illustrates the concerns of Group B of perceived CSG impacts altering, community conditions, media reports and fracking as their most important perceived CSG issues.

Figure 5.65 (appendix 10) word cloud appears to demonstrate Group C's perceived CSG fracking and community impacts, CSG legislative acts and community changes. Also focusing to a lesser degree on perceived groundwater, the environment, regional and community benefits and needs.

Figure 5.66 (appendix 10) word cloud appears to suggest Group D's concerns of perceived CSG impacts, activities and fracking, resources, community, properties, environmental, government, individual, information and work changes and systems (water).

Figure 6.7 (appendix 10) word cloud appears to illustrate the concerns of all groups. Suggesting perceived CSG fracking impacts, media reports and CSG activities and changes. To a lesser degree perceived government acts, community conditions, meetings, environmental. Systems (water).

5.16 Conclusion

Chapter 5 has comprehensively studied the CSG anonymous questionnaire participants representative responses and discussed the findings of the four interest groups involved using an epistemological approach of interpretive, qualitative text content study focusing on the participant's perceptions, knowledge and firsthand experience : Group A, the community group members; Group B, the community group individuals; Group C, the Australian government officials; and Group D, the gas industry employees. The findings of the anonymous questionnaire have been discussed and compared question by question interpreting each group's participant's perceptions and views using representative answers to reflect the perceptions and views, with comparisons of the ten participants in each of the four groups (40 participants in total), chosen to provide an impartial representative overview of how CSG fracking extraction is perceived and what potential and perceived impacts CSG fracking extraction may have. The limitations of using small representative groups have been challenging due to the research constraints discussed in chapters 3 and 4. Nonetheless, relevant research providing new and supportive data has been achieved.

The computer tool NVivo 12 designed for text content study, has been used to provide 'popular' generalised visual qualitative representations of the dataset in the form of word trees and word clouds for all fourteen survey questions and all four participant groups. This has been found to be, unfortunately, of only limited research value despite months of extensive and intensive application. See appendix 10.

In summary, in the anonymous participant survey, the interpretation of the perceived benefits of the CSG industry and its activities are less prevalent than the interpreted perceived negative impacts of the CSG industry and its activities impacts are, for the majority of survey participants, including their families, communities and others affected where stated.

It also appears that the perceived polarisation of opinion with respect to the groups was only prevalent with regard to Groups A, B and C, and Group D, the CSG industry employees regarding their perceived extent of government intervention, enforcement and legislation (Survey Question 12 and in Question 13 in the next paragraph). Groups A, B, and C most often providing answers interpreted as supporting more enforcement of legislative powers and intervention. And Group D, interpreted as suggesting there was sufficient, or too much government legislation and intervention regarding CSG industry activities.

Survey Question 13 also was interpreted as indicating perceived polarisation of opinion between Groups A and B with regards to their answers to necessary changes to CSG activities. Ban CSG activities, is frequently expressed. With the reasons given as perceived human and environmental (primarily water related) health related. Groups C and D were interpreted as more in favour of mitigation and legislation of ongoing CSG activities.

In conclusion, the CSG anonymous survey has provided many research responses, insights and informative data regarding: perceived CSG impacts on human and environmental health; perceived CSG activity transparency; views on CSG legislation and monitoring; polarisation of opinion concerning CSG and perceived CSG impacts; and perceived CSG issues relating to social licence, corporate social responsibility and social impact assessment (SIA) in general. Providing relevant research data to assist in addressing thesis research questions 1, 2 3 and 4 and the thesis aims 1, 2 3 and 4 to be discussed in chapter 7. The following chapter uses interpretive qualitative media content study, researching the last forty or so years of CSG activity by studying traditional media reports (international, national and local newspaper articles) concerning CSG extraction and the CSG industry, primarily in the Western Downs, Queensland, Australia.

CHAPTER 6: Factiva

6.1 Introduction

Chapters four and five explained the interpretive social scientific inquiry mixed methodology of the study and the responses and findings on the perceived possible CSG fracking based extraction impacts using an anonymous postal questionnaire and the computer tool NVivo for the text content study. This chapter is a traditional media overview using Factiva, a local, national and international, primarily newspaper, media computer search engine. Capable of macro media studies, but also a microscope capable of greatly detailed study focusing on any particular points, or specific newspaper articles of interest in the history of CSG and its fracking based extraction and its perceived possible impacts. The data used must rely on the absence of bias and the impartiality of the researcher and must also take into account any media bias in itself (Bernard, 2011, Creswell, 2013, Williamson, 2013, Creswell, 2017). In this chapter the interpretive social scientific inquiry mixed methodology has been employed to highlight the thesis questions 1, 2, 3 and 4 research questions, and the thesis aims 1, 2, 3 and 4 using the Factiva media content study, which provides a comprehensive, independent and non-selective way of viewing newspaper articles concerning CSG and its possible fracking based extraction impacts focusing on nine (9) research topics perceived as relevant to the thesis questions and thesis aims.

Extensive Factiva, traditional media analysis, consisting of some 357 pages of 1270 extracts and articles (derived from 3,000 pages focusing on Queensland and northern New South Wales, Australia) relating to CSG and its potential fracking based extraction impacts has been collated from the media content study with information on: CSG aka CBM (coal bed methane); and from the Queensland CSG industry located, respective artesian water basins, the Bowen, Surat and Moreton Clarence Basins, where CSG related information is located. The Factiva data period commenced from 1982, the first time a CSG/CBM article appears in the media, to December 31st, 2018. (Appendix 11 is a concise version of the comprehensive Thesis Annex Document). The CSG related issue extracts and articles can be revisited through Factiva at any time for further research on specific concerns and events. This chapter has highlighted

the findings to a manageable amount of perceived representative information concerning CSG, and its fracking based extraction related issues recorded and compiled during the thesis research period, from November 2015 to January 2019, focusing where possible, on the Western Downs, Queensland. This extensive traditional media data should additionally be found to be invaluable for post-doctoral research and expert witness purposes. The comprehensive data is found in the accompanying Thesis Annex Document.

6.1.1 Social Media Online Site Facebook

The Social media online site Facebook was initially chosen as the most coherent source of CSG social opinion and information over other social media sources. Facebook was found to be highly representative of the available social online site's alternatives, such as Twitter. Facebook was intensively studied as a source of social research analysis of CSG, and its possible fracking-based extraction until 31st December 2018. However, the bias, whether justified or not, was found to be almost totally anti-CSG on all critical and major issues. The implications of this bias, prevalent or not, made Facebook impossible to use in an impartial scientific, independent study. However, it did provide a 'pool of people' for the source of some of the survey participants as described in chapter four.

6.1.2 Traditional Media Major Issues:

- The economic growth and development of the Queensland CSG industry;
- 'Pros' of CSG extraction. Rural community infrastructure, local business generation and income, employment, gas industry CSG community and school educational programmes and roads. Possible short term and long term national and local socioeconomic gains and tax revenue;
- 'Cons' of CSG extraction. Possible negative water quality and quantity potential changes. Boom to bust towns and unemployment. Real estate crashes. Possible health issues: rashes, asthma, chronic nose bleeds, depression, and suicide. Possible related loss of 'many generation' rural communities and the community's adhesive cultural values and well-being. Police, community individual arrests, protests, and the establishment, at its peak between 2011-2016 of over 250 CSG extraction concerned community groups. Possible loss of environmental quality and biodiversity; biosecurity; and the loss of economic opportunity through poor water and land usage choices;
- The various government body's challenges with CSG issues; their legislation, regulation, control and political conflict over the economic and social management of a 200 billion-dollar (2015) industry; and

- The evolution of antagonistic, opposing, descriptive, individual and community group, and CSG company stakeholder labelling names. From community individual / concerned citizen, in early 2000s to anti-CSG activists, ‘greenwash spouting’, ‘leftist’ eco-terrorists, anarchists and economy destroying lunatics. And the pro-CSG labelling of careless (“*bought another farm in a CSG free area*”), economically greedy, money orientated, selfish people, and multi-million- and billion-dollar companies with ‘shareholder vested interests’, “*who do not think or care about human health or the environment*”. This means of social stigma is a small, but representative part of the polarisation phenomenon which is apparent when history is studied comprehensively through Factiva

It helps provide indicative answers to explain this thesis’s questions 1, and 4 objectives 2, and 3 in the study of this body of traditional media information as research data that is related to CSG, and its perceived possible fracking-based extraction impacts.

6.2 Brief summary of the Factiva Media Content Study

Please see Appendix 11 for a Concise Factiva Media Content Study and the full research document – Thesis Annex Document.

Commencing in **1982** with the media article: ‘Dow Jones News Service -Ticker, 8th October 1982. NY -DJ- Basic Resources Corp Said Its Wholly Owned Subsidiary Basco Energy Inc Has Agreed to Join Three Australian Companies in an Oil and Gas Exploration and Development Program. Work Will Proceed Under Petroleum Exploration License…’ Australia’s serious investment in CSG began, though coal gas had been extracted and used commercially since the late 1800 (see chapter 2). The Surat Basin, Western Downs, Queensland, Australia is one of the earliest commercial CSG extraction points at Chinchilla in 1995. Over $150 million was spent on exploration and research by 1992.

The first perceived CSG impact media article was reported: 22nd October **2004**, Daily Telegraph article ‘*Local fury over gas mining plan*’ regarding CSG/CBM with a call to investigate the ‘likely impact’ reported by the media. Hundreds of residents were expected to protest against CSG extraction in Dooralong and Yarralong valleys. Before this the 60 articles published focused on investment, exploration and production of CSG in an economically positive manner. And:

Mondaq Business Briefing. 5th October 2007.'Coal Seam Gas and Associated Water Production – An Environmental Perspective' Reports suggest that the life of CSG production is 15 to 20 years…the Environmental Protection Agency (EPA) has draft operational policy…does not have the force of law. Associated water is regarded as regulated waste.

2004-2007 36 more CSG economic and exploration and production-based media articles

In **2008**, 86 media reports. The majority economic and production based.

The Chronicle (Toowoomba) 22nd August 2008, '*Concerns raised over CSG Dams*', grazier Lee McNicoll at Dulacca and Wallambilla 'is taking up the fight' against "the propaganda machine…

The Chronicle (Toowoomba), 22nd August 2008.*'Owners anxious over salt management'.* Wayne Newton will be the lone representative for landholders speaking at this week's Surat Basin Energy Conference-speaking on behalf of AgForce and a group of landholders (including himself) with properties affected by exploration leases…

Dalby Herald, 23rd September 2008.*'Water debate simmers on'*. 5 CSG related media data entries noted concerns regarding CSG associated/co-produced water and water systems in 2008. CSH water evapouration Ponds to be phased out in the Western Downs, Dalby Herald, 4th November 2008.

2009 had 33 CSG economic and production-based media reports.

2010. The release of the 'Gaslands' movie on CSG impacts in the USA and political activity in a government election year in 2010 may have contributed to the increase to 145 CSG reported media articles and a higher increase in general of CSG activities both economic and relating to production. The majority were economic and CSG production based.

The Observer (Gladstone), 25th August **2010**. '*Government playing catch-up on coal seam gas*' The Queensland Government is continually scrambling out new legislation on coal seam gas (CSG) extraction in what's been termed a game of "catch-up"

The Chronicle (Toowoomba), 27th August 2010.*'Group questions CSG mining claims'*. Group questions CSG mining claims ACTIVIST groups in the battle to get more information about coal seam gas mining on the Downs have been stung by statements in the Rural Weekly last week by Matthew Paull of the Australian Petroleum Production and Exploration Association (APPEA)…APPEA representative claims no connectivity between coal seams and water aquifers and CSG mining activity was safe. Group member response "How can an industry be proud of the fact that the Co-ordinator General found 1200 problems in two companies EISs?"

The Chronicle, 3rd September 2010. '*CSG puts aquifer at risk*' CSG puts aquifer at risk A STUDY has found Queensland's largest freshwater aquifer is at serious risk of being drained as a result of coal seam gas extraction…Call for moratorium on CSG development in the area by The Central Downs Irrigators.

The Australian, 3rd September 2010.*'Coal gas industry slams Greens* --- *ELECTION 2010'*. Lobbyists say the party defies its own principles in trying to impose restraints.

Australian Government News, 5th October 2010.*'Ban Petroleum Compounds Containing Benzene, Toluene, Ethylbenzene and Xylenes'*. Brisbane, Qld., Oct 5 – The Honourable Stephen Robertson, Minister for Natural Resources, Mines and Energy and Minister for Trade issued the following Statement: *The Ban of CSG Fracking Chemical use of the Carcinogenic BTEX Group*.

Australian Broadcasting Corporation (ABC) News, 25th November 2010.*'Coal seam gas moratorium motion defeated'*. Both parties have rejected Queensland independent MP Aidan McLindon's motion to impose a moratorium on new coal seam gas (CSG) projects.

Australian Associated Press General News, 26th November 2010.*'QLD: Miner's access laws in Qld 'draconian''*. CSG By Steve Gray BRISBANE, Nov 26 AAP – Laws allowing miners to enter properties in Queensland are "incredibly draconian" and ignored the rights of landholders, the Queensland Council for Civil Liberties (QCCL) says.

254 CSG media reports in **2011**, making it a peak year in media reporting of CSG articles. The majority were CSG economic and production media reports.

Queensland Country Life 24th February 2011, '*Simmering tensions between landholders*', mining companies and the State government have reignited after ABC Television's four Corners program showed shocking images of coal seam gas (CSG) mining.

Australian Associated Press General News, 7th March 2011, *'QLD: Qld protestors rally against coal seam gas*'. Coal seam gas (CSG) mining constitutes one of the biggest land grabs in Australian history, a Brisbane rally has been told.

The Observer (Gladstone), 7th March 2011, *'Tara Estates protestors are taking gas fight to Parliament'*. Brisbane: Michael Bretherick says he moved to Tara Estates for peace and tranquillity, a good place for those of modest means to raise a family, but now finds it threatened by coal seam gas (CSG) exploration.

Also: CSG Fear for organic Farmers; Queensland Landholders get Training for CSG Negotiation, Tara, Western Downs Resident Bullied and Locked Off His Own Land; 70-year-old Great-Grandmother; Santos Spending $10,000 a Minute on Massive CSG Operation; CSG Carcinogens Found in Arrow Gas Field Bores; CSG Irrigation Water; and 3 million tonnes of salt – 10 Metres High and 11 Kilometres Long.

2012 132 CSG media reported articles in a Queensland Government election year. The majority are CSG economic and production media reports.

The Chronicle (Toowoomba), 27th January 2012. '*Negotiating a fair conduct and compensation Agreement (CCA)*'. Landholders will have the chance to access independent information about their rights and responsibilities and how to negotiate a fair CCA when AgForce…

Daily Telegraph, 23rd February 2012, *'Santos CSG failure'*. Oil and gas giant Santos have admitted an "unacceptable culture" at its recently acquired Eastern Star coal seam gas operations that included "failures in reporting" spills at the company's operations in…

Also; Boom or Bust? Towns on the Downs; The Actions of 'Anti-CSG Vigilantes'-a New label from Metgasco; Good Times Hit Roma; New IESC Formed Too Late, New QWC – Only 2.5% of Private Bores Affected by CSG in the Surat Basin; 500 Water Bores Affected by CSG Drilling in Southern Queensland; a Few CSG Wells 700-1000 Metres Apart According to CSG Industry; CSG Exploration Wells Within 200 Metres of Dwellings; and Politicians Quits-Accusing Party of Stifling Debate on CSG Mining and Hiding its True Intentions.

2013 177 CSG media reports. The majority CSG economic and production.

Dalby Herald, 8th January 2013,*'Family blames CSG for hippuric acid finding'*. A Tara family has claimed coal seam gas activity is responsible for high levels of hippuric acid in their son. The Palmer family said the finding from a urine test of their three-year-old Jackson followed a string of medical…

Australian Broadcasting Corporation ABC) News, 11th February 2013,*'Claims former Qld government put pressure on gas approvals'*. An industry group has dismissed claims two of Queensland's largest resource projects were approved because of pressure by the former Bligh Labor government

Also: Economic Pressure on Anti-CSG, CSG; Buying Supporter; Commonsense Water Use, Govt Advice; CSG Well Fields Leaking; CSG and Bio-Security Issues; Elevated Gas Level Horrifying, Radon Emissions; Arrow Will Generate 264 Billion Litres of Water; IESC, CSG, Public Uncertain; Exploration began 1976, Production Began 1995, by 2012 Over 50,000 Abandoned or Decommissioned Bores/Wells; 40,000 CSG Wells; Anti-CSG now "Anarchists"; CSG Projects now 'One-Stop-Shop' for Approvals; 5,500 Sq/Km CSG Licences Held by $100 Company; Realisation of CSG Economic Benefits; and Polarised Dispute on CSG Splits Families and Communities

2014 132 CSG media reports. The majority are economic and production.

Australian Associated Press General News, 221st January 2014.*'FED: Arrow says all options on the table in QLD'*. ARROW By Kim Christian Perth, Jan 21 AAP – Arrow Energy says all options are on the table as it sheds jobs and cuts costs at its coal seam gas (CSG) project in central Queensland.

Australian Broadcasting Corporation (ABC) News, 5 February 2014.*'Greens see red over federal CSG taskforce'*. The Greens say the prospect of a federal Government taskforce to sort out community problems with the coal seam gas industry is an outrage. The office of Industry Minister Ian Macfarlane has confirmed the group is being put together.

The Sydney Morning Herald, 7th February 2014.*'CSG and oil giants revealed as major donors to Nationals'*. Donations to the National Party from coal seam gas companies have risen tenfold in four years, but the party is not required to disclose the majority of donations it receives from the gas industry under electoral funding laws.

Also, CSG: Too Early to Determine Risks in the Long Term – after 19 Years of Production, Santos; CSG Protestors put 15,000 Jobs at risk; Anti-CSG Label – Activists, Anarchists now Lunatics; CSG: Drought Stricken Farmers; CSG Pond Leaks; CSG: Aquifer Poisoned; Santos: Uranium and Arsenic 'Pollution Incident'; CSG Opponents 'Scaremongering'; EPA on CSG Leak, Origin Energy; and Asbestos in Fracking Fluid Scare

2015 Significant drop to 48 CSG media reports. The majority economic and production.

The Chronicle (Toowoomba), 8th January 2015. *'Doctor says CSG fields bad for kids.'* Brisbane GP Geralyn McCarron is urging families with young children or pregnant women not to but lifestyle blocks near Surat Basin coal seam fields.

ForeignAffairs.co.nz, 20th February 2015. *'Expert groundwater concerns show need to stop CSG expansion*'. MIL OSI – Source: Australian Green Party – Press Release/Statement: Headline: Expert groundwater concerns show need to stop Qld CSG expansion The leaked Independent Expert Scientific Committee report on the Santos Gladstone LNG expansion…

Courier Mail, 1st March 2015. *'Industry is our lifeblood'*. You can't blame the greenie protestors for the troubles that have suddenly - and dramatically - beset the state's coal seam gas industry. But the fact that world oil prices have slumped at exactly the same time as the planned end of the…

Also: The Big CSG Player: Royal Dutch Shell; Chinchilla A town of CSG Extremes; CSG Water Spill Miles, Santos Warned Again on CSG Transparency; CSIRO: Methane Research – Baseline for Thermogenic CH_4; Chinchilla: Field Day to Look at CSG Impacts; and CSG: Australia Probes Funding for Environmental Groups

2016 42 CSG media reports. Low reports in a Federal Government election year. The majority CSG economic and production.

Chinchilla News, 31st March 2016. *'Family takes QGC to Land Court'*. After nine years of fighting, the Nothdurfts are taking a CSG company to court IN HINDSIGHT, the kid's nosebleeds and headaches began around the same time as the gas infrastructure went in, Narelle Nothdurft said. It's a story she's told to…

The Chronicle (Toowoomba). 4th April 2016. *'CSG issue reaches UN'*. The impact of the CSG industry on the Western Downs was one of the focal points at the United Nations' Human Rights Council session earlier this month.

Balonne Beacon, 14th April 2016. *'Secret drilling chemical of CSG'*. 15 months on and drilling chemical still a mystery. What is fracking?

Also: Queensland Government Commits $7 Million to CSG Compliance Unit; Western Down's CSG Industry Expansion Legal Challenge; 22 billion Tonnes of Brine into Dawson River; Queensland CSG Industry a Great Success Story; Anti-CSG Lies and Propaganda Killing Australia's Economy; CSG: Wells Devalue Land; and Tara Woman Protests About Sickness.

2017 74 CSG media reports. A rise in CSG media reporting. Queensland Government election year. The majority CSG economic and Production.

The Chronicle, 14th January 2017. *'Dalby hit as 92 Jobs lost'*. Ozcon folds after CSG downturn DALBY has been hit hard after the loss of nearly 100 Jobs as a result of Ozcon Industries closing. The multi-million-dollar manufacturing company was officially placed into liquidation this week by directors…

Australian Broadcasting Corporation (ABC) News, 25th January 2017. *'CSG-rich land in Surat Basin set aside for Australian-only sales.'* A 58-square-kilometre parcel of coal seam gas-producing land in the Surat Basin is set aside exclusively for the Australian market by the Queensland Government.

Global Energy Research, 26th February 2017. *'Australia – Projects – Gas – Pipelines'*. The Bowen Pipeline proposed by Arrow Energy, located in central Queensland, has started the front-end engineering design (FEED) phase at the end of 2014. The buried Arrow Bowen Pipeline (ABP) will transport coal bed methane over 580 km…

Also: Queensland Groundwater Monitoring Grant; Arrow Boosts Gas in $500m Project, Arrow to build 180 Wells at Dalby; Anti-CSG Car Stickers; CSG Polarised Feud in the Western Downs – Farmer's Wellbeing; Why CSG Advocates and Activists Both Like CSIRO's New Report; Senex Energy Commences Western Surat Gas Project, CSG Unlimited Water Take Unsustainable.

2018 59 CSG media reports. The majority economic and production related.

ArabianBusiness.com, 9th January 2018. *'State Gas Bowen Basin Wells Flow as Further Drilling Planned*'. Similar reservoir pressure could indicate connectivity between wells. State Gas Ltd (ASX: GAS), has had gas flows from three of its wells situated in Queensland Bowen Basin.

Gold Coast Bulletin, 17th January 2018. *'Gas Industry refutes hospital claims.'* The gas industry has hit back at a report suggesting pollutants from Queensland's coal seam gas could explain an increase in hospital admissions, describing it as lacking credibility and pushing a political agenda.

Awareness Times, 31st January 2018. *'Second Round of Meetings for 27-Year Gas Project*'. Arrow Energy will begin a second round of community consultation over its multi-billion-dollar Surat Gas Project this week. The upcoming sessions will provide details on Arrow's recent announcement relating to its 27-year gas supply.

Also: CSG Impacts in Roma; UQ Holds Meeting to Dissect Social and Economic Changes in Dalby; CSG: Labor to Tighten Regulations to Protect Water; CSG: 3 Companies supply 95% of CSG; CSIRO Stirs Debate; and CSG - Average Water Levels Decline in Queensland.

A total of 1270 CSG media reported data entries were recorded, from over 2,493 CSG/CBM associated media articles, which relate to the Western Downs between 1982- 2018. Many of the traditional media articles contain pertinent reported information that overlaps multiple research question topics germane to the media content study research, However the vast majority are CSG economic, relating to CSG companies and the industry and their CSG exploration and production. See Figure 6.1 for a temporal overview of the yearly CSG media reporting.

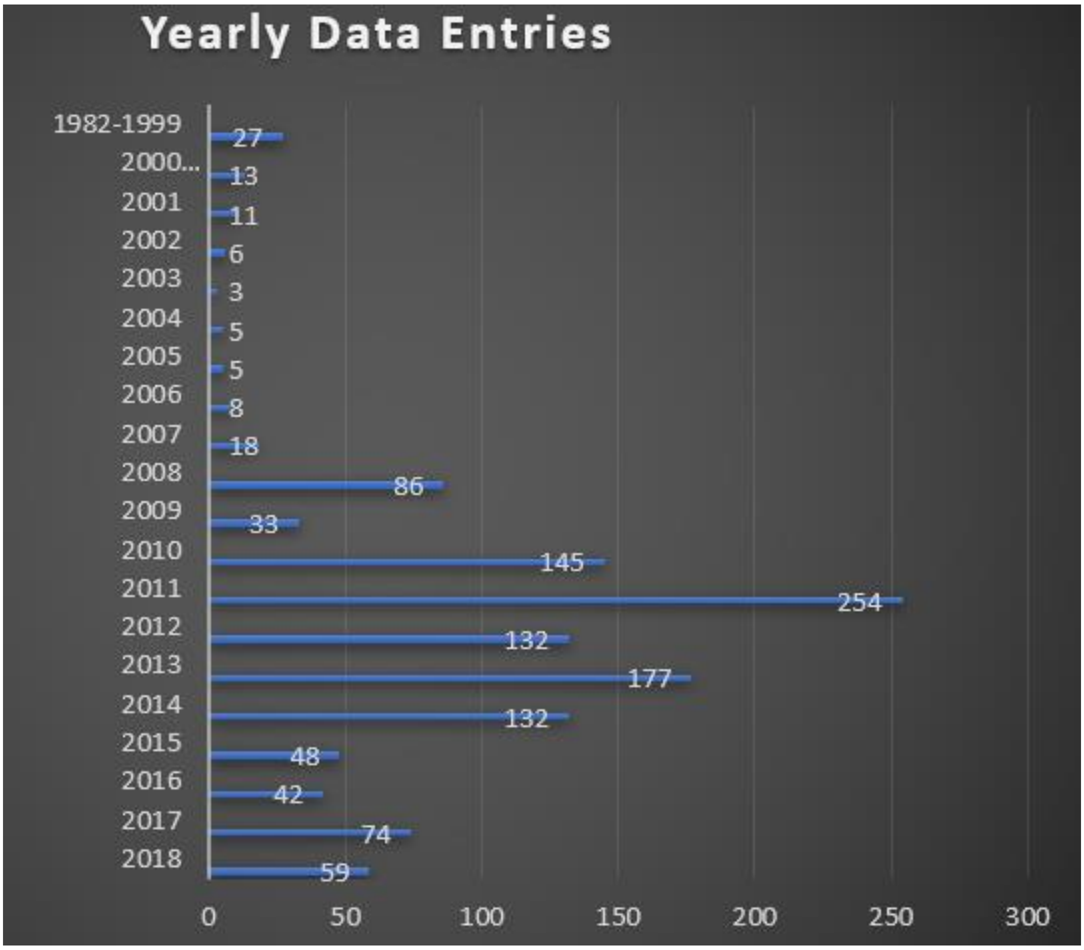

Fig.6.1 Yearly CSG Media Reports

6.3 NVivo Media Content Study

The computer tool NVivo 12 using word frequency has been used to focus on nine (9) topics selected for their relevance to the thesis aims 2 and 4 and research questions 1 and 4, which potentially indicate the perceived reasons for social conflict and the perceived polarisation of opinion in the community in the Western Downs, Queensland, perceived as caused by CSG activities and the perceived potential impacts on water systems interpreted as caused by perceived CSG activities reported by the media. The word frequency word clouds produced feature the 100 most frequently used words for each topic of four or more words to prevent the acronym CSG from dominating. The central and prominent words are those which are used most frequently and are qualitatively illustrated pictorially. A total of 1270 CSG related Factiva tradition media articles were recorded pertaining to the nine (9) topics:

1. The Media Reported Perceived Possible Economic Growth and Development of the CSG Industry;

2. The Media Reported Perceived Possible Social Benefits of the CSG Industry;
3. The Media Reported Perceived Potential Social Impacts of the CSG Industry;
4. The Media Reported Perceived Potential Human Health Benefits of the CSG Industry;
5. The Media Reported Perceived Potential Human Health Impacts of the CSG Industry;
6. The Media Reported Perceived Potential Environmental Benefits of the CSG Industry;
7. The Media Reported Perceived Potential Environmental Impacts of the CSG Industry;
8. The Media Reported Perceived Potential Water Benefits of the CSG Industry; and
9. The Media Reported Perceived Potential Water Impacts of the CSG Industry.

6.3.1 The Media Reported Perceived Possible Economic Growth and Development of the CSG Industry in the Western Downs, Queensland

The word cloud Figure 6.2 relates to 638 of 1270 of Factiva media reported article data entries that reported perceived possible economic growth and the development by the CSG industry in the Western Downs, Queensland. Primary news reported concerned: CSG exploration and mining, CSG volume predictions and production, in particular, fracking, fracking based extraction and fracking chemical use, industry ownership and changes, share price movements, CSG related pipelines, CSG infrastructure and roads, rural community demographic changes, social and business activities and increased political manoeuvring around election times associated with the CSG industry activities. Access to Landholders farms by CSG companies is still a perceived major bone of contention interpreted as alleviated to a degree by the signing of CCAs by landholders potentially benefiting from CSG industry activity. Pro and anti CSG supporters appear to develop from 2004 onwards in the perceived wake of the USA anti-CSG activity. Perceived labelling by the CSG industry of anti-CSG community groups is interpreted as becoming progressively more radical: from protestors and greenies to ‘activists’, ‘leftist eco-terrorists’ and later ‘environmental anarchists’. The anti-CSG groups are perceived as being blamed by CSG industry and some government bodies for perceived slowing and impeding of the perceived CSG industry growth and economic development. There is perceived community, government and CSG industry polarisation of opinion on potential impacts and potential benefits of CSG and conflict within CSG industry affected rural communities. By the end of the thesis research period December 2018, there appears to be a perceived ongoing need for community, government and CSG industry community debates/meetings to discuss perceived CSG industry potential benefits, potential negative impacts, and the potential compatibility/incompatibility of co-existence of farming and the CSG industry. Other issues include: the potential opportunity loss of water for farming;

and the unlimited availability of water for CSG industry activities, in particular, in times of drought. The depreciation of real estate value of housing and farm properties in CSG industry affected rural areas, particularly farm properties potentially degraded by exploration and production CSG wells, pads, and roads.

Figure 6.2: The Media Reported Perceived Possible Economic Growth and Development of the CSG Industry in the Western Downs, Queensland.

6.3.2 The Media Reported Perceived Possible Social Benefits of the CSG Industry in the Western Down, Queensland

Figure 6.3 relates to 101 of 1270 Factiva media reported article data entries on possible social benefits by the CSG industry in the Western Downs, Queensland. The possible social benefits principally concern employment, increases in town business profits and rentals, landholders benefiting from CSG Conduct and Compensation Agreements (CCAs), community infrastructure (*e.g.*, building community centres), CSG school education programs, and the building of CSG produced wastewater re-cycling plant for local water use.

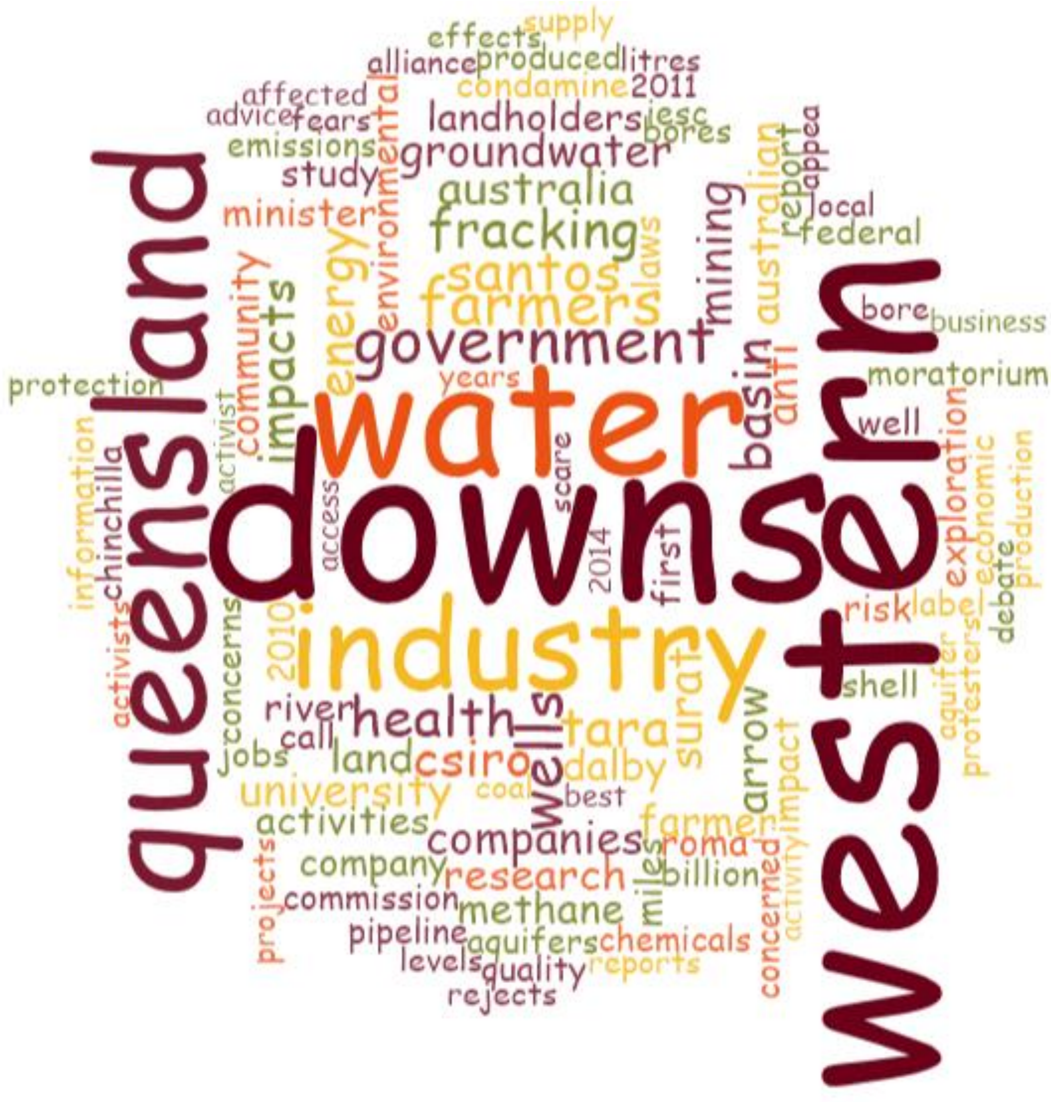

Figure 6.3: The Media Reported Perceived Possible Social Benefits of the CSG Industry in the Western Downs, Queensland

6.3.3 The Media Reported Perceived Potential Social Impacts of the CSG Industry in the Western Downs, Queensland

Figure 6.4 relates to 494 of 1270 of Factiva media reported article data entries concerning possible social impacts by the CSG industry at the Western Downs, Queensland.

References to: long term residents leaving affected areas; increases in crime and road accidents; itinerant workers; local boom-bust business; rental and employment impacts; increased traffic; resentment concerning landholders perceived as possibly benefiting from CCAs; concerned citizen anti-CSG activity (labelled 'activists', etc.); and the as many, possible saturation of CSG related community meetings, interviews, questionnaires from CSG industry, government bodies, university and community groups reported. Community groups of concerned citizens form in 2004, peaking in 2015-16 (2016 Federal election year). Arrests of protesting 'activists'. Polarisation of opinion and community conflict potentially concerning CSG.

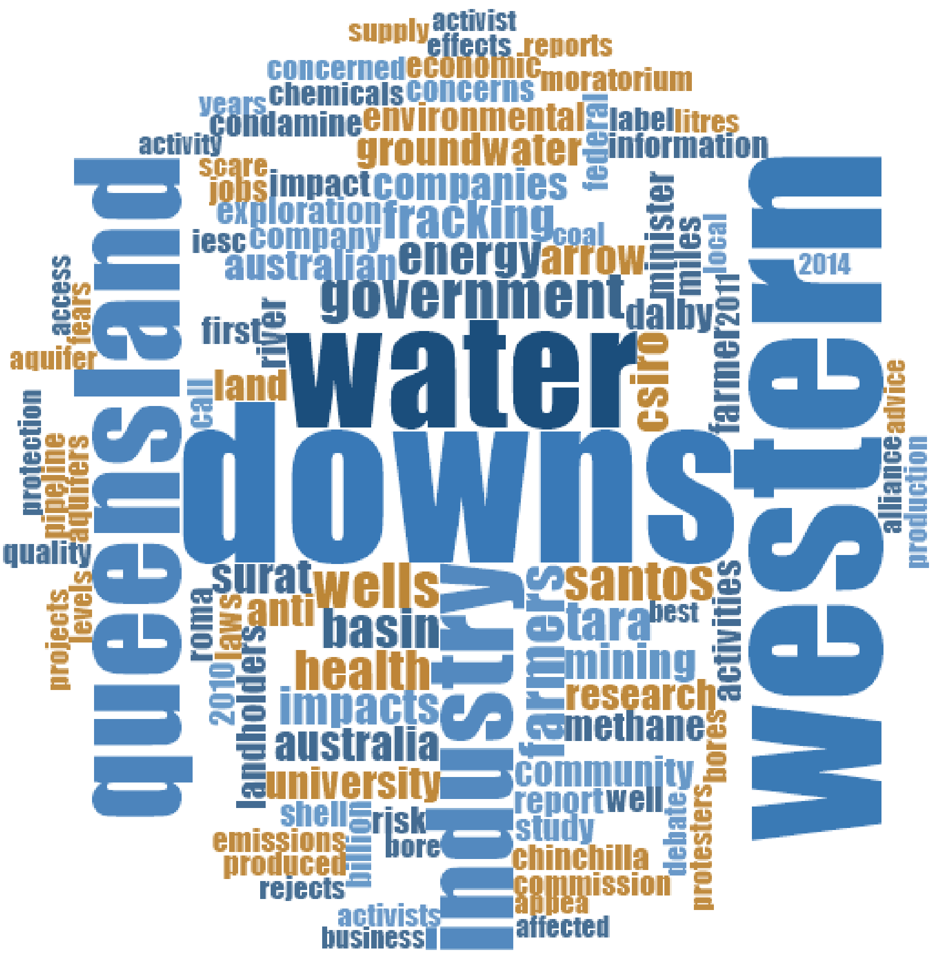

Figure 6.4: The Media Reported Perceived Potential Social Impacts of the CSG Industry in the Western Downs, Queensland

6.3.4 The Media Reported Perceived Potential Human Health Benefits of the CSG Industry in the Western Downs, Queensland

0 of 1270 of Factiva media reported article data entries concerning perceived possible human health benefits by the CSG industry activities in the Western Downs, Queensland. This may or may not be due to media bias.

6.3.5 The Media Reported Perceived Potential Human Health Impacts of the CSG Industry in the Western Downs, Queensland

Figure 6.5 relates to 399 of 1270 of Factiva media reported article data entries relating to potential human health impacts by the CSG industry in the Western Downs. Reported, unconfirmed, potential CSG: air; water pollution; and mental health (depression, stress, and suicide) related. And potential human health issues including: respiratory, headaches, bleeding noses, and sore eyes stress.

Figure 6.5: The Media Reported Perceived Potential Human Health Impacts of the CSG Industry in the Western Downs, Queensland

6.3.6 The Media Reported Perceived Potential Environmental Benefits of the CSG Industry in the Western Downs, Queensland

0 of 1270 of Factiva media reported article entries concerning potential environmental benefits by the CSG industry activities in the Western Downs, Queensland. This may or may not be due to media bias.

6.3.7 The Perceived Potential Environmental Impacts of the CSG Industry in the Western Downs, Queensland

Figure 6.6 relates to 383 of 1270 of Factiva media reported article entries concerning potential environmental impacts by the CSG industry at the Western Downs. Reported, confirmed and unconfirmed potential: air; water pollution; land and native vegetation clearing from CSG industry related activities. CSG fracking extraction perceived as potentially causing: aquifer interference; soil contamination; and potentially unsafe and contaminating disposal of massive quantities of CSG produced water solid toxic waste. Potential de-watering of CSG wells taking from months to years to potentially return. The potential use of large, unlimited amounts of water in hydraulic fracking. Reported: potential falls in groundwater levels; bore water quality and quantity; legal and illegal dumping of CSG water onto land and into water systems; potential leaking of evapouration ponds; and potential CSG industry gas release 'flaring'. Also, potential National Forest, farmland degradation and habitat loss. Further, potential atmospheric methane and other CSG activity related gases, and potential pollution, disruption, and destruction of water dependent ecosystems.

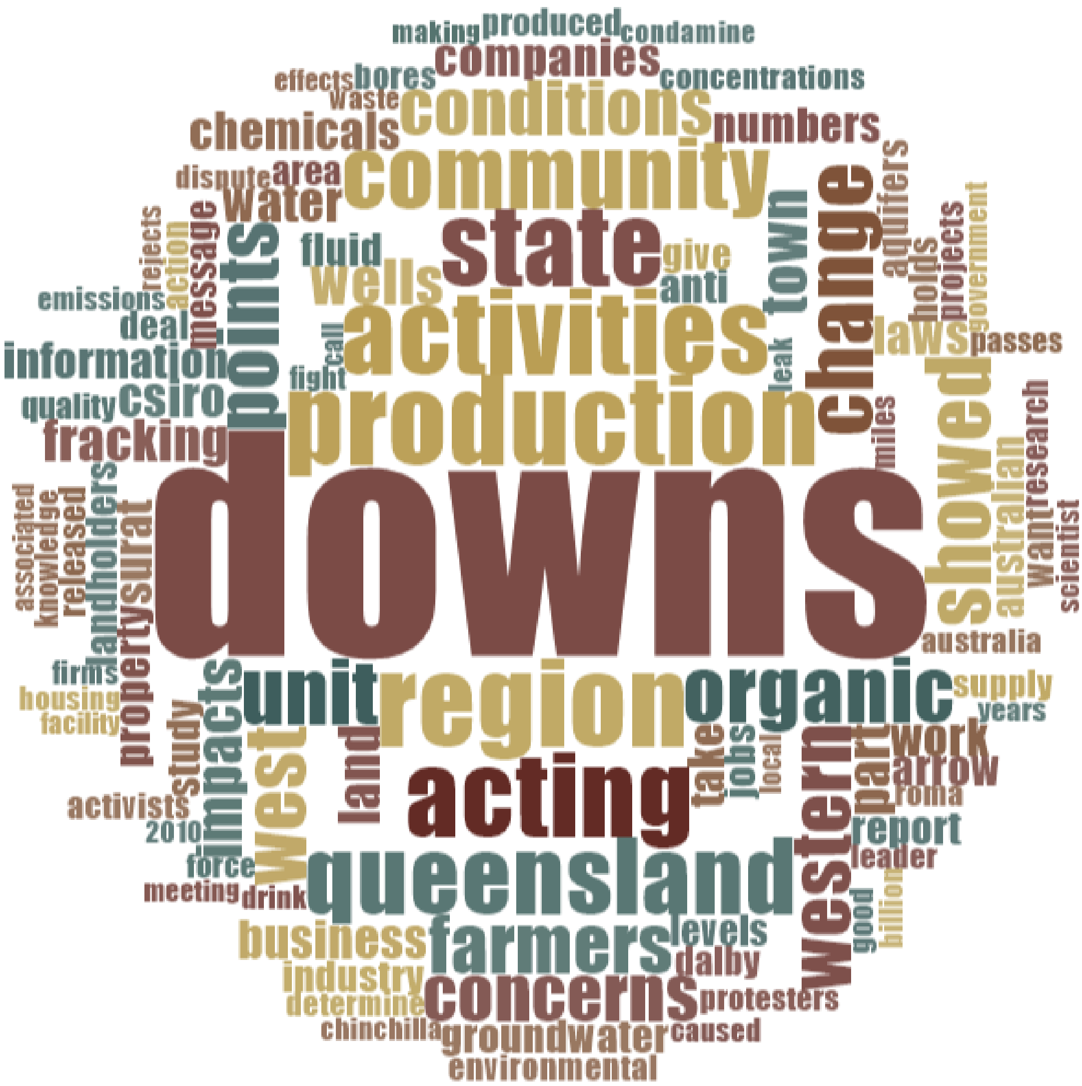

Figure 6.6: The Media Reported Perceived Potential Environmental Impacts of the CSG Industry in the Western Downs, Queensland.

6.3.8 The Media Reported Perceived Potential Water Benefits of the CSG Industry in the Western Downs, Queensland

Figure 6.7 relates to 21 of 1270 of Factiva media reported article data entries concerning potential water benefits by the CSG industry at the Western Downs, Queensland. Potentially the CSG produced water processed in Western Downs treatment plant used for perceived healthy irrigation and livestock by local farms. Also, the prospect of the potential for healthy human drinking water consumption has not been met with a positive reception.

Figure 6.7: The Media Reported Perceived Potential Water Benefits of the CSG Industry in the Western Downs, Queensland.

6.3.9 The Media Reported Perceived Potential Water Impacts of the CSG Industry in the Western Downs, Queensland

Figure 6.8 relates to 457 of 1270 of Factiva media reported articles concerning potential negative water impacts by the CSG industry at the Western Downs, Queensland. Reported legal and illegal dumping of potentially polluting and toxic CSG produced water on to and land and into water systems. Potential pollution of surface water, groundwater and aquifer interference and the reduction of groundwater and aquifer levels due to CSG industry activities. The potential: pollution; and reduction of bore water levels and quality and potential leaking of toxic, highly saline CSG produced water from evapouration ponds into all water systems. Potential pollution and disruption of ephemeral water and water dependent ecosystems due to CSG industry activities.

Figure 6.8: Media Reported Perceived Potential Water Impacts of the CSG Industry in the Western Downs, Queensland

6.3.10 The Media Reported Total Perceived Potential Negative Impacts Associated with the CSG Industry in the Western Downs, Queensland

Figure 6.9 relates to 1733 of 1270 of Factiva media reported article data entries that referred to more than one of the reported potentially negative impacts associated with the CSG industry activities in the Western Downs. The sum total of 1733 reported potential negative impacts pertaining to social, human, and environmental health, in particular water systems and its inhabitants, dependents and consumers is due to the overlapping of potential impacts and potential multiple impacts in many individual traditional media reported article data entries (Figures 6.9 and 6.10).

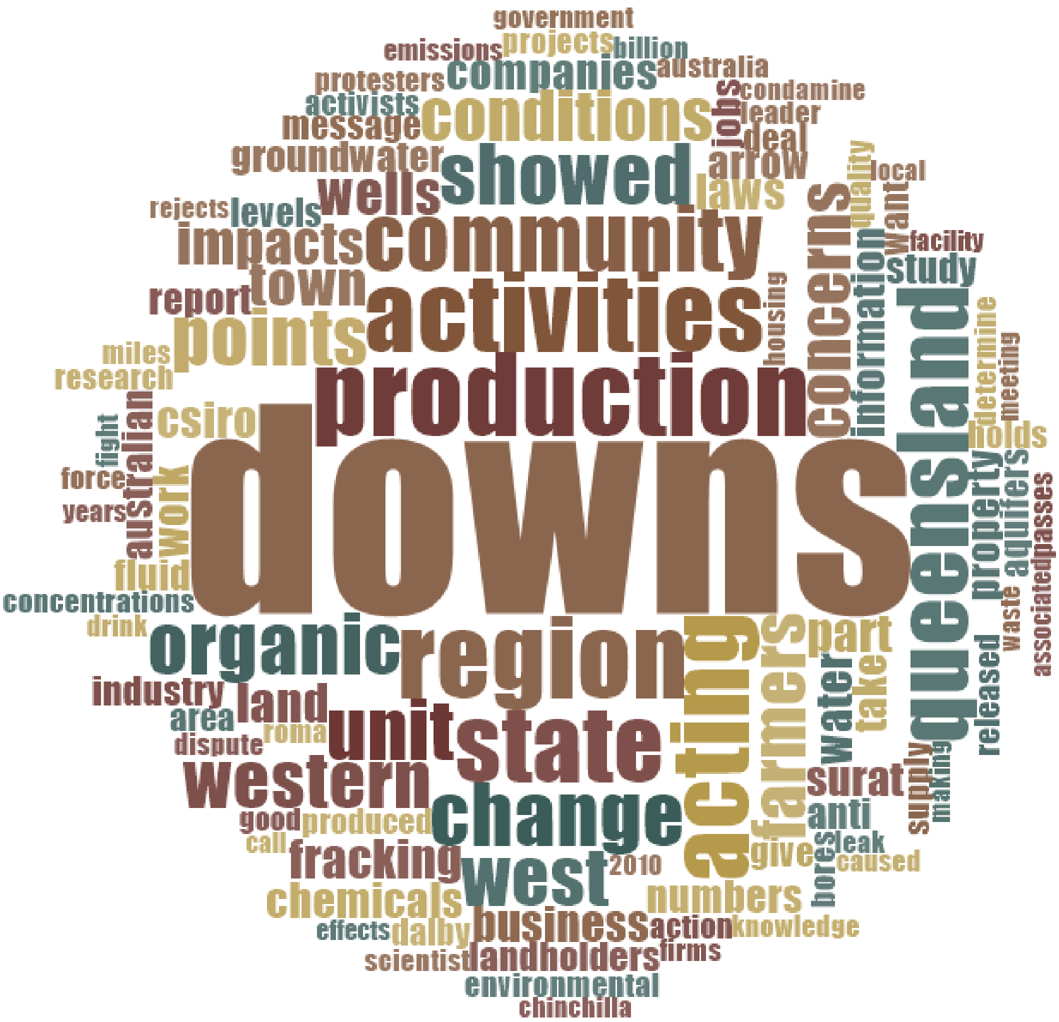

Figure 6.9: The Media Reported Total Perceived Potential Negative Impacts Associated with the CSG Industry in the Western Downs, Queensland

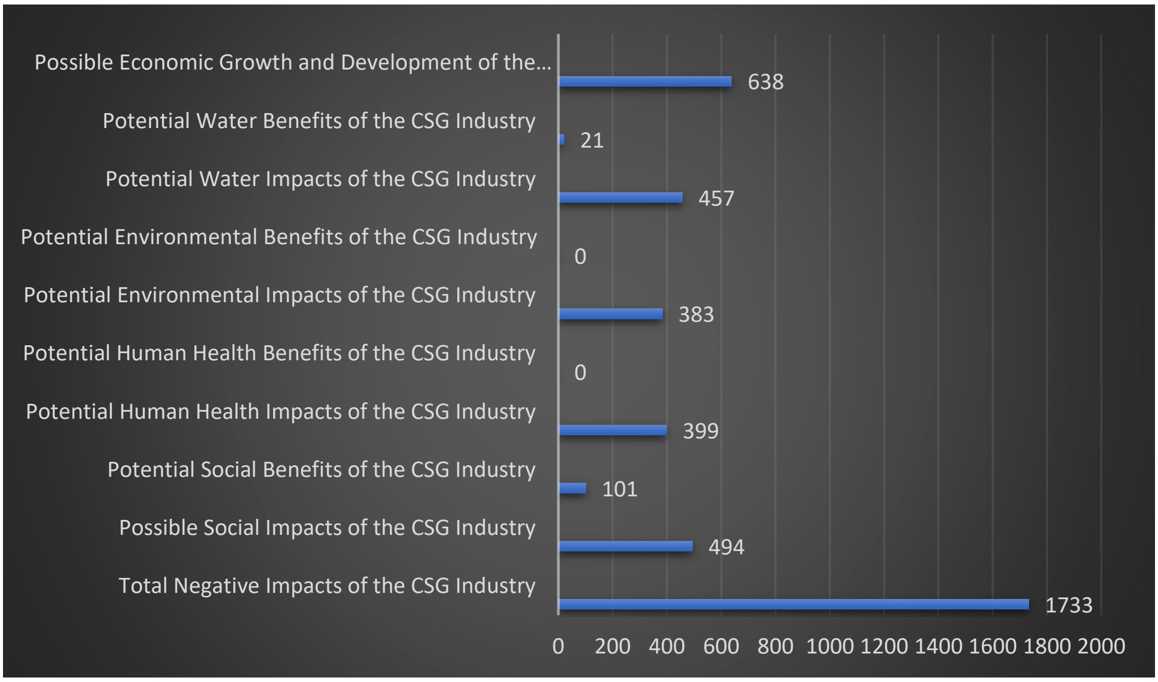

Figure 6.10: Comparative Chart of the Perceived Potential Benefits and Impacts of the CSG Industry and its Related Activities that are Reported in the Traditional Media News Articles Concerning the Western Downs, Queensland

6.4 Conclusion

Media content study (MCS) of the database in chapter 6 has provided a condensed, however still comprehensive and extensive, historical yet up to date, perspective of the CSG industry and CSG activities, in particular, unconventional CSG fracking based extraction at the Western Downs, Queensland, Australia, providing perceived possible answers to thesis research questions 1 and 4 and thesis research objectives 2 and 3. To be discussed further in chapter 7.

The MCS provides individual word clouds and a summary comparative chart in Figure 6.10, focusing on the perceived possible and potential benefits and perceived possible negative impacts on water, human and environmental health and society, and perceived possible economic growth and development of the CSG industry activities reported in the Factiva traditional media reported article entries at the Western Downs. The number of media reported article appearances of the nine (9) research topics are indicative of the perceived possible reasons for the perceived social polarisation of opinion and the controversy surrounding the CSG industry in the Western Downs Queensland and are based on the 1270 media reported news articles. The total of perceived possible and potential benefits of CSG industry activity potential benefits in the Western Downs, Queensland is 122. Perceived potential social benefits of 101 is due primarily to local employment, landholders signing CCAs and local business profits. The balance of perceived potential water benefits at 21 is attributed to the perceived potential of using treated CSG co-produced water for irrigation and livestock.

Traditional media reported articles concerning perceived potential human and environmental health benefits of the CSG industry and its activities in the Western Downs, Queensland were zero. These statistics suggest that the perceived potential positive benefits of the CSG industry in the Western Down, Queensland are the least prevalent in the Factiva data. This may or may not be due to media bias.

The CSG industry activity perceived potential negative impacts for: social 494; water 457; human health 399; and environmental impacts 383 appear frequently. The sum total of the four perceived potential CSG industry activity impacts of the media content study reported appear most frequently at 1733 of the 1270 CSG industry activity traditional media reported article data entries. This result is due principally to many of the traditional media reported articles containing relevant reported information which overlaps: affecting multiple CSG industry activity perceived potential negative impact topics in the media content study. However, this does not negate the relevance of the reported prevalence of the perceived negative impacts by the CSG industry activity at the Western Downs, Queensland.

The perceived possible economic growth and development of the CSG industry in the Western Downs, Queensland appears, statistically, frequent at 638, though this must be tempered due to the number of purely CSG industry related traditional media reported articles e.g., CSG company manoeuvring (proposed company sales and purchases, buy-outs, politics, etc.), share price fluctuations, pipeline proposals, etc. Any local perceived potential economic gains must be weighed against the CSG industry, and its activities perceived potential impacts at the Western Downs, Queensland. The media content study has provided perceived possible answers to thesis research questions 1 and 4 and thesis objectives 2 and 3. To be discussed in chapter 7.

Please refer to the Thesis Annex Document for the complete comprehensive Factiva research data used in the media content study. The following chapter brings together the implications of the literature review and the major findings of chapters 5 and 6 in the form of a general discussion focussing on the thesis research questions 1, 2, 3 and 4 and the thesis research objectives 1, 2, 3 and 4 related to CSG fracking based extraction and its perceived possible reasons for polarisation of community opinion on the topic.

CHAPTER 7: General Discussion

7.1 Introduction

The available literature on CSG and its impacts have been reviewed in the thesis, which led to defining the key aim with the four thesis objectives. 1. To ascertain the current state of knowledge about the nature and extent of the impacts on groundwater and surface water systems in the Western Downs, Queensland, Australia. 2. To examine the CSG stakeholder's perspectives on impacts of CSG activities on groundwater and surface water systems in the Western Downs, Queensland, Australia. 3. To study CSG stakeholder's perceptions and interpretations of the causes of conflict and community polarisation relating to CSG extraction. 4. To develop conflict mitigation strategies to reduce community conflict about CSG extraction. The four thesis research questions 1. What is the current state of knowledge about the nature and extent of the impacts on groundwater and surface water systems from unconventional coal seam gas (CSG) extraction in the Western Downs, Queensland? 2. How have these impacts been perceived and experienced by different stakeholders and represented in the traditional media? 3. What is the nature and extent of community conflict and polarisation of opinion over CSG extraction in the Western Downs, Queensland? 4. What is the potential for community conflict over CSG to be resolved and what strategies could contribute to this?

Chapter five interpreted the findings of the anonymous survey of relevant CSG stakeholders. Chapter six presents the results of a media content study of the 1270 traditional media reported articles.

This chapter discusses the major findings of chapters 5 and 6, and intergrates it with the key information in the literature review and discusses its broader context and relevance compared to other land use conflicts. Possible explanations are discussed and it elaborates on possible mitigating choices that may provide answers to the thesis research questions. An environmental peacebuilding theoretical framework developed by Conca and Dabelko 2002, is used to present '*cooperation as a win-win solution and escape from the zero-sum logic of conflict. It rests on the assumption that the biophysical environment's inherent characteristics can act as incentives for cooperation and peace, rather than violence and competition*'(Dresse *et al.*, 2018). Lucas and Warman 2018 employ a similar, less confrontational theoretical approach expanded upon in this chapter. The more standard person-environment (PE) fit theoretical framework was considered, however due to the thesis nature of polarisation of opinion and communal conflict, the PE fit theoretical framework was felt to be less appropriate as the underlying premise of the PE fit theory is the degree of fit, or match, between the compatibility of a person(s) and their life/work environment, not communal polarisation and behavoural conflict. The EIS section on social impact assessment (SIA), social licence and corporate social responsibilty are dicussed in section 7.2.2.

7.2 Understanding Stakeholder Views

In general there were significant consistencies between the findings of the stakeholder surveyand the media content study. This demonstrates an interrelationship between stakeholder views and the reporting of these views in the traditional media. On the one hand this can be interpreted as traditional media reflecting and reporting without bias on these views. It may also reflect that the traditional media drives and/or potentially amplifies or polarises stakeholder views. Mercer *et al.* 2014 found examining the ideas that underlie texts: the CSG beliefs of the 'actors', or stakerholders is key to understanding their socio-economic struggles represented in their underlying beliefs concerning CSG in Eastern Australia. Their analysis indicating an opposition of Lock the Gate to CSG extraction with views that differ from retaining a '*neoliberalising political economies'*, that is, conflicting with Queensland Government and CSG proponents who express a similar and consistent position in texts produced by them. Mercer *et al.* sees this as problematising the state government: a neutral arbitrator restoring the balance of the beliefs of the gas industry and community groups such as 'Lock the Gate', advancing the viewing of underlying polarities. In a broader context concerning general polarisation of opinion and environmental conflict this has both similarities yet significant differences of CSG to other land use conflicts discussed further in section 7.2.2.

7.2.1 Assessing the Perceived Impacts

1. What is the current state of knowledge about the nature and extent of the impacts on groundwater and surface water systems from unconventional coal seam gas (CSG) extraction in the Western Downs, Queensland? As discussed in the thesis, for ethical and safety reasons, it was not possible to directly assess the impacts of CSG extraction on groundwater and surface water systems. The thesis though has provided important information - both primary and secondary on stakeholder views of such impacts.

The questionnaire undertaken for Chapter five provided extensive representative responses from the four interest groups[1] studied regarding their informed perceived opinions to the questions. Media content study is used to systematically interpret the qualitative responses from participants and the consistency of these reponses. This makes a contribution to knowledge on possible CSG activity on human, social environmental water system related perceived impacts and provide valuable insights to thesis research question 2 - How have these impacts been perceived and experienced by different stakeholders and represented in the traditional media? The survey participant responses were found to be, most frequently, that there were possible impacts due to CSG industry water usage, fracking, disposal of CSG produced water into waterways, groundwater and bore water contamination.

The media content study described in chapter six used word frequency study to present the data in word clouds, summarised in a comparative chart to add an illustrative visual representation of possible and potential benefits and perceived impacts. These representations were important in terms of allowing visual interpretation of a large dataset of traditional media reported articles. In answer to thesis research question 1 and consistent with the results of the stakeholder survey, the media content study most frequently suggested that it is commentators and the public view that water resources are perceived to be impacted by CSG extraction in the Western Downs, Queensland. The frequency of media entries concerning negative water impacts (457) is much greater than the frequency of water benefits (21). It may be argued that this could be consistent with biased media reporting *i.e.*, media reporting more water risks than benefits. However, this is not consistent with media reporting 638 media entries concerning CSG industry economic developments and is also not consistent with the following major findings of the literature review**.**

Present groundwater modelling is said to address aquifer connectivity. However, they are said to invariably under-predict the extent of inter-aquifer leakage due to CSG activity created dynamic preferential pathways, with long reaching temporal potential impacts to aquifers, groundwater, GDEs and environmental health (Golding *et al*., 2010, Moore, 2012, IESC, 2014*a*, Davies *et al*., 2015, Askarimarnani, 2017, Nelson, 2019) Resulting in, but not limited to include: (Golding *et al*., 2010, Moore, 2012, Hamawand *et al*., 2013, Taulis and Milke, 2013, IESC, 2014*a*, Davies *et al*., 2015, Askarimarnani, 2017):

[1] Reiterating, the groups are: Group A community group members, Group B community individual participants, Group C Australian government officials and Group D gas industry employees.

- *Leakage of water from overlying and underlying aquifers and aquitards, resulting in the coincidental depletion of water in these resources;*
- *Mobilisation of natural salts from overlying and underlying aquifers and aquitards, resulting in the coincidental deterioration of water quality in the pumped aquifer;*
- *Mobilisation of anthropogenic contaminants from overlying and underlying aquifers and aquitards;*
- *Changes in the nature and fluxes between surface water and groundwater systems near the ground surface; and*
- *Water level declines in shallow aquifers, leading to changes in the recharge and/or discharge rates.*

Therefore, industrial groundwater developments, such as CSG extraction and dewatering of coal seams require sophisticated knowledge of aquifer connectivity (Moore, 2012, IESC, 2014*a*, NSW Government, 2014*b*, Askarimarnani, 2017).

These findings are consistent with the questionnaire responses detailed in Chapter five and the media content study, contributing theoretically and practically to understanding contentions regarding CSG impacts and has relevance to understanding contentions regarding environmental impacts of the extractive industry in general. These contributions are expanded upon in this chapter.

7.2.2. Understanding Conflict and Polarisations

The third thesis research question is what at is the nature and extent of community conflict and polarisation of opinion over CSG extraction in the Western Downs, Queensland? Both the stakeholder survey and the media content study documented conflict and contentions. The drivers of this conflict are controversial and polarised as discussed earlier by Mercer *et al*., 2014. de Rijke, 2013 pp. 29-58, and Curran, 2017 pp. 427-435 who view CSG conflict in terms of the EIS section on Social Impact Assessment (SIA) and Social Licence. Social licence is expressed further by Paragreen and Woodley 2013 pp. 48-49 as founded in interpretation, where the majority of community support may be seen as the determining factor of outcome and ‘right’ and corporate social responsibility is seen in terms of a democratic theoretical framework underpinned by CSG industry transparency as supported by de Rijke, 2013 pp. 10-11. Curran 2017 pp. 429-431 who explores contestation in his case study of the ‘Bentley blockade’, Lismore, New South Wales, Australia. Curran sees social licence as a response to ‘past disasters, conflicts and challenges’ ‘through a prism to operate’ regarding contestation between pro and anti CSG protagonists.

In a broader context CSG conflict gravitates around water, social issues, human and environment health, legislation, and the lack of government control and self-regulation by the CSG industry are possibly the cause (Wester-Herber, 2004, Vink *et al*., 2008, GEOSCIENCE and Habermerhl, 2010, Barnet *et al*., 2012, de Rijke, 2013, Paragreen and Woodley, 2013, Comino *et al*., 2014, Lacy and Lamont, 2014, Walton *et al*., 2014, Rifkin *et al*., 2015, OCE, 2015, Tan *et al*., 2015, Vickas *et al*., 2015, Adger, 2016, UQ-CCSG, 2016, Curran, 2017, Nelson 2019).

In broader general land use conflicts this is similar to the conflict found in the Tasmanian forestry case (Lucas and Warman, 2018) of polarisation and conflict discussed at length in the next section. However, the broader significant difference between the two, which is also representative and generally comparative to the majority of other land use and natural resource conflicts, is the lack of data and gaps in data regarding CSG extraction and its impacts exacerbated by there being: no establishment of any ‘baseline’ measurements or, any information on ‘natural’, or native formative constituents; methane and elements, chemicals, products and other potential organic and inorganic, environmental contaminant levels; and before the commencement of CSG exploration or the production of CSG (Lloyd-Smith and Senjen, 2011, Day *et al*., 2012, 2014, 2015, Pitt and Cherry (Saddler), 2012, 2013, Santos and Maher, 2012, SKM, 2012, Comino *et al*., 2014, IESC, 2014*d*, Maher *et al.*, 2014, Davies *et al*., 2015, Mudd, 2015, Tan *et al*., 2015, Lafleur *et al*., 2016, Nelson 2019).

In the broader context of communal polarisation and environmental conflict, Tasmania presents us with the most influential environmental law case in Australian history, the Tasmanian Dam Case (Franklin Dam Case) involving the flooding of a large section of the Franklin River for a hydro-electric scheme. It is also a landmark in Australian constitutional law (Environmental Law Australia, 2018) as the *EPBC ACT 1999* depends for its constitutional validity on the Tasmanian Dam Case regarding the external affairs power *i.e.*, the protection of: World Heritage properties; Ramsar wetlands; threatened species and threatened ecological communities; and migratory species. And its amendment in 2013, making water resources a ‘trigger’ a MNES. The land use conflict was resolved after six years (1978-1983) in the High Court by seven judges (split 4:3) to stop the dam.

Tan *et al.* 2015 found the legal regulatory framework is complex and changing in Queensland concerning land use and may contribute to polarisation and environmental conflict. The survey participant responses in chapter 5 are divided on the reasons for the community conflict and polarisation of opinion.

Groups A and B, the community individuals and community group members, most frequently commented possible and potential CSG activity impacts on water systems and issues relating to water, social and human and environment health, and the lack of government control and self-regulation by the CSG industry were possibly the cause. Group C, government officials frequently commented on possible CSG impacts on water systems and issues relating to water, social, human, and environmental health, and the lack of government control and self-regulation by the CSG industry. And Group D, gas industry employees less frequently commented on possible CSG activities impacts on water systems as the cause of community conflict and polarisation of opinion, rather often reporting a bias because of misinformation and social media being the main possible causal factors. The media content study on potential human health, social, environment and water impact due to the CSG industry are most frequently negative compared to its benefits. This may provide, indirectly, explanations to help rationalise the community conflict and polarisation of opinion of anti and pro-CSG proponents (de Rijke, 2013, Paragreen and Woodley, 2013, Comino *et al*., 2014, Lacey and Lamont, 2014, Mercer *et al*., 2014, Uhlmann *et al*., 2014, Tan *et al*., 2015, OCE, 2015, Curran, 2017, Nelson 2019).

The primary legislation for CSG mining is the *Petroleum and Gas (Production and Safety) Act 2004 (P&G Act),* which states its "*main purpose is to facilitate and regulate responsible petroleum activities and the development of a safe, efficient and viable petroleum and fuel industry*". In achieving this State Government is to have regard to ecological sustainable development and needs of all Queenslanders.

However, this Act does not establish the need for or specifically enable independent scientific consideration in decision making. The lack of scientific independence, however, is indicated in the Queensland Government's 2015 *Code of Practice. For the construction and abandonment of petroleum wells and associated bores in Queensland*, formulated by the Department of Natural Resources and mines (DNRM) and APPEA. The level of compliance by drillers within the guidelines is largely unknown: and or unpublished. The *National framework for compliance and enforcement systems for water resource management,* outlines offences that regulators must endeavour to prevent (SEWPaC, 2012). Including: unlicensed, and improper bore construction and material usage, by well drillers; licensed drillers non-compliance, *e.g.*, failing to record in drilling logs and inappropriate bore drilling and poorly constructed wells (SEWPaC, 2012).

A key regulatory concern expressed by Tan *et al.* 2015 pages 686-687. This leaves CSG industry open to criticism: having privileges not shared with other water consuming industries *e.g.*, agriculture. Thus, the government legislative settings have potentially contributed to conflict by creating potential inequitable access to a natural resource. Similarly, coal extraction in Queensland is favoured over other primary producers in its use of water in accordance with the same legislation.

Also, in a broader context, the polarisation and environmental conflict over the Murry-Darling Basin water is greatest in Australia. Agriculture uses two-thirds of Australia's water. Flowing through Queensland, New South Wales, Victoria, South Australia and the Australian Capital Territory, the Murry-Darling supplies Australia's most irrigated areas, also suppling many major cities. Poor cooperation or a proper legal management framework, has contributed to conflicts between environmental and other users, exacerbated in times of drought and a lack of flow at the Murry River estuary with cumulative impacts on freshwater and estuarine biota and Ramsar Convention-listed wetlands dependent on the river's flow (Murry-Darling Basin Comm, 2008). Taking ten years and Australia's worst drought before the National Water Initiative received endorsement introducing national and state reforms to address overallocation of water and ensure minimum flow environments. Introducing mechanisms to adjust water entitlement volumes and federal buy backs of water rights or properties. Also, the separating water rights from property in land to allow water rights trading to highest value use (Commonwealth Environment, Water Office, 2014). Similar to CSG, water supply and usage is a critical issue for communal polarisation and environmental conflict with ongoing cumulative impacts, including the usual flow related problems in 2020 after a very dry 2019. The fundamental difference between the possibly manageable Murry-Darling dilemma and CSG is the potential human health issues and potential long term if not permanent water contamination and depletion of both groundwater and surface water systems.

Representative of the destructive, violent consequences of this, the global and locally much-loved Australian tourist 'show-case' attraction the Gold Coast, Moreton Bay, Queensland is but a paucity, a degraded polluted remnant, a shadow of the pristine bioregion it once was before European arrival and competition for land use and natural resources (Hundloe *et al*., 2015, McPhee, 2017). Similarities may be drawn to CSG and the billion-dollar multi-national gas industry's activities. Characteristic of this area's inheritance and the ongoing phenomenon of the persistent practice of anthropogenic irreparable land use mismanagement.

It is difficult to apply a broader context and compare the potential impacts of long-term ongoing CSG fracking and fracking fluids to other environmental conflicts, with the possible exception of substances including fertilisers, pesticides, and herbicides, which however may be banned if found to be detrimental to human and environmental health. A major potential impact of CSG fracking based extraction possibly responsible for community conflict and polarisation of opinion is the use and disclosure of fracking chemicals and additives. The Commonwealth of Australia is aware that many fracking additives on the Australian Inventory of Chemical Substances (AICS) have not been assessed for fracking by the National Industrial Chemicals Notification and Assessment Scheme (NICNAS) (Senator Ludwig, 2011). NTN 2011 estimates that just 2 of the 23 main additives in fracking fluids in Australia have been approved for fracking. Concerns focus on possible health issues, both human and environmental from contaminated groundwater and surface water systems. Also, release of existing naturally found toxic heavy metals (*e.g*. boron, arsenic, etc.), radioactive substances and toxins through aquifer interference in water systems by CSG activities effects on human and environmental health (Lloyd-Smith and Senjen, 2011, Day *et al*., 2012, 2014, 2015, Pitt and Cherry (Saddler), 2012, 2013, Santos and Maher, 2012, SKM, 2012, Comino *et al*., 2014, IESC, 2014*a*, *d*, Maher *et al.*, 2014, Davies *et al*., 2015, Mudd, 2015, Tan *et al*., 2015, Lafleur *et al*., 2016, Nelson 2019).

The regulations for industrial chemicals are complicated and administered by the National Industrial Chemicals Notification and Assessment Scheme (NICNAS), and is evidence-based on risk assessments of industrial chemicals to: public and occupation health; safety; and the environment. An assessment certificate issued under the *Industrial Chemicals (Notification and Assessment) Act 1989* (*ICNA Act 1989*) is required to allow a new industrial chemical into Australia (IESC, 2014*d*).

Additives in fracking fluids are to be notified and assessed by NICNAS before being added to the Australian Inventory of Chemical Substances (AICS). If an additive listed on the AICS has been assessed by NICNAS for other uses and a CSG proponent wishes to frack with it, companies must notify NICNAS (NICNAS, 2013, IESC, 2014*d*).

An area of community conflict in the thesis research in both the survey participants and the media content study is that many landholders in the Western Downs, Queensland (applicable anywhere in Australia) were not aware until earlier in the 2000s that the ownership, or rather their use of the land they hold, only extends down some two (2) metres. They do not have the mineral rights required for mining-based extraction of anything. However, the bitter pill with respect to this is the responsibility of knowing the tenure of your land rests with the landholder. Ignorance is no excuse. The CSG industry or the Queensland government did not change the tenure. Mining companies and general financial speculators can buy the leasing (tenure of tenements) rights to access and mine on the land they hold (See Factiva 22/09/2014). Again, farmers could have also made the business decision to purchase these mineral rights themselves, which some have done. This particular issue, still, has caused many CSG activity water system related and human and environmental conflicts (De Rijke, 2013, Paragreen and Woodley, 2013, Queensland Government, March 2013, Comino *et al*., 2014, IESC, 2014*a*, *b*, *c*, *d*, Uhlmann *et al*., 2014, OCE, 2015, Tan *et al*., 2015, Curran, 2017, IESC, 2017, Nelson 2019). At their peak, between 2010-2015, in excess of 250 community groups were formed in Australia because of the possibility of real and perceived CSG extraction impacts (Refer to Thesis Annex Document).

Makki 2015, in his unpublished University of Queensland PhD thesis, appears to seek to de-legitimise and discredit anti-CSG movement, he describes 'founding members' from the outskirts of Chinchilla and Tara in the Western Downs. From his research he appears to have 'borrowed' the label 'Blockies'- self-interested, unemployed individuals, seeking publicity and possible financial gain, from their stance against CSG and gas companies. Makki appears to seek to minimise CSG activity potential impacts or may simply be misguided.

The term 'Blockies' has been used ubiquitously throughout the Darling and Western Downs (and no doubt the rest of Queensland at the least, in some form or another) to describe newcomers to rural communities with small acreages that have been subdivided from much large acreages of generally poorer land quality close to townships for many decades. There have been past and ongoing multitudinal conflicts between long term and generational rural residents and newcomers concerning a multitude of issues before the gas companies entered the fray.

7.2.3. Resolving Conflicts

The fourth thesis research question - What is the potential for community conflict over CSG to be resolved and what strategies could contribute to this? The results of both the stakeholder survey and the media content study demonstrate that resolving the conflict is not simple. Groups A, B, and C most frequently commented that there was no resolution possible between the gas industry activities and affected communities and the concept of co-existence was not possible. Group D comments were also, but less frequently, similar. It was demonstrated in a broader context that the conflict involves multiple sources of conflict and contentions including those associated with impacts on the natural environment, human health and local social and economic norms and structures. This is not unusual in polarisation of opinion and environmental conflict. Curran 2017 pp. 429-431 found this concerning CSG extraction at the 'Bentley Blockade', Lismore, NSW, Australia.

Lucas and Warman 2018 found that Tasmania has demonstrated severe polarisation concerning environmental problems using a citizens of Hobart study and recent case study of an effort to disrupt polarisation regarding forestry in Tasmania in an attempt to formulate a novel conceptualisation of 'ruts' concerning environmental conflict. Ruts form as social polarity constructs gain impetus which may perpetuate entrenchment of discourse coalitions and storylines into previous problems. Supported by attitudinal survey results, also interviews illustrating content of storylines concerning the forestry debate frame, or characterise, people's responses, in particular, to climate change. Involving negotiations in the forestry conflict demonstrating positive outcomes in the disruption of polarised scenarios.

When government and scientific bodies failed to ameliorate conflict regarding Tasmania's forests, a sub-political process eventuated directly renegotiating a shared definition of risk. Lucas and Warman study illustrates new coalitions outside traditional systems of authority may have the ability to disrupt polarisation of issues, by the formulation of storylines. Ability to recognise legitimacy of differing values and find framings sidestepping instead of confronting conflicting values.

Further, Lucas 2018 sees climate change as a partisan problem with increased political polarisation. Politics having a role in influencing concerns regarding climate change and policy, recognising the values that form attitudes may offer better outcomes rather than concentrating on political polarities. These views are supported theoretically and empirically by Schwartz, 1992, Wester-Herber, 2004, Corner *et al*., 2014, Adger, 2016, Mahony and Hulme, 2016.

The Queensland Government provided significant and direct financial support in the form of compensation to landholders that had CSG wells or other infrastructure on their land. It was estimated that over 5,000 Conduct and Compensation Agreements (CCAs) have been signed by landholders with gas companies in Queensland (APPEA, 2015, OCE, 2015). As is common to contractual arrangements between entities (government and private), the details of these arrangements are confidential (non-disclosure).

A perception of the lack of fairness and transparency regarding Conduct and Compensation Agreements (CCAs) was found to concern landholders and is a source of conflict. The inherent, confidential substance of the negotiated CCA by individuals created a community perception that the settlement amount received represented negotiation skills rather than the true value economic loss. Also, time spent, and productivity loss, are not included in their compensation (Hamstead and Fermio, 2012, Cavaye and Kelly, 2015, Rifken *et al*., 2015).

Differing access to compensation and differing values of compensation are important considerations when trying to understand conflict in this instance. The value of a unit of land for agriculture and CSG extraction are not equal, and compensation may alter a landholder's financial circumstance relative to others. The relative component is an important consideration in terms of equity. A landholder may have received a large compensation payout from a CSG company for marginally productive land, whereas another with more productive land may have received the same but sustaining a greater impact from CSG. OCE 2015, p.22 stated, *"a major component of the coexistence between CSG and communities is land access. The Queensland Government's land access laws have been updated to ensure that:*

- *Landholders are fairly compensated for activities on their land and: and*
- *Resource companies minimise the impact on existing land and business operations."*

There is a 'make good' provision of water for landholders with impacted bore level drops of 5 metres or more, which is the responsibility of gas companies (OCE, 2015, Tan *et al*., 2015).

As is most often the case in negotiating fair equity in compensation for the landholder, especially with regard to any natural resource found below ground in Australia, it invariably comes down to negotiating skills and it has proven best for the landholder to seek legal advice or pay privately for a legal mediator to negotiate the best compensation on their behalf. It must be borne in mind and respected that such compensation agreements are strictly confidential and when entering into financial agreements with, large, often multi-national companies it is wise to adhere to the confidentiality of the contractual agreement signed, if the landholder does not wish to be threatened with legal action and or sued.

Transparency, commercially sensitive 'trade secrets' (de Rijke, 2013, IESC, 2014*b, d*, Vickas *et al*., 2015, Askarimarnini, 2017, Curran, 2017) of CSG fracking based extraction are a major source of community conflict and polarisation of opinion mentioned by both survey participants and in Factiva. There are many other examples of the gas industry's possible lack of transparency, *e.g*., the lack of information regarding CSG fracking based extraction procedures and CSG fracking fluid constituents. Further, much of the publicly released CSG activity related information is reference dated 2012 or before, in publications released years later. Many reviews, journal papers and gas company reports are consistent with this and are possibly too 'outdated'. These are further areas of CSG activity which may have mitigating outcomes and solutions and lessen sources of possible community conflict, distrust and CSG polarisation of opinion (Arrow Energy, 2012, de Rijke, 2013, Paragreen and Woodley, 2013, Queensland Government, March 2013, IESC, 2014*a, b, c, d*, OCE, 2015, Vickas *et al*., 2015, Curran, 2017).

The CSG industry, to a large extent self-manages, monitors, and reports, to Australian state and territory governments (IESC, 2014*a, b, c, d*, NSW Government, 2014, Queensland Government, 2015). This may possibly contribute to the low level of 'transparency' by the CSG industry, community conflict and polarisation of opinion.

The cost of gas supplies to local domestic and industrial end users begins at the contract price. This is a possible source of community conflict and polarisation of opinion on CSG activities. Hence, the need for more CSG production and *ipso facto* more CSG well fields resulting in possibly more real and potential negative impacts on water systems. The controversy possibly stemming from the gas industry arguing that we do not have enough gas to supply the eastern seaboard from existing production CSG wells. This has resulted in increased domestic gas prices and the need for more CSG wells in production. The present eastern seaboard CSG production is required to meet existing export contract demands. These are potential areas where mitigation, possibly alleviating community conflict and polarisation of opinion on CSG extraction may be possible (See the Thesis Annex Document).

In a global context, the United Nations have highlighted conflict prevention concerning increased competition over resource depletion, *e.g.*, land and water, environmental degradation, population growth and climate change. Mismanagement of resources contributing conflicts, obstructing the peaceful resolution of existing ones (UN, 2012). These polarised conflicts over renewable resources are extremely common and dangerous and are similar to CSG extraction because they are global and are forms of often irreparable unsustainable development.

The conflict surrounding CSG in the Western Downs, Queensland, is but one example of environmental conflicts that have communal polarising affects, it differs from many other conflicts involving natural resources, due to it being representative of globally ubiquitous, complex anthropogenically caused environmental problems that generate communal conflict concerning extraction processes. Its affects are long term and potentially permanent, a trade-off for limited short-term economic gain and social benefits through the continued use and extraction of fossil fuel derivatives backed by enormous financial investments of many hundreds of billions of dollars by the largest multi-national companies in the world, with incredible global political leverage.

CSG extraction has compounding affects that are definitive and all-encompassing of the total gambit of the earth's environmental anthropogenically responsible problems because it has the potential to pollute and threaten irretrievably freshwater and the health of our planet's life. What is at stake *i.e.*, limited short term economic gain and the continued use of fossil fuels compared to the potential loss of the sustainable use of our most valuable asset, healthy water.

Dresse *et al*., 2018 sees the theoretical framework of environmental peacebuilding (page 34) has the capacity to offer a new approach focusing on responsibly shared natural resources as a conflict resolution tool. It is currently active and ongoing. It appears be developing into a transformative framework that encompasses conflict prevention and post-conflict peacebuilding that is highly pertinent to this study. When used in conjunction with minimalised polarisation in environmental conflict. Combined with effective SIAs in EIS and the development of social licence and corporate social responsibility (de Rijke, 2013, Paragreen and Woodley, 2013, Curran, 2017, Lucas and Warman, 2018) we may have potential mitigation -strategies to assist in presenting alternatives.

The literature review and implications on CSG industry activities and issues discussed above have pertinence to the thesis questions 1, 2, 3 and 4 and the thesis aims 1, 2, 3 and 4 provide questions and answers to the thesis research theoretically and practically.

7.3 Conclusion

This chapter has discussed the participant responses in the questionnaire in chapter 5 and their importance to the thesis research questions and research objectives and has drawn comparisons and contrasts at a broader level. It has discussed chapter 6 and media content study fidings and its comprehensive researching of CSG related media reported article data regarding CSG fracking based extraction, community conflict and the polarisation of opinion on CSG extraction in the Western Downs, Queensland, and its relevance to the thesis research questions 1, 2, 3 and 4 and the thesis research objectives 1, 2, 3 and 4 blending and drawing them together with the literature review and its implications, providing theoretical and practical research contributions in a broader context with an emphasis on similarities and differences.

Chapter 8 outlines the study and the states the conclusions established by the results of the thesis research data and information on unconventional CSG extraction and the community conflict and polarisation of opinion on CSG extraction. The major results are discussed in the light of the thesis research questions and the thesis research objectives. Recommendations and future research are explained and the limitations of the thesis are expressed.

CHAPTER 8: Conclusion

8.1 Introduction

The previous chapter is a general discussion of the thesis research questions and thesis research objectives and the blending and drawing together with the literature review and its implications. Chapter 7 also began to indicate possible and potential mitigating premises and possible solutions that the thesis research identified in addressing the research questions 1, 2, 3, and 4 and thesis research objectives 1, 2, 3, and 4 and the thesis theoretical and practical research contributions with respect to perceived potential water system impacts by unconventional or fracking based CSG extraction and the perceived reasons for the community conflict and the polarisation of opinion on CSG extraction activities which will be concluded in this chapter. Thesis recommendations, future research and the thesis limitations are broached.

8.2 Media Content Study

Chapter 6 and the Thesis Annex Document are sources of extensive media content study, consisting of 1270 extracts and articles (derived from 3,000 pages focusing, primarily on Queensland, Australia) relating to CSG and its perceived potential fracking-based extraction impacts, in particular socially and on water systems. The content study research contributes a comprehensive dataset source of traditional media reported articles on perceived potential water system impacts, CSG industry activities and its perceived possible effects on community conflict and the polarisation of opinion concerning CSG activities in the Western Downs, Queensland. In conclusion, it provides extensive background information and data contributions, both theoretical and practical, and supports the answers to the thesis research questions 1, 2, 3, and 4 and the thesis research aims 1, 2, 3, and 4 discussed in chapter 7. The comprehensive data content will I believe be valuable as data for additional post-doctoral research and a data source for other researchers.

8.3 Thesis Research Questions and Objectives

Thesis Research Questions 1 and 2: What is the current state of knowledge about the possible nature and extent of the impacts on groundwater and surface water systems from unconventional coal seam gas (CSG) extraction in the Western Downs, Queensland? How have these impacts been perceived and experienced by different stakeholders and represented in the traditional media? The literature review's second part provides extensive information and data on real and potential CSG extraction impacts, particularly related to water, and highlights CSG extraction data gaps. The findings of major importance to thesis research in chapter 5, suggest that the anonymous questionnaire participant's responses are frequently that: there are perceived, possible impacts to groundwater and surface water systems in the Western Downs, Queensland. They suggest that the media content study of traditional media reported articles findings in Chapter 6 frequently support the anonymous questionnaire participant responses of the perceived possibility of potential negative impacts to groundwater and surface water systems. The thesis research provides new theoretical and practical research information and data contributions which fills research gaps in CSG background reviews conducted by the IESC. The thesis research also supports the IESC, 2014*a, b, c, d* findings. The thesis research results contribute, theoretically and practically, to CSG extraction information and data with respect to the Western Downs, Queensland found in the literature review. .

Thesis Research Question 3: What is the nature and extent of the perceived community conflict and polarisation of opinion over CSG extraction in the Western Downs, Queensland? The findings of major importance to the perceived reasons for community conflict and polarisation of opinion, most frequently, concern the CSG industry and its related economic and other activities, community individuals and families who are perceived to possibly benefit from CSG activities: and those community members and families who do not benefit or are perceived as possibly simply affected by CSG activities, even while perceivably benefitting from CSG. Further, whether the perceived benefits derived from CSG are through employment or Conduct and Compensation Agreements (CCAs) signed with gas companies. Concluding that this has possibly and potentially contributed to perceived community conflict and division, and generational farming families leaving their farms and the Western Downs.

The media content study of the traditional media reported articles in Chapter 6 support survey participant responses in chapter 5. CSG industry activity perceived potential impacts on social, human, and environmental health, in particular, groundwater and surface water systems are more perceived as more prevalent compared to CSG industry perceived benefits. The thesis research provides new theoretical and practical contributions of data regarding this study area of CSG extraction with perceived possible explanations for CSG stakeholder perceptions and behaviour *i.e*., CSG activities are the drivers perceived as potentially responsible.

The thesis finding also, contribute to, and support the findings of the studies conducted by the Rolfe *et al*., 2007, de Rijke, 2013, Paragreen and Woodley, 2013, Comino *et al*., 2014, IESC, 2014*a*, *b*, *c*, *d*, Huth *et al*., 2014, Lacey and Lamont, 2014, Mercer *et al*., 2014, Uhlmann *et al*., 2014, OCE, 2015, Tan *et al*., 2015, Towler *et al*., 2016, Curran, 2017, and Nelson 2019, in their research on human, social and environmental health. Perceived real and potential impacts by the economic development of unconventional CSG extraction. In addition, the thesis research adds to data concerning the perception of real and potential conflict and polarisation of opinion, and the division of communities and individuals, and the interpreted social licence of corporations and community groups and individuals concerning their perceived reactions to disputes regarding the economic development of unconventional CSG extraction. The thesis study findings provide additional new findings, information, and data on the possible primary perceived reasons for community conflict and polarisation of opinion on CSG extraction in the Western Downs, Queensland found in the literature review.

Research Question 4: What is the potential for the perceived community conflict over CSG to be resolved and what strategies could contribute to this? The general discussion in chapter 7 introduced mitigation, resolution, and solutions to some of the perceived, possible, and potential CSG extraction related community conflict issues, which may perceivably possibly contribute to the perceived community conflict in the Western Downs, Queensland, however there are no straightforward solutions. It appears to be in the hands of the government bodies (CSIRO, GISERA, CFCQ) and informed education institutions *e.g*., CCSG-UQ, in collaboration with the multiple gas companies and associated pro and anti CSG extraction related organisations and groups, active in the Western Downs to possibly address this problem. The ongoing research conducted by de Rijke, 2013, Paragreen and Woodley, 2013 and Curran 2017 and others into the effectiveness of the SIA section EIS, social licence and corporate social responsibility, is however promising. In conclusion, there appears no single, simple solution, it is perceived as an ongoing, cumulative problem and requires an ongoing, independent, cumulative research solution. Perceived recommendations in chapter 7 and in the next section may proffer some perceived overall guidance for mitigating options. The thesis study findings contribution's, theoretical and practical, in conclusion to thesis research question 4, were perceived as adding to and supporting ongoing research into perceived real and potential community conflict resolution by independent researchers and government bodies with the cooperation of the CSG industry.

The thesis research aims 1 and 2: To ascertain the current state of knowledge about the nature and extent of the possible impacts on groundwater and surface water systems in the Western Downs, Queensland, Australia. To examine the CSG stakeholder's perceived perspectives on impacts of CSG activities on groundwater and surface water systems in the Western Downs, Queensland, Australia. The comprehensive second part of the thesis literature review, provides a thorough insight into the CSG industry and its activities, in particular, unconventional CSG fracking extraction and its real and potential impacts. It also indicates the gaps in the ongoing research.

The anonymous survey participant's responses are perceived as most frequently comment on perceived possible and potential groundwater and surface water impacts due to CSG activity, in particular, are perceived as well drilling and fracking related. This concurs with the media content study. The frequency of media reported entries concerning perceived real and potential negative water impacts is much greater than the frequency of perceived potential water benefits. This is perceived as agreeing with the literature review that there are perceived possible and potential impacts on groundwater and surface water systems due to CSG well drilling and fracking in the Western Downs, Queensland. In conclusion, the thesis study findings are perceived to support and contribute, theoretically and practically, to the research data on perceived potential and possible groundwater and surface water impacts due to CSG well drilling and fracking in the Western Downs, Queensland (Arrow Energy, 2012, Queensland Government, March 2013, IESC, 2014*a*, *b*, *c*, *d*, OCE, 2015).

Thesis research aim 3: To study CSG stakeholder's perceptions and interpretations of the causes of conflict and community polarisation relating to CSG extraction. In conclusion, the anonymous questionnaire survey participant responses in chapter 5 are divided on their interpreted perceived reasons for the perceived community conflict and polarisation of opinion as discussed in chapter 7, though it is frequently found to mention that it concerned perceived CSG industry activity. The media content study in chapter 6 on media reported perceived potential human health, social, environment and perceived water negative impacts due to the CSG industry are perceived as most frequent compared to its perceived benefits. This may provide, an explanation to help rationalise the perceived community conflict and polarisation of opinion of anti and pro-CSG proponents.

There is existing and ongoing research and information on this area of research in the literature review (Wester-Herber, 2004, Rolfe *et al*., 2007, de Rijke, 2013, Paragreen and Woodley, 2013, Comino *et al*., 2014, Huth *et al*., 2014, Lacey and Lamont, 2014, Mercer *et al*., 2014, Uhlmann *et al*., 2014, OCE, 2015, Tan *et al* 2015, Adger, 2016, Towler *et al*., 2016, Curran, 2017, Dresse *et al*., 2018, Lucas, 2018, Lucas and Warman, 2018, Nelson 2019). The thesis study has contributed, theoretically and practically, to data on this area of CSG activity research which may assist in future ongoing studies on this controversial area of research concerning CSG activity and its ramifications in the Western Downs, Queensland.

Thesis aim 4: To develop conflict mitigation strategies to reduce the perceived community conflict about CSG extraction. In conclusion, the anonymous questionnaire survey participants were perceived as frequently divided on this. Groups A, B, and C were perceived as most frequently commenting that there was no resolution possible between the gas industry activities and the perceived affected communities, including the potential co-existence of agricultural activities and unconventional CSG extraction mining. Group D CSG industry employee's comments were also, but less frequently perceived as similar, except for co-existence which they felt may be conceivably possible. The media content study for perceived potential human health, social, environmental and perceived water negative impacts due to the CSG industry activities are perceived as most prevalent compared to CSG industry activity perceived potential benefits. This may suggest contributing causes of the perceived community conflict over CSG extraction in the Western Downs, Queensland with possible opportunities for mitigation of the conflict as discussed in chapter 7 and in section 8.4 Recommendations. The thesis study has contributed theoretical and practical information and data on this area of CSG activity research which has ongoing investigation in the literature review part one (Rolfe *et al*., 2007, de Rijke, 2013, Paragreen and Woodley, 2013, Comino *et al*., 2014, Huth *et al*., 2014, Lacey and Lamont, 2014, Mercer *et al*., 2014, Uhlmann *et al*., 2014, OCE, 2015, Tan *et al.*, 2015, Towler *et al*., 2016, Curran, 2017, Dresse *et al*, 2018, Nelson, 2019). In addition, this study has supported and contributed to Wester-Herber, 2004, de Rijke, 2013, Paragreen and Woodley, 2013, Adger, 2016, Curran, 2017, Dresse *et al*., 2018, Lucas, 2018, Lucas and Warman, 2018 with regard to the study of social licence, polarisation of opinion and environmental conflict.

8.4 Recommendations

There are many issues which the results of this thesis study have brought to light which require mitigation whether they are real or perceived potential impacts regarding the Western Downs, Queensland's water systems from unconventional or CSG fracking based extraction (Queensland Government, March 2013, IESC, 2014*a, b, c, d*, and OCE, 2015). First, mitigation may come from existing Commonwealth of Australia and Queensland laws and guidance in the literature review.

Second, the gas industry 'best practice', self-regulation and their general lack of transparency has not provided many perceived positive, independent survey participant responses in this thesis. These may be areas where significant mitigation may be achieved, and solutions found. As outlined in chapter 7 an environmental peacebuilding theoretical framework developed by Conca and Dabelko 2002, may be used to present cooperation as a win-win solution and escape from the zero-sum logic of conflict. It rests on the assumption that the biophysical environment's inherent characteristics can act as incentives for cooperaration and peace, rather than violence and competition (Dresse *et al*., 2018). Lucas 2018 and Lucas and Warman 2018 employ a similar, less confrontational theoretical approach. When this is combined with better CSG industry transparency, and the ongoing interpretation of social licence and corporate social responsibilty it may provide mitigation and resolution of real and perceived existing conflicts.

Third, the importance of water as a MNES (*EPBC Act 1999*). This would be facilitated by a greater systematic discussion of the issue in statutory environmental assessments. This should be explored and usefully employed, through education, further and continually ongoing, cumulative independent research and followed through with enforcement where breaches occur in the many existing laws, primarily the Commonwealth *EPBC Act 1999* and *Industrial Chemicals (Notification and Assessment) Act 1989* (*ICNA Act 1989*) and Queensland's *Petroleum and Gas (Production and Safety) Act 2004 (P&G Act)* (Parliament of Australia, 2013, IESC*, a, b, c, d,* 2014).

Fourth, some of the present IESC CSG extraction guidelines (*EPBC Act 1999*) may require upgrading to more than just 'read to comply 'status, if perceived, possible and potential impacts to water are to be taken seriously by the CSG industry.

8.5 Future Research

The future research required is outlined in the chapter 2, and the implications of the literature review and the recommendations of this section. This thesis has concentrated on just several of the research gaps discussed by the IESC, 2014. The extent of, and breadth of research required into the real, possible, potential and perceived CSG impact related studies, primarily water systems, are enormous. The development of theoretical frameworks to avoid and mitigate polarisation and environmental conflict over natural resources as discussed in chapter 7 is fundamental to the success of future research and its outcomes.

In closing Lucas and Warman 2018, stated succinctly and insightfully, environmental risk conflicts have carved 'ruts' that persist long after the resolution or relevance of the formative dispute**.** Ruts being a set of polarising social constructs that have their own momentum- comprising of storylines that appeal to certain values and definitions of the environment and are tied to the social identities of certain groups of people. 018).

8.6 Limitations of this Study

Unconventional CSG fracking based extraction has and remains a controversial research topic. The imperative of ensuring the confidentiality and safety of the research participants and the researcher cannot be understated as discussed in the ethical dilemmas chapter 3. The small participant pool of 40 persons favoured the qualitative, interpretive approach allowing the participants to speak. However, it may have lessened the study's significance. A larger pool of 1,000 anonymous participants may have lent itself to a more empirical analysis, which may be important as ongoing post-doctoral research in the Western Downs, Queensland, Australia, which is applicable globally.

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APPENDIX 1: Ethics Approval

HUMAN RESEARCH
ETHICS COMMITTEE
Bond University
Gold Coast Queensland 4229
Australia

Phone: +61 7 5595 4194
(from overseas)

Email: ethics@bond.edu.au

ABN 88 010 694 121
CRICOS Provider Code 00017B

16 May 2018

Daryl McPhee
Faculty of Society and Design
Bond University

Dear Daryl

Application ID:	**JS00398**
Project Title:	**The Impact of Coal Seam Gas (CSG) Extraction Wells On Groundwater and Surface Water Systems in the Western Downs, Queensland, Australia.**
Researchers:	**Daryl McPhee, Joseph Stroud, Bhishna Bajracharya, Tor Hundloe**

I am pleased to confirm that your project was reviewed by Bond University Human Research Ethics Committee and you have been granted approval to proceed.

The Committee requires, as a condition of approval, that all investigations be carried out in accordance with the National Health and Medical Research Council's (NHMRC) *National Statement on Ethical Conduct in Human Research* (2007). Approval is subject to conduct of the research in accordance with the requirements set out in the National Statement.

Approval is given subject to the protocol of the study being undertaken as described in your application, and approved amendments. As you may be aware the Ethics Committee is required to annually report on the progress of research it has approved. We would greatly appreciate if you could respond promptly and fully to the request for information on this project which will be distributed in March/April each year.

Under the terms of the National statement BUHREC has a role to monitor approved research projects and if necessary may withdraw approval. Conduct of unapproved research or deviation from the approved protocol may constitute academic misconduct and will be investigated in accordance with Part B of the *Australian Code for the Responsible Conduct of Research* (2007). Please refer to the Research Ethics website for more detail on Research Integrity and Bond University processes for dealing with instances of research misconduct.

You are reminded that the Principal Investigator must immediately report anything that might warrant review of ethical approval of the project. Should you have any queries or experience any problems, please contact us promptly.

We wish you well with your research project.

Yours sincerely

Dr Mark Bahr
Chair Bond University Human Research Ethics Committee

bond.edu.au

APPENDIX 2: Participant Consent Form

BOND UNIVERSITY
BRINGING AMBITION TO LIFE

FACULTY OF SOCIETY & DESIGN

Bond University
Gold Coast, Queensland 4229
Australia

Toll free 1800 650 121
(within Australia)

Ph: +61 7 5595 2522
Fax: +61 7 5595 1474
(from overseas)

Email: fsd@bond.edu.au

ABN 88 010 694 121
CRICOS CODE 00017B

Participant Consent Form

Research Project: '***The Impacts of Coal Seam Gas (CSG) Extraction on Groundwater and Surface Water Systems in the Western Downs, Queensland, Australia'.***

Project ethics application no: JS000398

I agree to take part in the above Bond University research project. I have read the Participant Information Sheet. I am willing to:

• Complete a survey

I also understand that my participation is voluntary; that I can choose not to participate in part or all of the project, and that I can withdraw freely at any stage of the project. My non-identifiable data may contribute towards publications on the research subject.

Name: .... (please print)

Signature: .... Date: ....

APPENDIX 3: Participant Information Sheet

BOND UNIVERSITY
BRINGING AMBITION TO LIFE

FACULTY OF SOCIETY & DESIGN
Bond University
Gold Coast, Queensland 4229
Australia
Toll free 1800 650 121
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Ph: +61 7 5595 2522
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Email: fsd@bond.edu.au
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CRICOS CODE 00017B

Participant Information Sheet

22th June 2018

Thesis Ethics Application Number - JS00398

'The Impact of Coal Seam Gas (CSG) Extraction Wells on Groundwater and Surface Water Systems in the Western Downs, Queensland, Australia.'

My name is Joseph Stroud and I am currently completing a PhD at Bond University under the supervision of Dr. D. McPhee and Dr. B. Bajracharya.

I am conducting a research investigation into the apparent polarisation of opinion on Coal Seam Gas extraction. I am specifically interested in your perception of this polarisation.

As part of this study, I will invite you to complete a survey on this topic. I estimate it should take you between twenty to thirty minutes.

Participation in this study is completely voluntary and you may withdraw at any time without risking any negative consequences. If you choose to withdraw your participation in this study, the information you have provided will be immediately destroyed.

Your participation in this study will enhance work towards understanding this controversial topic and help clarify why it is so.

The information I/we obtain from you will be dealt with in a manner that ensures you remain anonymous. Data will be stored in a secured location at Bond University for a period with the guidelines set out by the Bond University Human Research Ethics Committee, will be kept permanently.

It is anticipated that the data collected during this study will assist us in understanding of the potential benefits and impacts of coal seam gas extraction.

If you experience distress from participation in this research, please contact <*an appropriate Australian counselling resource*>.

Should you have any complaints concerning the manner in which this research is being conducted please make contact with –

Bond University Human Research Ethics Committee,
Bond University Office of Research Services.
Bond University, Gold Coast, 4229, Australia
Tel: +61 7 5595 4194 Fax: +61 7 5595 1120 email: ethics@bond.edu.au

We thank you for taking time to assist us with this research.

Yours sincerely,

Signed

Dr. D. McPhee

Dr. B. Bajracharya

Mr. J. Stroud

APPENDIX 4:

Anonymous Participant Questionnaire

BOND UNIVERSITY
BRINGING AMBITION TO LIFE

Participant Questionnaire

1 In your personal view has CSG extraction affected water quality in your area?

O- Very significant negative impact
O- Significant negative impact
O- Not at all
O- Significant positive impact
O- Very significant positive impact

2 There appears to be a polarisation of opinion on CSG extraction methods, particularly fracking. Do you believe this is true? If not, why?

3 Where do you obtain information on CSG extraction (you may answer more than one)?

O- Word of mouth in the community

O- Public meetings

O- Traditional media (e.g., newspapers, radio, television, etc.)

O- Online sites

O- Social media

O- Other

4 Of the sources identified in the question 3, what is the most important source of CSG extraction information?

5 How do you perceive, or view the CSG benefits compared to the possible impacts on water systems?

6 What are your personal, or first-hand experiences of CSG fracking?

7 Are you personally affected adversely, or positively by CSG extraction? How? By whom?

8 What challenges do you think we face due to CSG fracking based extraction regarding water systems (groundwater and surface water); for example, quantity use, or water quality impacts?

9 Can you think of any possible solutions to mitigate or reduce negative impacts, or increase the benefits of CSG fracking based extraction?

10 Do you think the present government guidelines are fair for all stakeholders, those with interests, positive or negative, in CSG fracking based extraction?

11 How do you believe decisions on CSG fracking based extraction should be decided regarding present and future activities involving CSG fracking based extraction?

12 Are the existing control mechanisms for CSG extraction sufficient? For example: Australian Petroleum Production and Exploration Association's (APPEA) 'best practice' approach; and

the Commonwealth and State laws and guidelines governing CSG fracking based extraction. If so, how and why? If not, how and why?

13 If changes to CSG extraction are required, what do you believe should be done, and by whom to protect water systems?

14 Is there any further information, or comment you would like to provide?

For additional space please write overleaf

We thank you for your time spent taking this survey.
Your response has been recorded.

APPENDIX 5: Other Chemicals Used in CSG Extraction Fracking Fluid

-Nitrogen for proppant suspension

-Crystalline silica (sand and quartz)

-Glycerine as an additive

-Methyl-isothiazol used to eliminate bacteria in the water that produces corrosive by- products

-Hydrochloric acid used to help to dissolve minerals and initiate cracks in rock

-Glutaraldehyde used to help eliminate bacteria in the water that produces corrosive by-products

-Quaternary Ammonium Chloride used to help eliminate bacteria in the water that

produces corrosive by-products

-Ammonium Persulphate used to allow a delayed break down of the gel

-Sodium Chloride used as a product stabiliser

-Magnesium Peroxide used to allow a delayed break down of the gel

-Magnesium Oxide used as a product stabiliser

-Calcium Chloride used to prevent clays from swelling or shifting

-Choline Chloride used to prevent clays from swelling of shifting

-Sodium Chloride used to prevent clays from swelling and shifting

-Isopropanol used as a product stabiliser and/or wintering agent

-Methanol used as a product stabiliser and/or wintering agent

-Formic acid used to prevent corrosion of the pipe

-Acetaldehyde used to prevent corrosion of the pipe

-Petroleum Distillate used as a carrier for borate or zicornate crosslinker

-Hydrotreated Light Petroleum Distillate used for a borate or zicornate crosslinker

-Potassium Metaborate used to maintain fluid viscosity as temperature increases

-Triethanolamie Zirconite used to maintain fluid viscosity as temperature increases

-Sodium Tetraborate used to maintain fluid viscosity as temperature increases

-Boric Acid used to maintain fluid viscosity as temperature increases

-Zirconium Complex used to maintain fluid viscosity as temperature increases

-Borate Salts used to maintain fluid viscosity as temperature increases

-Ethylene Glycol used as a product stabiliser and/or a wintering agent

-Methanol used as a product stabiliser and/or wintering agent

-Polyacrylamide use apparently 'slicks' the water to minimize friction

-Petroleum Distillate used as a carrier fluid for polyacrylamide friction reducer

-Hydrotreated Light petroleum distillate used as a carrier fluid for polyacrylamide friction reducer

-Methanol used as a product stabiliser and/or wintering agent

-Ethylene Glycol used as a product stabiliser and/or wintering agent

-Guar Gum use thickens the water in order to suspend the sand

-Petroleum Distillate used as a carrier fluid for guar gum in liquid cells

-Hydrotreated Light petroleum distillate used as a carrier fluid for guar gum in liquid cells

-Methanol used as a product stabiliser and/or wintering agent

-Polysaccharide blend use thickens the water in order to suspend the sand

-Ethylene Glycol used as a product stabiliser and/or wintering agent

-Citric Acid used to prevent precipitation of metal oxides

-Acetic Acid used to prevent precipitation of metal oxides

-Thioglycolic Acid used to prevent precipitation of metal oxides

-Sodium Erythorbate used to prevent precipitation of metal oxides

-Lauryl Sulphate used to prevent formation of emulsions in fracture fluid

-Isopropanol used as a product stabiliser and/or wintering agent

-Ethylene Glycol used as a product stabiliser and/or wintering agent

-Sodium Hydroxide used to adjust the pH of fluid

-Potassium Carbonate used to adjust the pH of fluid

-Acetic acid used to adjust the pH of fluid

-Sodium Carbonate used to adjust the pH of fluid

-Potassium Carbonate used to adjust the pH of fluid

-Copolymer of Acrylamide, Sodium Acrylate used to prevent scale deposits in the pipe

-Sodium Polycarboxide used to prevent scale deposits in the pipe

-Phosphonic Acid Salt used to prevent scale deposits in the pipe

-Lauryl Salt used to increase the viscosity of the fracture fluid

-Ethanol used as a product stabiliser and/or wintering agent

-Napthalene used as a carrier for the active surfactant ingredients

-Methanol used as a product stabiliser and/or wintering agent

-Isopropyl Alcohol used as a product stabiliser and/or wintering agent

-2-Butoxethanol used as a product stabiliser

Lloyd-Smith and Senjen (2011) found that though they might be in low concentrations the effects of the complex mixture of chemicals on the environment was not well understood and there were no water quality guidelines for many compounds. Many of the chemical compounds have demonstrated human health effects, e.g., skin exposure to sodium Persulphate can lead to sensitization, ethylene glycol is a respiratory toxicant, napthalene is a potential carcinogen and isopropanol is a reproductive toxicant. Hemicellulase enzyme concentrate, ethoxylated 4-nonyphenol are also used in CSG fracking, amongst some 980 chemicals used in the gas industry (Lloyd-Smith & Senjen, 2011).

Source: Lloyd-Smith & Senjen, (2011) (APPEA, Australian Government) table, retrieved from https://www.environment.gov.au/about-us/publications/archive#water Creative Commons Licence CC BY 4.0

APPENDIX 6: Other Additives, Chemicals and Chemical Compounds that May be Used as Fracking Proppants Chemicals which may be used in the hydraulic fracturing process

It has been estimated that there could be up to 980 different fracking additives. Ferrer and Thurman 2015 stated 2500 hydraulic fracking products derived from 750 chemicals.

Chemical name	Purpose	Percentage of fracturing fluid
Water	Proppant suspension	98.5-99.6%
Nitrogen	Proppant suspension	
Crystalline silica (sand and quartz)	Proppant	
Glycerine	Additive	<1.5% in total
Methyl-isothiazol	Eliminates bacteria in the water that produces corrosive by-products	
Hydrochloric acid	Helps dissolve minerals and initiate cracks in rock	
Glutaraldehyde	Eliminates bacteria in the water that produces corrosive by-products	
Quaternary Ammonium Chloride	Eliminates bacteria in the water that produces corrosive by-products	
Phosphonium Sulfate	Eliminates bacteria in the water that produces corrosive by-products	
Ammonium Persulfate	Allows a delayed break down of the gel	
Sodium Chloride	Product stabiliser	
Magnesium Peroxide	Allows a delayed break down of the gel	
Magnesium Oxide	Product stabiliser	
Calcium Chloride	Prevents clays from swelling or shifting	
Choline Chloride	Prevents clays from swelling or shifting	
Tetramethyl ammonium chloride	Prevents clays from swelling or shifting	
Sodium Chloride	Prevents clays from swelling or shifting	
Isopropanol	Product stabilizer and/or wintering agent	
Methanol	Product stabilizer and/or wintering agent	
Formic Acid	Prevents corrosion of the pipe	

Acetaldehyde	Prevents corrosion of the pipe	
Petroleum Distillate	Carrier fluid for borate or zicornate crosslinker	
Hydrotreated Light Petroleum Distllate	Carrier fluid for borate or zicornate crosslinker	
Potassium Metaborate	Maintains fluid viscosity as temperature increases	

Chemical name	**Purpose**	**Percentage of fracturing fluid**
Triethanolamie Zirconate	Maintains fluid viscosity as temperature increases	
Sodium Tetraborate	Maintains fluid viscosity as temperature increases	
Boric Acid	Maintains fluid viscosity as temperature increases	
Zirconium Complex	Maintains fluid viscosity as temperature increases	
Borate Salts	Maintains fluid viscosity as temperature increases	
Ethylene Glycol	Product stabilizer and/or wintering agent	
Methanol	Product stabilizer and/or wintering agent	
Polyacrylamide	'Slicks' the water to minimise friction	
Petroleum Distillate	Carrier fluid for polyacrylamide friction reducer	
Hydrotreated Light petroleum distillate	Carrier fluid for polyacrylamide friction reducer	
Methanol	Product stabilizer and/or wintering agent	
Ethylene Glycol	Product stabilizer and/or wintering agent	
Guar Gum	Thickens the water in order to suspend the sand	
Petroleum Distillate	Carrier fluid for guar gum in liquid cells	
Hydrotreated Light petroleum distillate	Carrier fluid for guar gum in liquid cells	
Methanol	Product stabilizer and/or wintering agent	
Polysaccharide blend	Thickens the water in order to suspend the sand	
Ethylene Glycol	Product stabilizer and/or wintering agent	
Citric Acid	Prevents precipitation of metal oxides	
Acetic Acid	Prevents precipitation of metal oxides	
Thioglycolic Acid	Prevents precipitation of metal oxides	
Sodium Erythorbate	Prevents precipitation of metal oxides	
Lauryl Sulfate	Prevents formation of emulsions in fracture fluid	
Isopropanol	Product stabilizer and/or wintering agent	
Ethylene Glycol	Product stabilizer and/or wintering agent	

Ethylene Glycol	Product stabilizer and/or wintering agent	
Sodium Hydroxide	Adjusts the pH of fluid	
Potassium Hydroxide	Adjusts the pH of fluid	
Acetic Acid	Adjusts the pH of fluid	
Sodium Carbonate	Adjusts the pH of fluid	
Potassium Carbonate	Adjusts the pH of fluid	
Copolymer of Acrylamide, Sodium Acrylate	Prevents scale deposits in the pipe	
Sodium Polycarboxylate	Prevents scale deposits in the pipe	

Chemical name	Purpose	Percentage of fracturing fluid
Phosphonic Acid Salt	Prevents scale deposits in the pipe	
Lauryl Salt	Used to increase the viscosity of the fracture fluid	
Ethanol	Product stabilizer and/or wintering agent	
Napthalene	Carrier fluid for the active surfactant ingredients	
Methanol	Product stabilizer and/or wintering agent	
Isopropyl Alcohol	Product stabilizer and/or wintering agent	
2-Butoxyethanol	Product stabilizer	

Source: Lloyd-Smith and Senjen, (2011), APPEA (www.appea.com.au) table, retrieved from https://www.environment.gov.au/about-us/publications/archive#water Creative Commons Licence CC BY 4.0

APPENDIX 7: Summary of the Fluids and Particles Used in Hydraulic Fracturing Fluid in Australia

Injected substance	Purpose	Products used	CAS number	Notes
Water	Fractures the coal when injected under high pressure	Bore water, farm pond water or groundwater previously extracted from coal seams is often used	7732-18-5	Volume of water required is ~0.2 to 1.3 ML per well (USEPA 2011)
Proppant	Keeps the fractures open once the high pressure fluid is removed	Sand Resin-coated sand Ceramics Bauxite (aluminium ore)	99439-28-8 None or proprietary 66402-68-4 90669-62-8	The latest technology advances in proppants include high strength ceramics and sintered bauxite
Acid	Dissolves calcite in the coal prior to fracturing	Hydrochloric acid Muriatic acid Acetic acid	7647-01-0 75-00-3 64-19-7	Not all wells require this treatment because coal seams do not always contain calcite
Gelling agent or Clay stabilisers	Increases the viscosity of the fluid, to allow more proppant to be carried into fractures	Guar gum Starches Cellulose derivatives Polydimethyldiallylammonium chloride (Claytrol) Tetramethylammonium chloride (Claytreat 3C)	None or proprietary 9005-25-8 9004-34-6 26062-79-3 75-57-0	Not all hydraulic fracturing uses a gel; gel-free fracturing is termed 'slickwater'
Crosslinker	Increase the viscosity of gelling agents	Borate salt Ethyl glycol Isopropanol Disodium octaborate tetrahydrate Boric acid Boric oxide	1330-43-4 107-21-1 67-63-0 12280-03-4 52869-79-1 1303-86-2	There are different crosslinkers for different gelling agents

Injected substance	Purpose	Products used	CAS number	Notes
Biocide	Limits or prevents growth of bacteria that could damage the gelling agent	Glutaraldehyde 2,2-Dibromo-2-cyanoacetamide (DBNPA) Tetrakis(hydroxymethyl)phosphonium sulfate (THPS, Magnacide 575) bronopol (2-bromo-2-nitropropane-1,3-diol) Sodium hypochlorite Sodium thiosulfate Boric acid Caustic soda	111-30-8 10222-01-2 55566-30-8 52-51-7 7681-52-9 7681-52-9 7772-98-7 10043-35-3	The natural polymer gelling agents are good food for bacteria so they encourage bacterial growth - biocides kill these bacteria
pH buffer	Keeps the pH of the fluid in a specified range	Acetic acid Sodium hydroxide Potassium carbonate Sodium carbonate,	64-19-7 1310-73-2 584-08-7 497-19-8	Required for the stability of crosslinked polymers
Breaker	Chemically break the bonds of the gel in order to reduce the viscosity back to that of water	Hydrogen peroxides Sodium persulfate Diammonium peroxidisulphate	7722-84-1 7775-27-1 7727-54-0	Only required if a gel is used
Corrosion scale inhibitors		Aloe resin n,n-dimenthyl formamide Methanol Nonyl phenol	None or proprietary 68-12-2 67-56-1 68152-92-1	
Friction reducers	Reduce fluid surface tension	Oxyalkylated alcohol	None or proprietary	
Other additives	Includes foamers, gel stabilisers, clay stabilisers, preservatives, surfactants	Terpenes and terpenoids Sweet orange oil Polyacrylamide Alcohols n,n-dimenthyl formanide Citric acid Ammonium bisulfite Ethylene glycol Potassium chloride	65996-96-5 68647-72-3 25085-02-3 None or proprietary 68-12-2 77-92-9 7803-63-6 107-21-1 7447-40-7	Operators in NSW and Queensland are required to disclose a full list of additives prior to hydraulic fracturing

Source: Economides & Martin, (2007), Golder Associates, (2010*b*), DEHP (2012*b*), APLNG (2011), AGL, (2011), Santos, (2011), QGC, (2011), Arrow Energy, (2012*b*) table, retrieved from https://www.environment.gov.au/about-us/publications/archive#water Creative Commons Licence CC BY 4.0.

APPENDIX 8: Typical CSG Co-Produced Water Quality from Data Collected from Across Australia and Typical Guideline Values

Water quality variable	Unit	Min	Max	Guideline trigger value range	Guideline description from ANZECC 2000
TDS	mg/L	200	10000	1000	Recreation
SAR	mg/L	16	567	2-102	Primary industries (irrigation)
Temperature	C	22	32	20^{th}-80^{th} percentile	Aquatic ecosystems
pH	pH	7	9.1	6.5-9.0^{+}	Aquatic ecosystems
EC	µS/cm	200	16000	30-5000^{+}	Aquatic ecosystems
SS	mg/L	9	2669	<40	Primary industries (aquaculture)
Colour (Apparent)	PCU	125	340		No guideline recommended
Colour (True)	PCU	5	14.5		No guideline recommended
UV Transmission @ 254nm	%	99.7	99.98		No guideline recommended
Turbidity	NTU	230	935	0.5-200^{+}	Aquatic ecosystems
Total Hardness as $CaCO_3$	mg/L	39	185	500	Recreation
Hydroxide Alkalinity as $CaCO_3$	mg/L	0	1		No guideline recommended
Carbonate Alkalinity as $CaCO_3$	mg/L	36.5	600		No guideline recommended
Bicarbonate Alkalinity as $CaCO_3$	mg/L	580	8200		No guideline recommended
Total Alkalinity as $CaCO_3$	mg/L	899.5	1460		No guideline recommended
Sodium	mg/L	35	4500	3000	Recreation
Calcium	mg/L	0.5	49	1000	Primary industries (stock watering)
Magnesium	mg/L	0.7	16	2000	Primary industries (stock watering)
Iron	mg/L	1	25	0.2-10	Primary industries (irrigation)
Barium	mg/L	1	10	1	Recreation

Water quality variable	Unit	Min	Max	Guideline trigger value range	Guideline description from ANZECC 2000
Chloride	mg/L	150	2500	400	Recreation
Sulphate	mg/L	1	10	400	Recreation
Silicon	mg/L	7	20		No guideline recommended
Potassium	mg/L	1	300		No guideline recommended
Boron	mg/L	0.05	3.1	0.37	Aquatic ecosystems
Aluminium	mg/L	0.01	0.3	0.055#	Aquatic ecosystems
Arsenic	mg/L	0.001	0.0065	0.013	Aquatic ecosystems
Beryllium	mg/L	0.001	0.001	0.1-0.5	Primary industries (irrigation)
Cadmium	mg/L	0.0001	0.0002	0.0002	Aquatic ecosystems
Chromium	mg/L	0.005	0.3	0.001	Aquatic ecosystems
Copper	mg/L	0.001	0.2	0.0014	Aquatic ecosystems
Lead	mg/L	0.001	0.2	0.0034	Aquatic ecosystems
Manganese	mg/L	0.004	0.3	1.9	Aquatic ecosystems
Nickel	mg/L	0.0001	0.003	0.011	Aquatic ecosystems
Selenium	mg/L	0.001	0.01	0.011	Aquatic ecosystems
Zinc	mg/L	0.005	0.15	0.008	Aquatic ecosystems
Bromine	mg/L	1	12		No guideline recommended
Mercury	mg/L	0.0001	0.001	0.0006	Aquatic ecosystems
Silica	mg/L	15.6	20		No guideline recommended
Fluoride	mg/L	0.4	5.9	1-2	Primary industries (irrigation)
Nitrite and Nitrate as N	mg/L	0.01	0.01	0.005-0.2	Aquatic ecosystems
Sulphide	mg/L	0.1	0.1	0.05	Recreation
TOC	µg/L	2000	3900		No guideline recommended
C6-C9 Fraction	µg/L	20	20		No guideline recommended
C10-C14 Fraction	µg/L	50	50		No guideline recommended
C15-C28 Fraction	µg/L	100	100		No guideline recommended
C29-C36 Fraction	µg/L	50	113		No guideline recommended
1,2-Dichloroethane-D4	µg/L	118	120	ID	Aquatic ecosystems
Toluene-D8	µg/L	94.6	98.22	ID	Aquatic ecosystems

Water quality variable	Unit	Min	Max	Guideline trigger value range	Guideline description from ANZECC 2000
4-Bromofluorobenzene	μg/L	99.2	102.9		No guideline recommended

+ - specific guideline depends on geography (southeast Australia, tropical Australia, southwest Australia, south central Australia), receiving environment (upland river, lowland river, freshwater lakes and reservoirs, wetlands) or beneficial use.

ID - insufficient data to determine guidelines.

- dependent on ph.

Source: SKM, (2011), ANZECC/ARMCANZ, (2000) table, retrieved from https://www.environment.gov.au/about-us/publications/archive#water

APPENDIX 9: Summary of Treatment Options Available for CSG Co-Produced Water

Treatment option	Description	Contaminant removal	Suitability/Application	Limitations	Additional process requirements	Waste
Membrane Desalination (RO)	Water subject to high pressure through a semi-permeable membrane for separation of contaminants	Broad constituents including salt, heavy metals and trace organic matters	Well-suited for broad ranges of dissolved contaminants, including TDS, heavy metals and organics	Stringent pre-treatment required. High energy demand. May not remove all contaminants to minimum levels. May make water too clean for receiving environment.	Multi-media or membrane filtration. Post-treatment, including chemical adjustment (for SAR). Ion exchange for improving recovery	High concentration brine
Electrodialysis (ED) and Electrodialysis Reversal (EDR)	An electrochemical process in which ions migrate through ion-selective semi-permeable membranes as a result of their attraction to two electrically-charged electrodes	Broad constituents, including salt and heavy metals	Well-suited for removal of TDS, mainly for charged contaminants, including salts and heavy metals	No removal of uncharged forms of contaminants. Not economical for feed TDS > 4000 mg/L.	Filtration – for SS removal. GAC/Advanced oxidation/wetl and for the removal of uncharged forms of contaminants	High concentration brine
Thermal Desalination	Water subjected to a phase change for purification	Broad constituents, including salt, heavy metals and trace organic matters	Well-suited for broad ranges of dissolved contaminants, including TDS, heavy metals and organics	High energy demand unless heat source is already available.	Post-treatment, including chemical adjustment	High concentration brine

Treatment option	Description	Contaminant removal	Suitability/Application	Limitations	Additional process requirements	Waste
Ion Exchange	Charged resin replaces conductive salts with replacement ions (e.g. H^+ and OH^-)	Targeted contaminant removal	Not practical for gross TDS removal. May be suited for reduction of targeted contaminants and/or pre-treatment for the desalination processes	No reduction in salinity. Irreversible organic matter adsorption.	None	Regeneration fluid with high salt content
Ion Exchange	Charged resin replaces conductive salts with replacement ions (e.g. H^+ and OH^-)	Targeted contaminant removal	Not practical for gross TDS removal. May be suited for reduction of targeted contaminants and/or pre-treatment for the desalination processes	No reduction in salinity. Irreversible organic matter adsorption.	None	Regeneration fluid with high salt content
Advanced Oxidation	Generation and use of hydroxyl radical for destruction of trace organic contaminants and micro-organisms	Microorganisms and trace organics	Well-suited for post-treatment to target specific trace organic contaminants as necessary	No reduction in salinity. Effectiveness highly influenced by contaminant levels.		None
Granular Activated Carbon	Adsorption of dissolved organics onto activated carbon	Trace organics and heavy metals	Well-suited for post-treatment as necessary	No reduction in salinity. Blockage of media by solids. Ineffective at high organic concentrations.	Filtration – reduction of suspended solids required	Spent GAC

Clarification	Removal of suspended solids via gravity/floatation	Suspended solids and algae	Well-suited for pre-treatment for subsequent filtration process and provides ad hoc removal of excessive suspended solids	No reduction in salinity		Captured solids and coagulant residuals
Filtration	Suspended solids removed by filtering media or membrane	Suspended solids	Well-suited as a pre-treatment to remove suspended solids for desalination	No reduction in salinity	Screening required for gross solids	Waste backwash water with high suspended solids content
Wetland	Biological removal and plant uptake of nutrients and minerals. Sorption by the sediments in the wetland	Nutrients, organic matters and heavy metals	Well-suited for product polishing to remove trace elements/nutrients prior to discharge	Unfeasible for salinity reduction. Large footprint.	Up-front primary treatment	Vegetation clippings/ periodical removal of sediments

Source: SKM, (2011) table, retrieved from https://www.environment.gov.au/about-us/publications/archive#water Creative Commons Licence CC BY 4.0

Appendix 10: Chapter 5 NVivo Text Content Study Word Trees and Word Clouds

5.3.1 Response 2 Group A

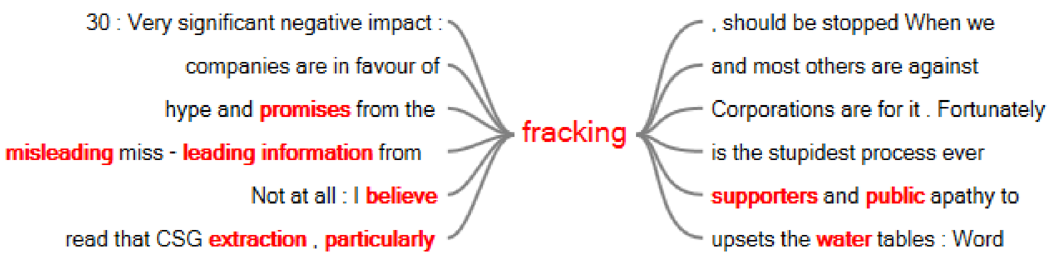


Figure 5.2: Response 2 Group A

5.3.2 Response 2 Group B

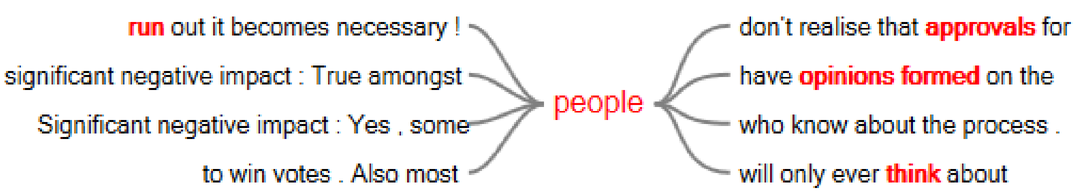


Figure 5.3: Response 2 Group B

5.3.3 Response 2 Group C

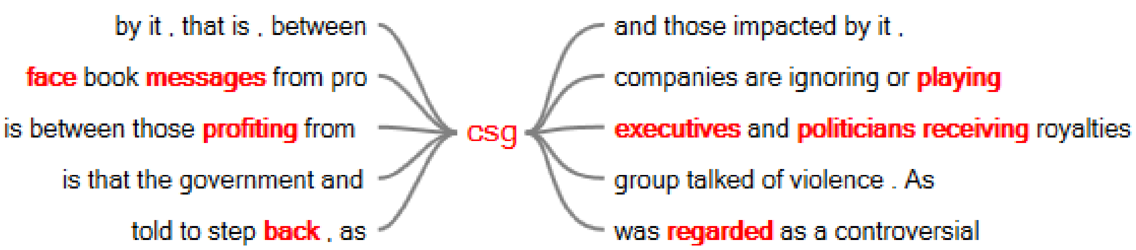


Figure 5.4: Response 2 Group C

5.3.4 Response 2 Group D

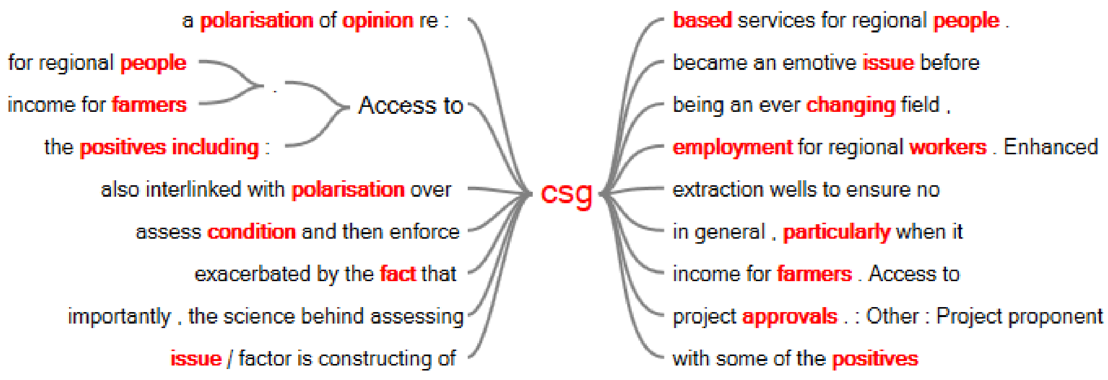


Figure 5.5: Response 2 Group D

5.3.5 Response 2 Groups A, B, C and D

Figure 5.6: Response 2 Groups A, B, C and D

5.5.1 Response 4 Group A

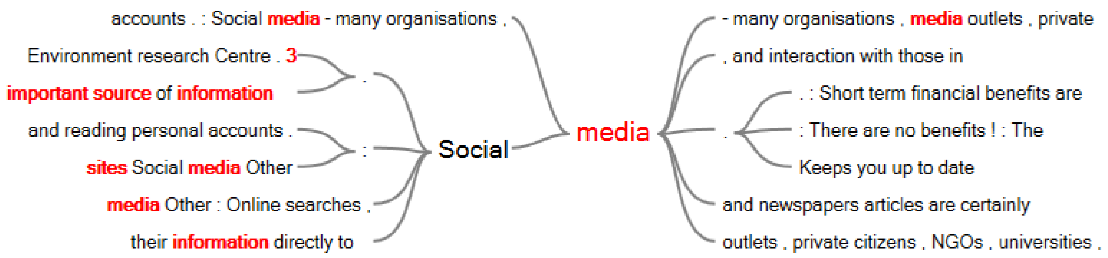


Figure 5.8: Response 4 Group A

5.5.2 Response 4 Group B

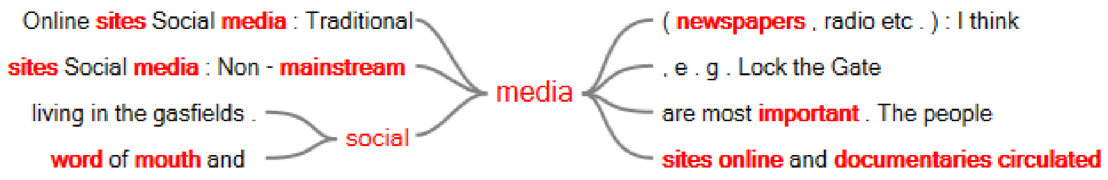


Figure 5.9: Response 4 Group B

5.5.3 Response 4 Group C

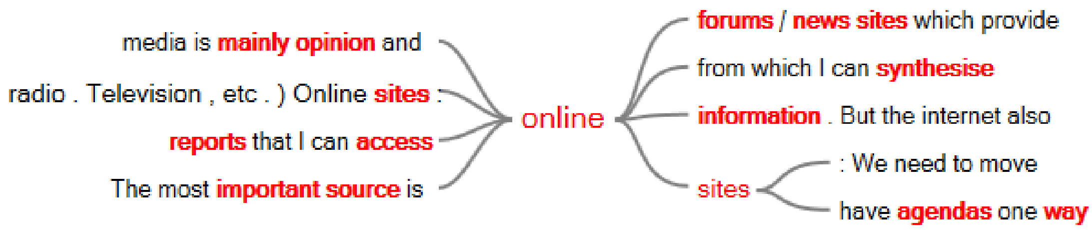


Figure 5.10: Response 4 Group C

5.5.4 Response 4 Group D

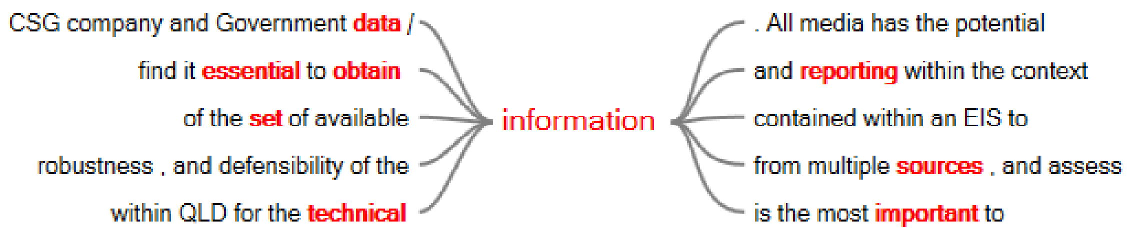


Figure 5.11: Response 4 Group D

5.5.5 Response 4 Groups A, B, C and D

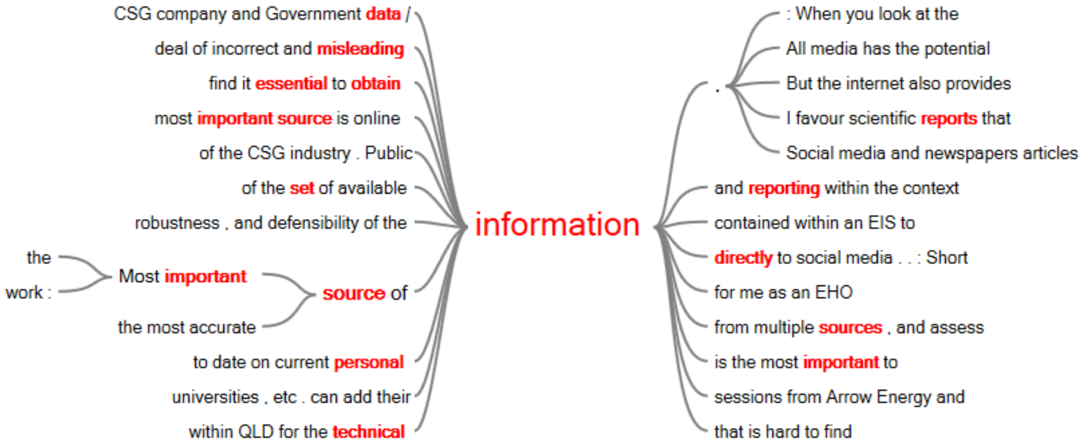


Figure 5.12: Response 4 Groups A, B, C and D

5.6.1 Response 5 Group A

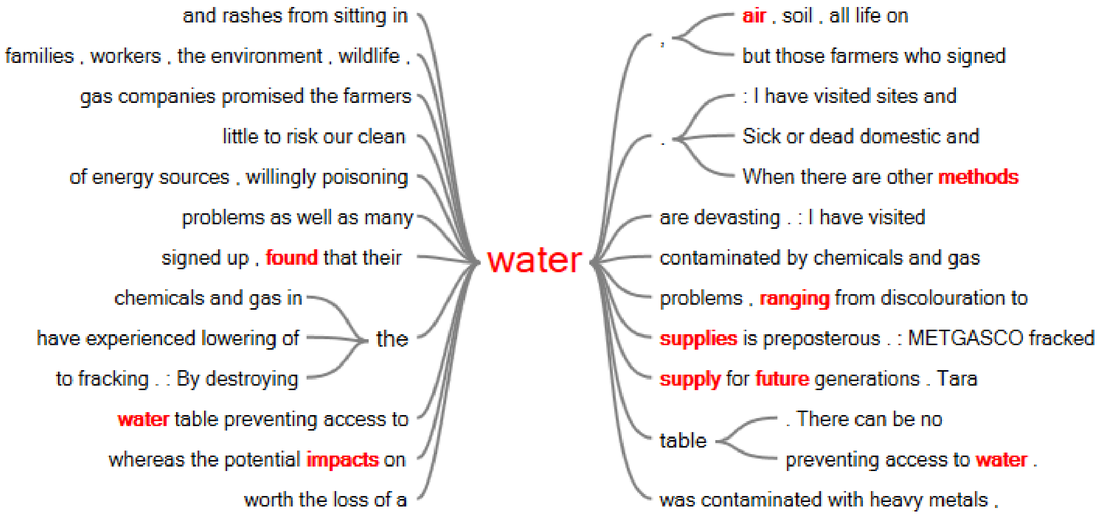


Figure 5.13: Response 5 Group A

5.6.2 Response 5 Group B

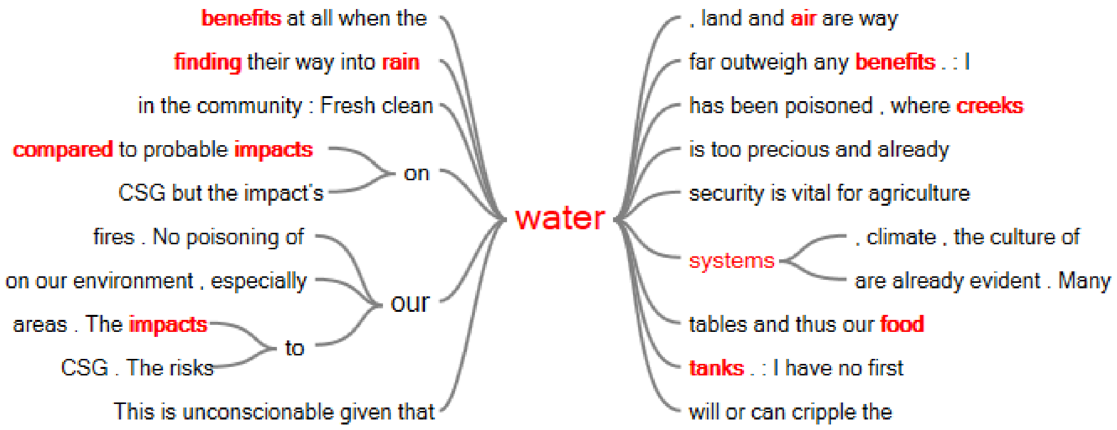


Figure 5.14: Response 5 Group B

5.6.3 Response 5 Group C

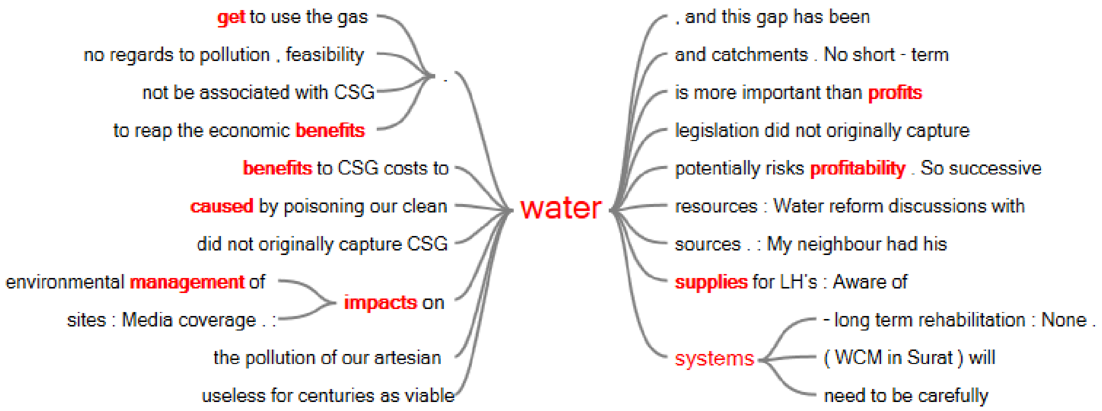


Figure 5.15: Response 5 Group C

5.6.4 Response 5 Group D

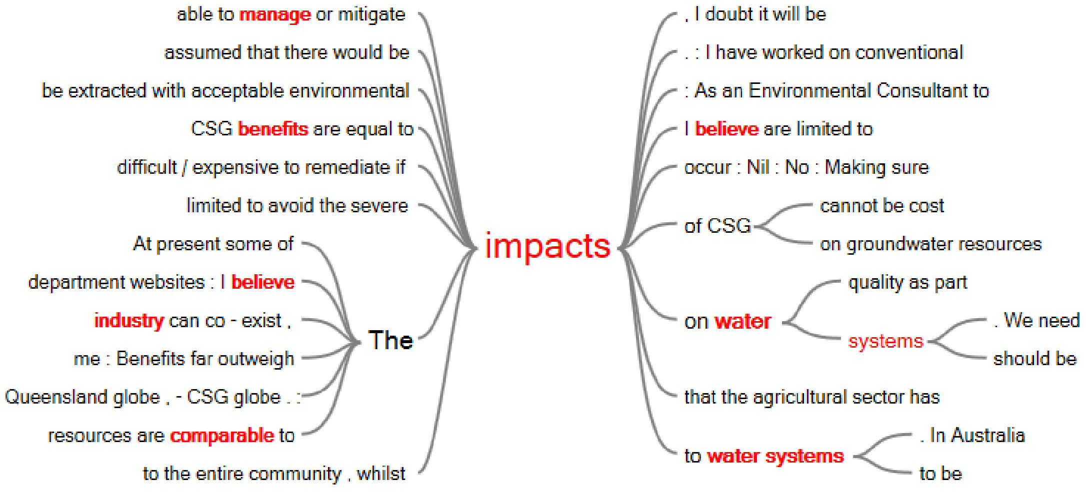


Figure 5.16: Response 5 Group D

5.6.5 Response 5 Groups A, B, C and D

Figure 5.17: Response 5 Groups A, B, C and D Word Cloud

5.7.1 Response 6 Group A

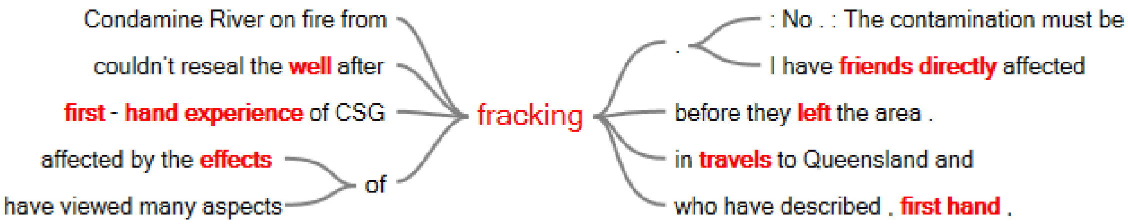


Figure 5.18: Response 6 Group A

5.7.2 Response 6 Group B

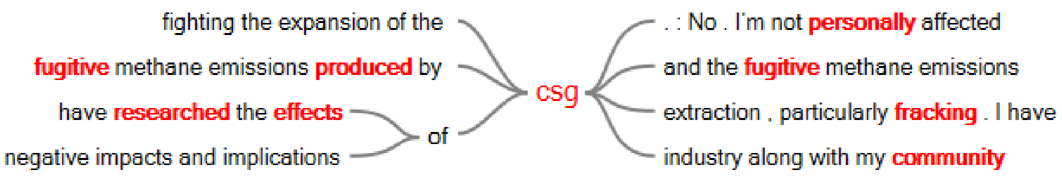


Figure 5.19: Response 6 Group B

5.7.3 Response 6 Group C

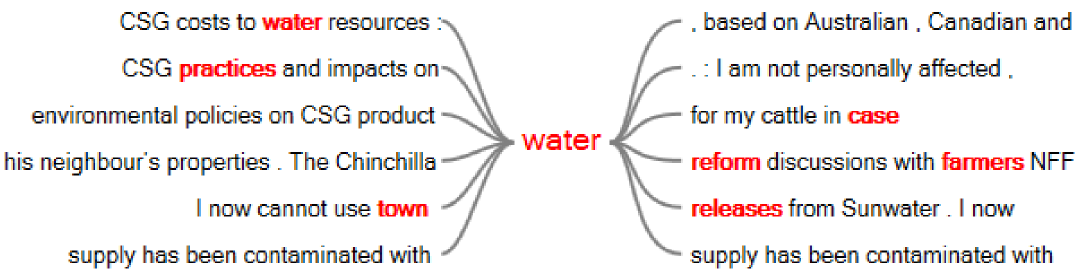


Figure 5.20: Response 6 Group C

5.7.4 Response 6 Group D

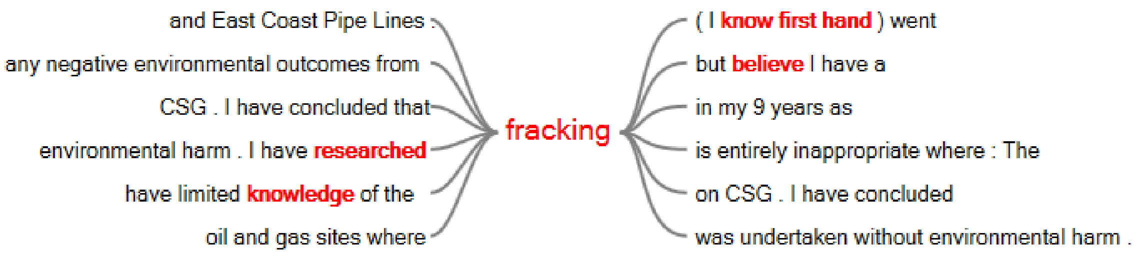


Figure 5.21: Response 6 Group D

5.7.5 Response 6 Groups A, B, C and D

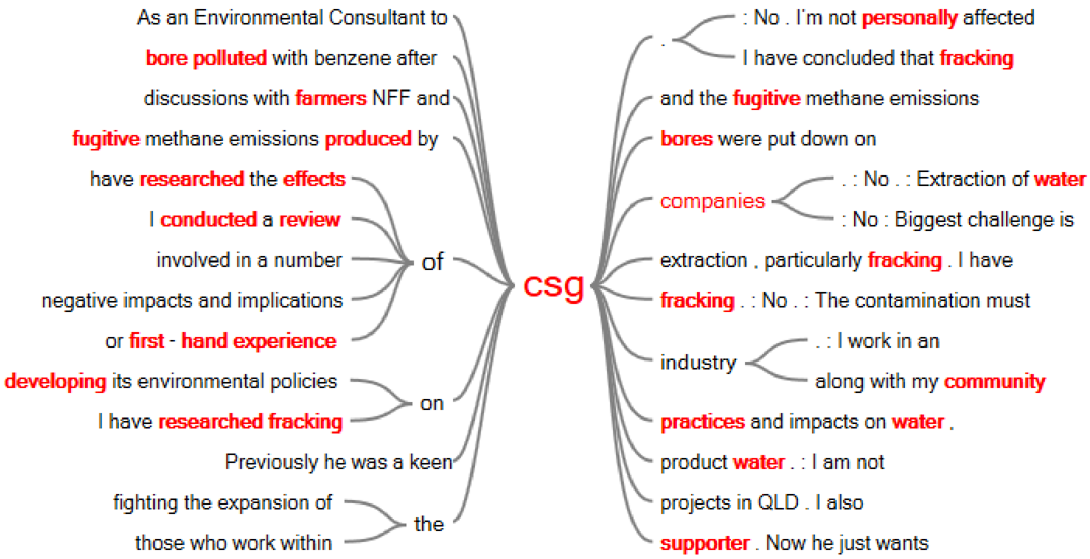


Figure 5.22: Response 6 Groups A, B, C and D

5.8.1 Response 7 Group A

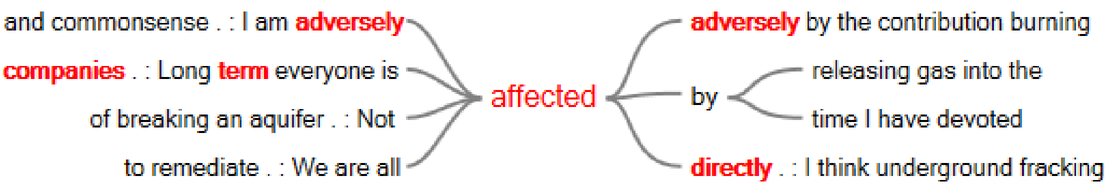


Figure 5.23: Response 7 Group A

5.8.2 Response 7 Group B

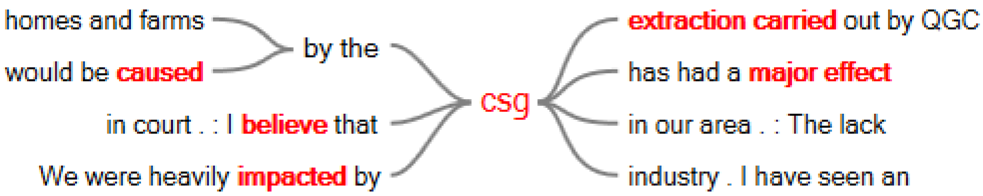


Figure 5.24: Response 7 Group B

5.8.3 Response 7 Group C

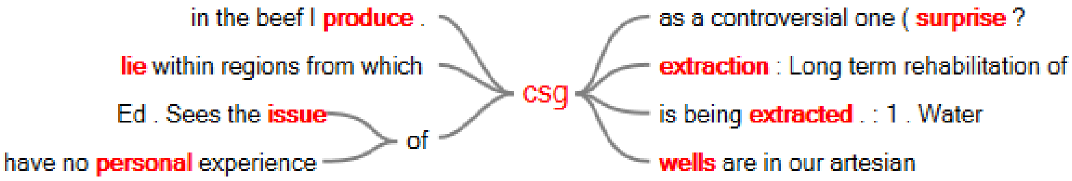


Figure 5.25: Response 7 Group C

5.8.4 Response 7 Group D

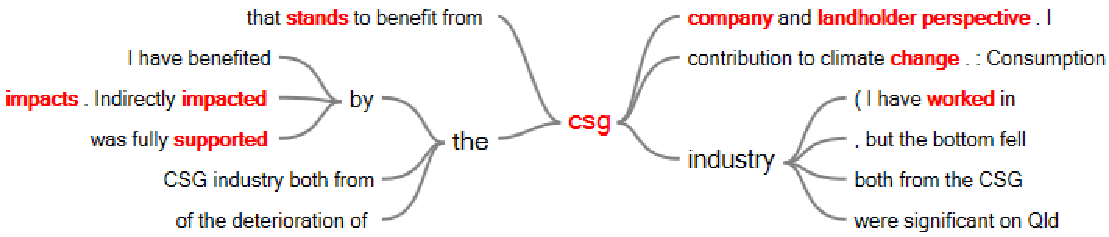


Figure 5.26: Response 7 Group D

5.8.5 Response 7 Groups A, B, C and D

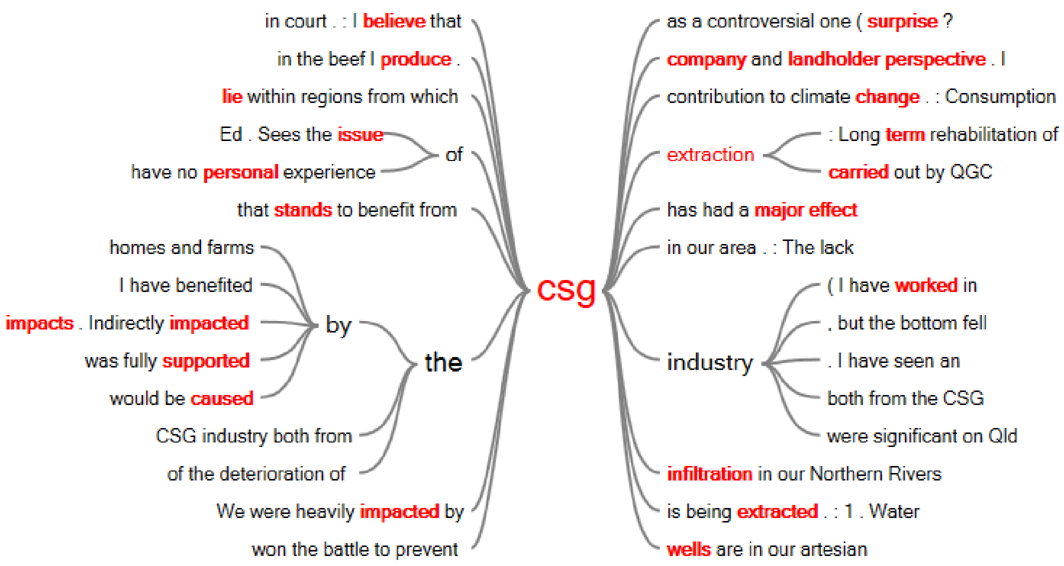


Figure 5.27: Response 7 Groups A, B, C and D

5.9.1 Response 8 Group A

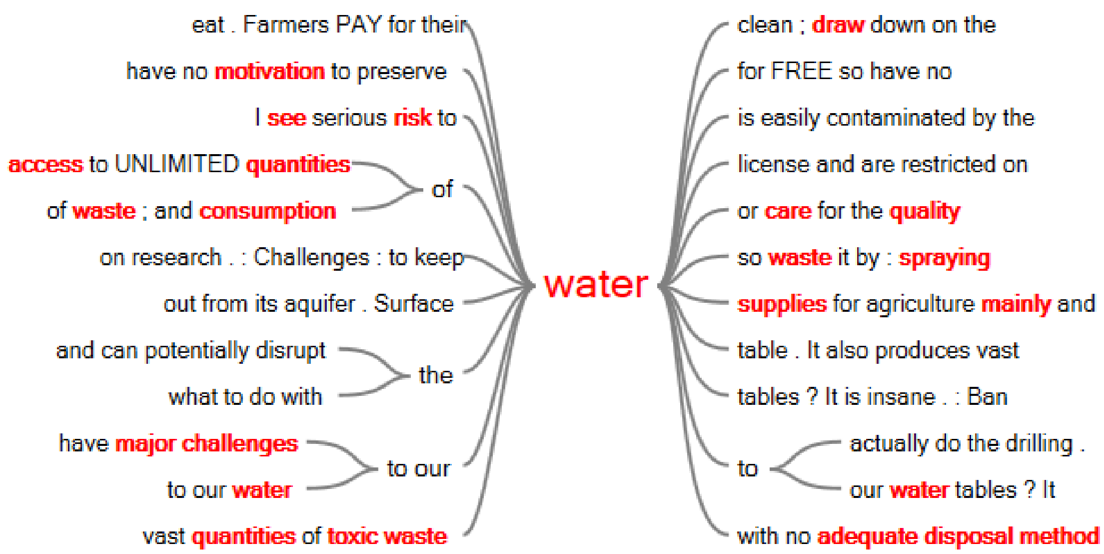


Figure 5.28: Response 8 Group A

5.9.2 Response 8 Group B

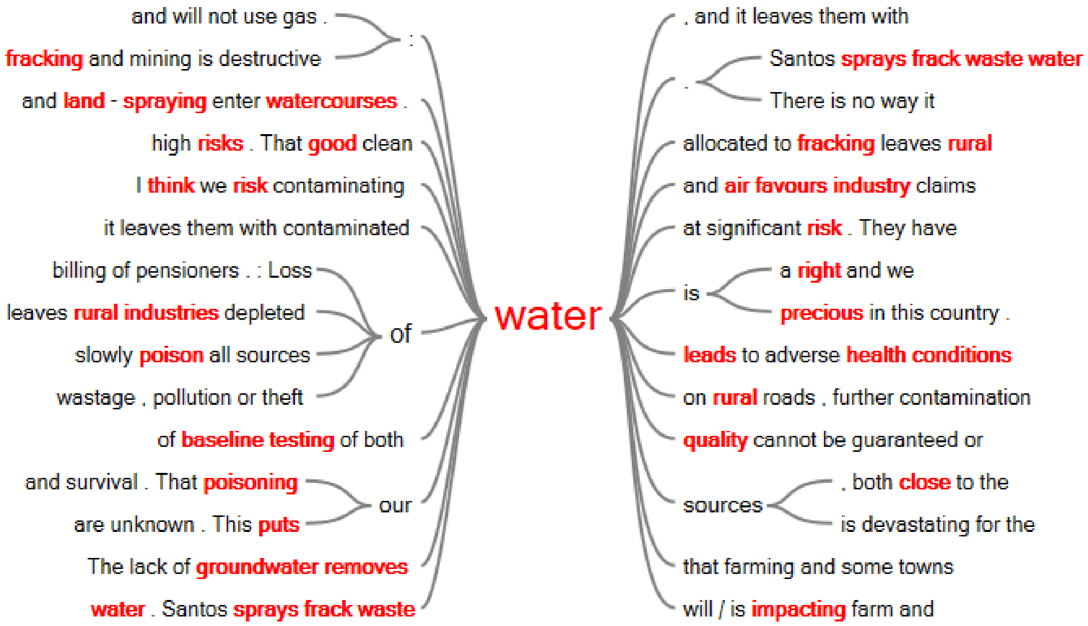


Figure 5.29: Response 8 Group B

5.9.3 Response 8 Group C

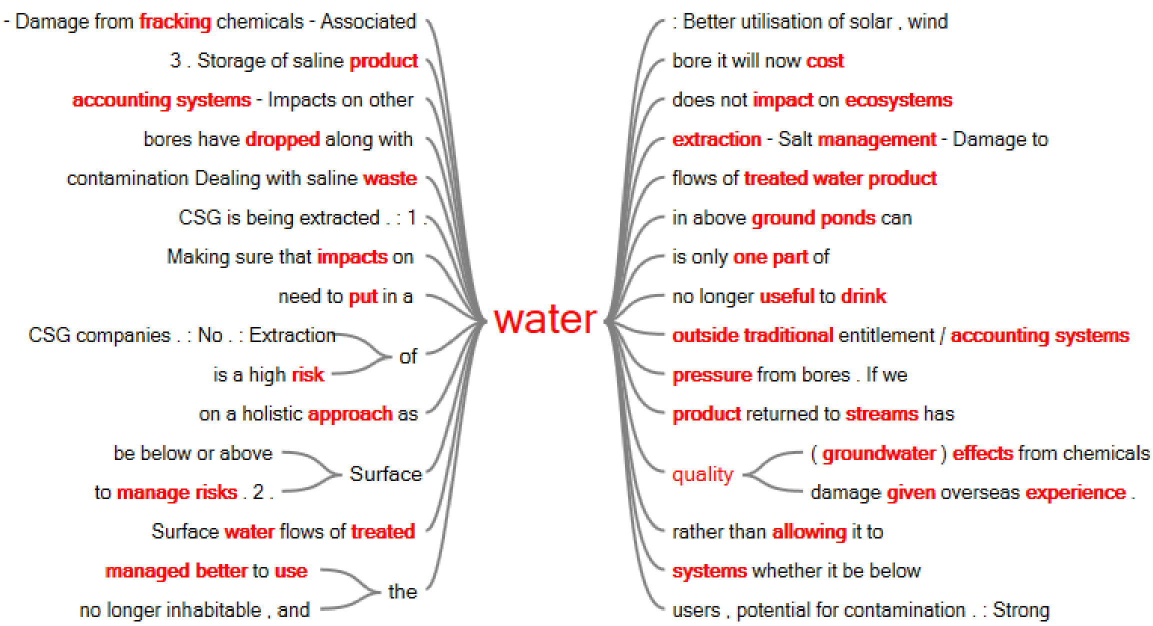


Figure 5.30: Response 8 Group C

5.9.4 Response 8 Group D

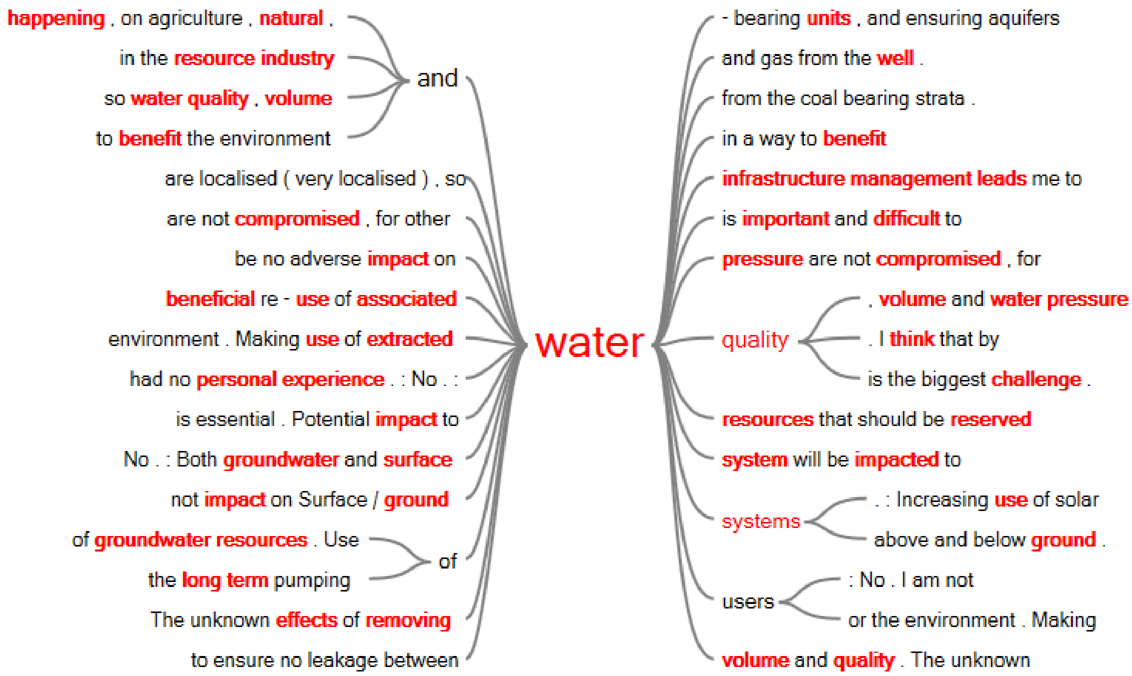
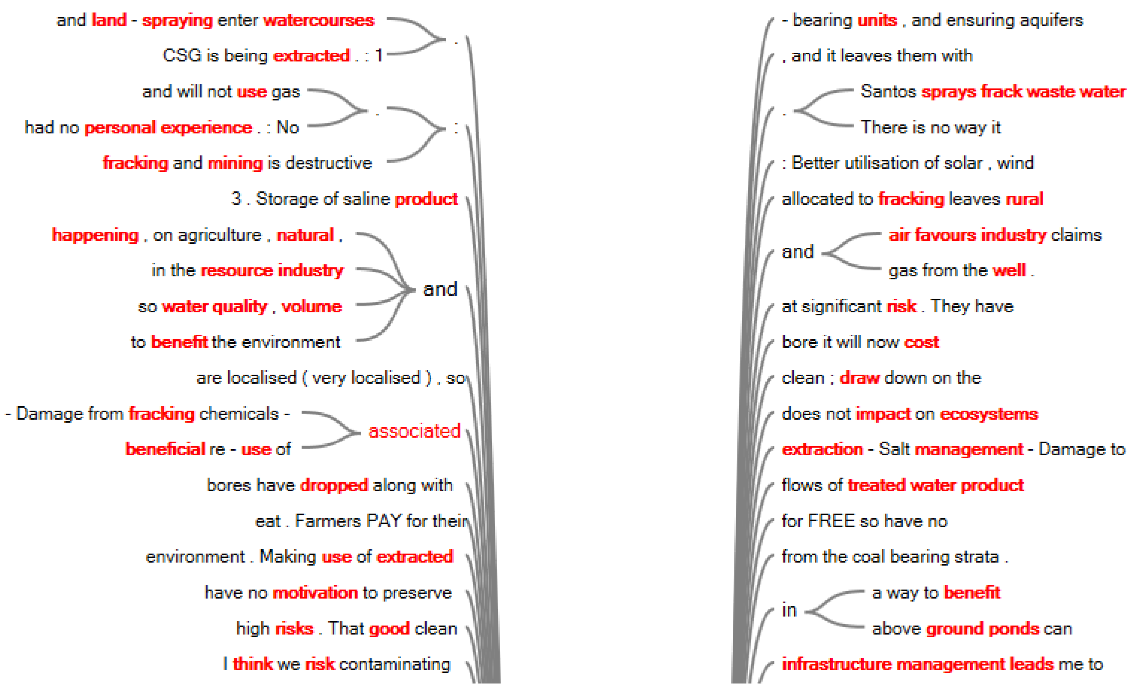
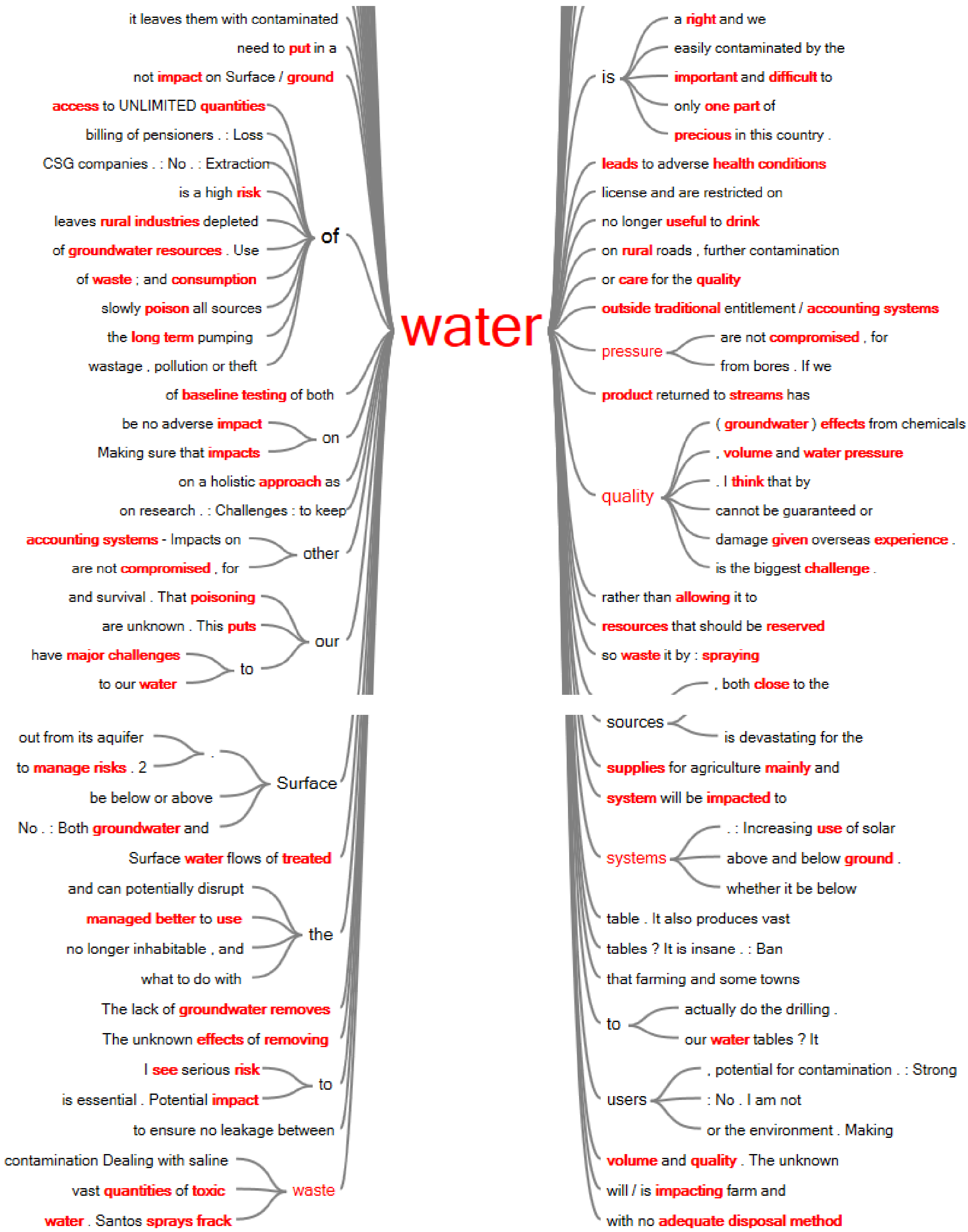


Figure 5.31: Response 8 Group D

5.9.5 Response 8 Groups A, B, C and D




water
it leaves them with contaminated
need to put in a
not impact on Surface / ground
of
access to UNLIMITED quantities
billing of pensioners . : Loss
CSG companies . : No . : Extraction
is a high risk
leaves rural industries depleted
of groundwater resources . Use
of waste ; and consumption
slowly poison all sources
the long term pumping
wastage , pollution or theft
of baseline testing of both
on
be no adverse impact
Making sure that impacts
on a holistic approach as
on research . : Challenges : to keep
other
accounting systems - Impacts on
are not compromised , for
our
and survival . That poisoning
are unknown . This puts
to
have major challenges
to our water
is
a right and we
easily contaminated by the
important and difficult to
only one part of
precious in this country .
leads to adverse health conditions
license and are restricted on
no longer useful to drink
on rural roads , further contamination
or care for the quality
outside traditional entitlement / accounting systems
pressure
are not compromised , for
from bores . If we
product returned to streams has
quality
(groundwater) effects from chemicals
, volume and water pressure
. I think that by
cannot be guaranteed or
damage given overseas experience .
is the biggest challenge .
rather than allowing it to
resources that should be reserved
so waste it by : spraying
, both close to the
Surface
.
out from its aquifer
to manage risks . 2
be below or above
No . : Both groundwater and
Surface water flows of treated
the
and can potentially disrupt
managed better to use
no longer inhabitable , and
what to do with
The lack of groundwater removes
The unknown effects of removing
to
I see serious risk
is essential . Potential impact
to ensure no leakage between
waste
contamination Dealing with saline
vast quantities of toxic
water . Santos sprays frack
sources
is devastating for the
supplies for agriculture mainly and
system will be impacted to
systems
. : Increasing use of solar
above and below ground .
whether it be below
table . It also produces vast
tables ? It is insane . : Ban
that farming and some towns
to
actually do the drilling .
our water tables ? It
users
, potential for contamination . : Strong
: No . I am not
or the environment . Making
volume and quality . The unknown
will / is impacting farm and
with no adequate disposal method

Figures 5.32*a* and *b*: Response 8 Groups A, B, C and D

5.10.1 Response 9 Group A

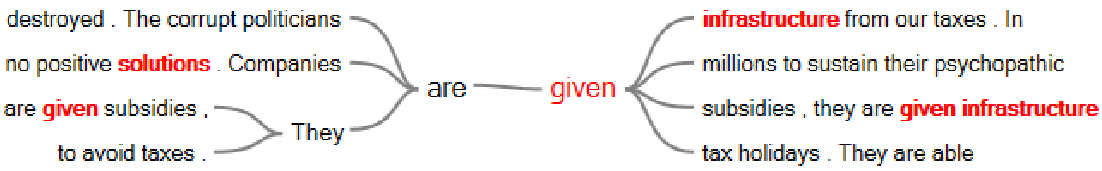


Figure 5.33: Response 9 Group A

5.10.2 Response 9 Group B

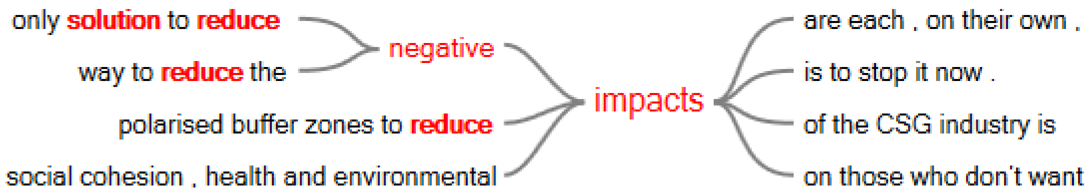


Figure 5.34: Response 9 Group B

5.10.3 Response 9 Group C

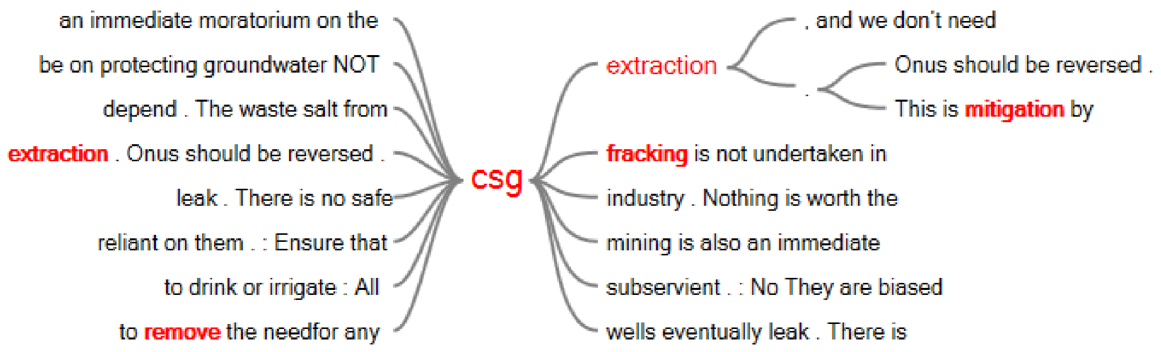


Figure 5.35: Response 9 Group C

5.10.4 Response 9 Group D

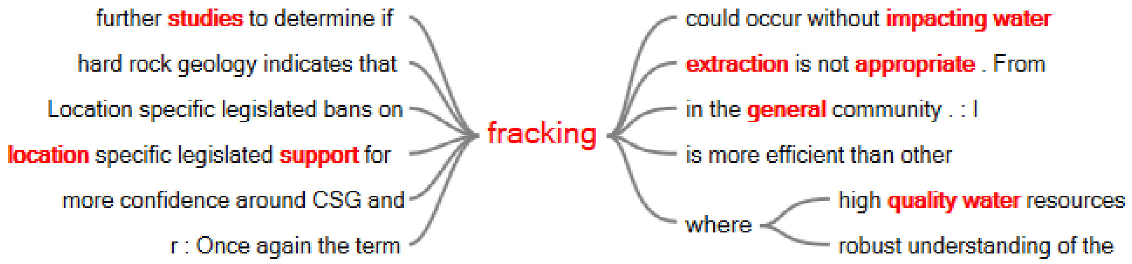


Figure 5.36: Response 9 Group D

5.10.5 Response 9 Groups A, B, C and D

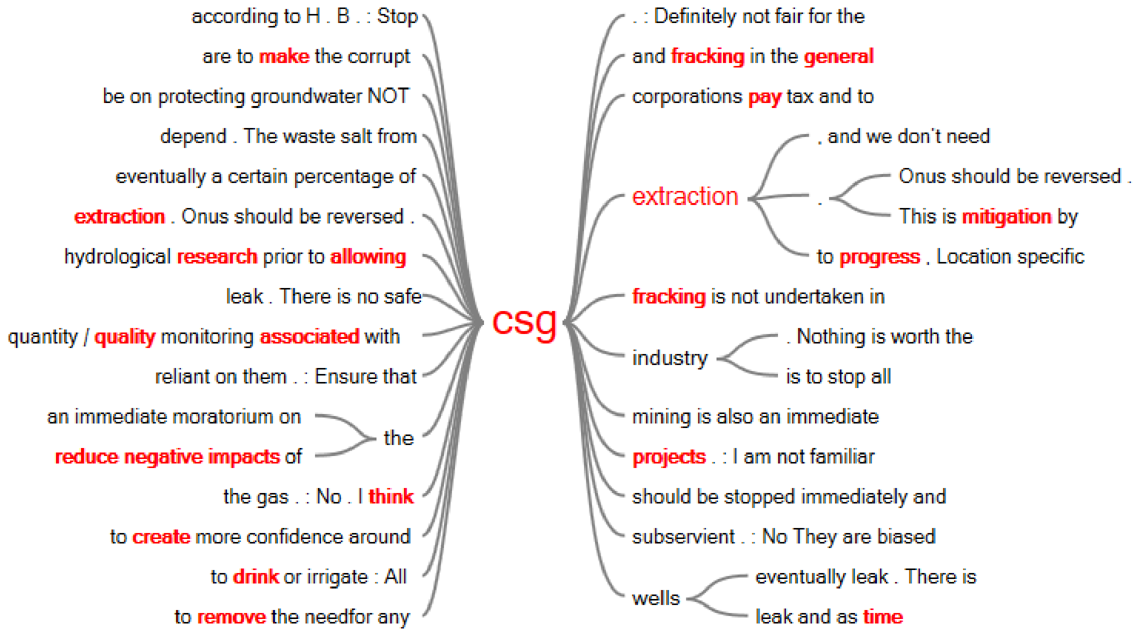


Figure 5.37: Response 9 Groups A, B, C and D

5.11.1 Response 10 Group A

Figure 5.38: Response 10 Group A

5.11.2 Response 10 Group B

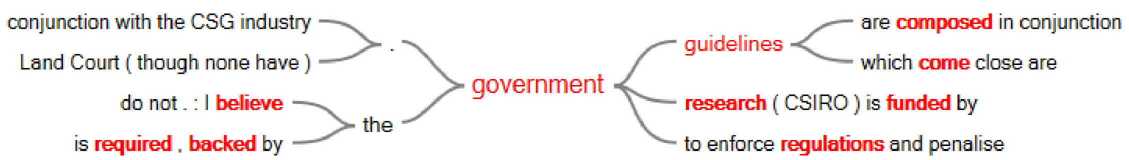


Figure 5.39: Response 10 Group B

5.11.3 Response 10 Group C

Figure 5.40: Response 10 Group C

5.11.4 Response 10 Group D

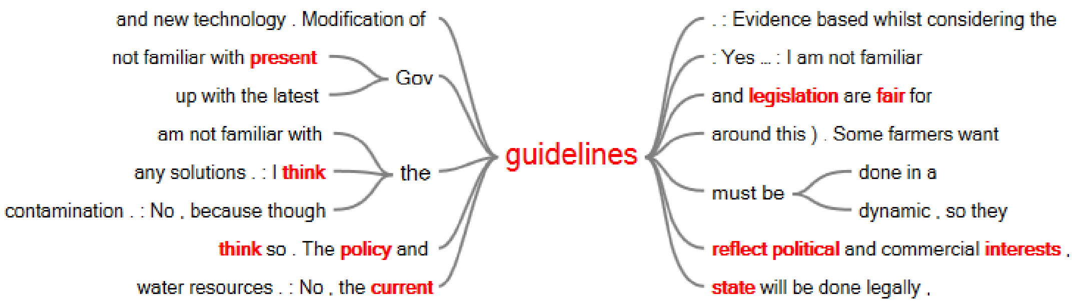


Figure 5.41: Response 10 Group D

5.11.5 Response 10 Groups A, B, C and D

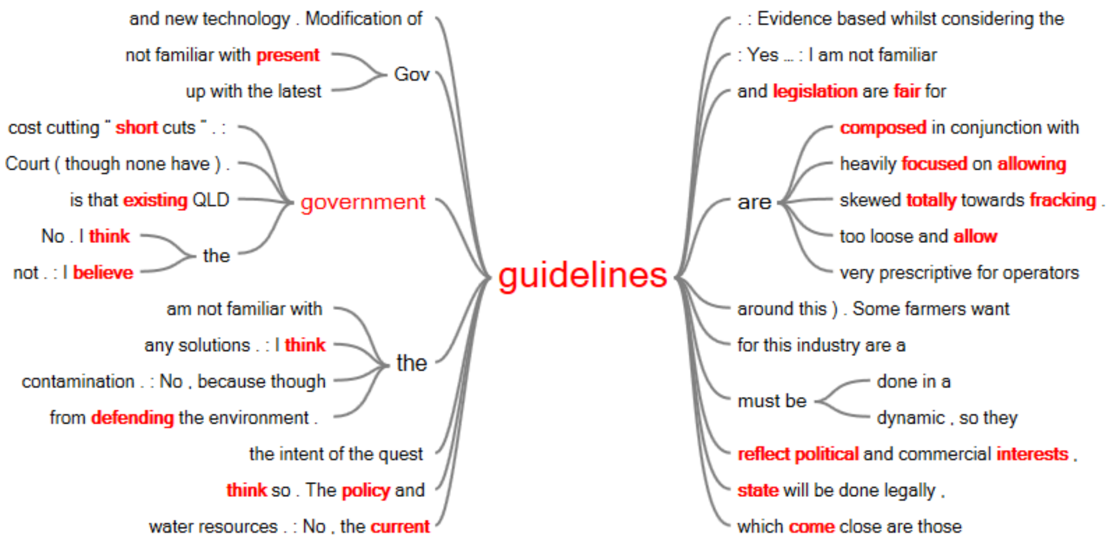


Figure 5.42: Response 10 Groups A, B, C and D

5.12.1 Response 11 Group A

Figure 5.43: Response 11 Group A

5.12.2 Response 11 Group B

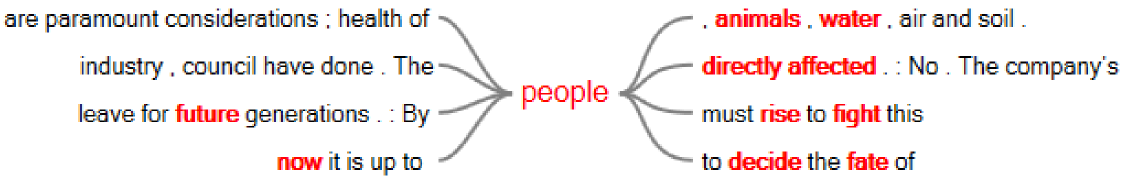


Figure 5.44: Response 11 Group B

5.12.3 Response 11 Group C

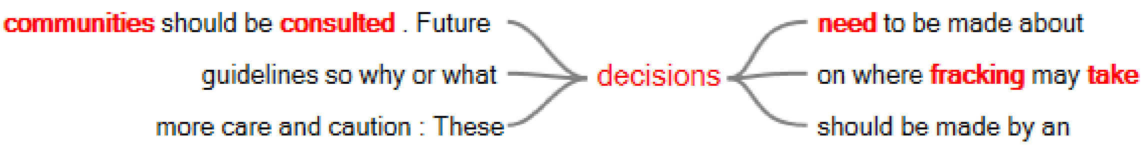


Figure 5.45: Response 11 Group C

5.12.4 Response 11 Group D

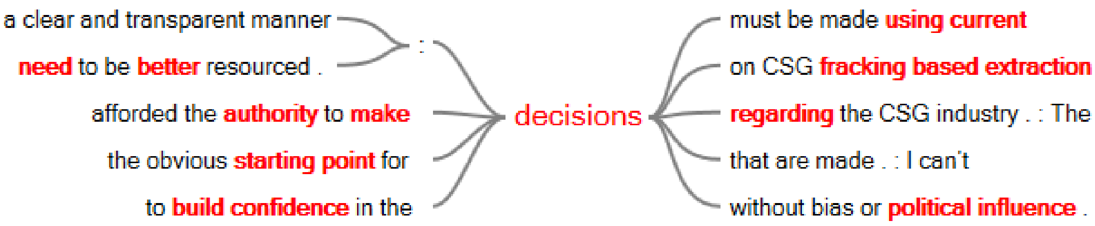


Figure 5.46: Response 11 Group D

5.12.5 Response 11 Groups A, B, C and D

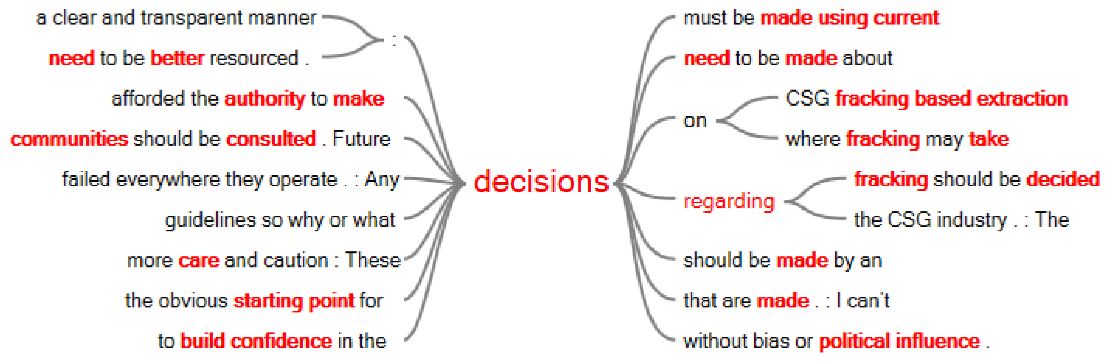


Figure 5.47: Response 11 Groups A, B, C and D

5.13.1 Response 12 Group A

Figure 5.48: Response 12 Group A

5.13.2 Response 12 Group B

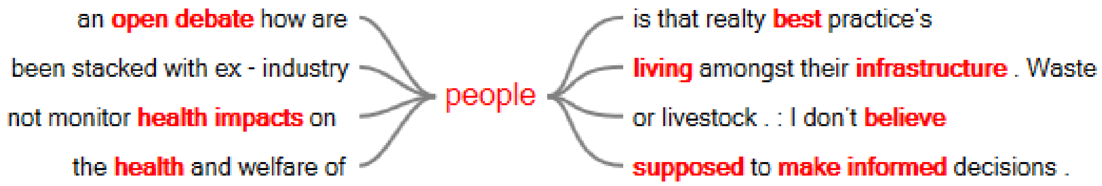


Figure 5.49: Response 12 Group B

5.13.3 Response 12 Group C

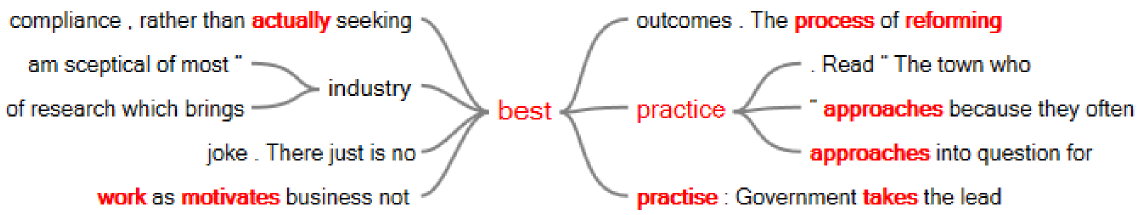


Figure 5.50: Response 12 Group C

5.13.4 Response 12 Group D

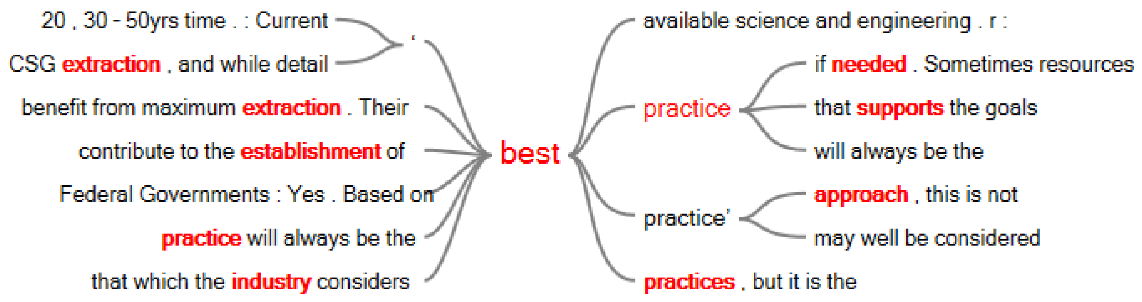


Figure 5.51: Response 12 Group D

5.13.5 Response 12 Groups A, B, C and D

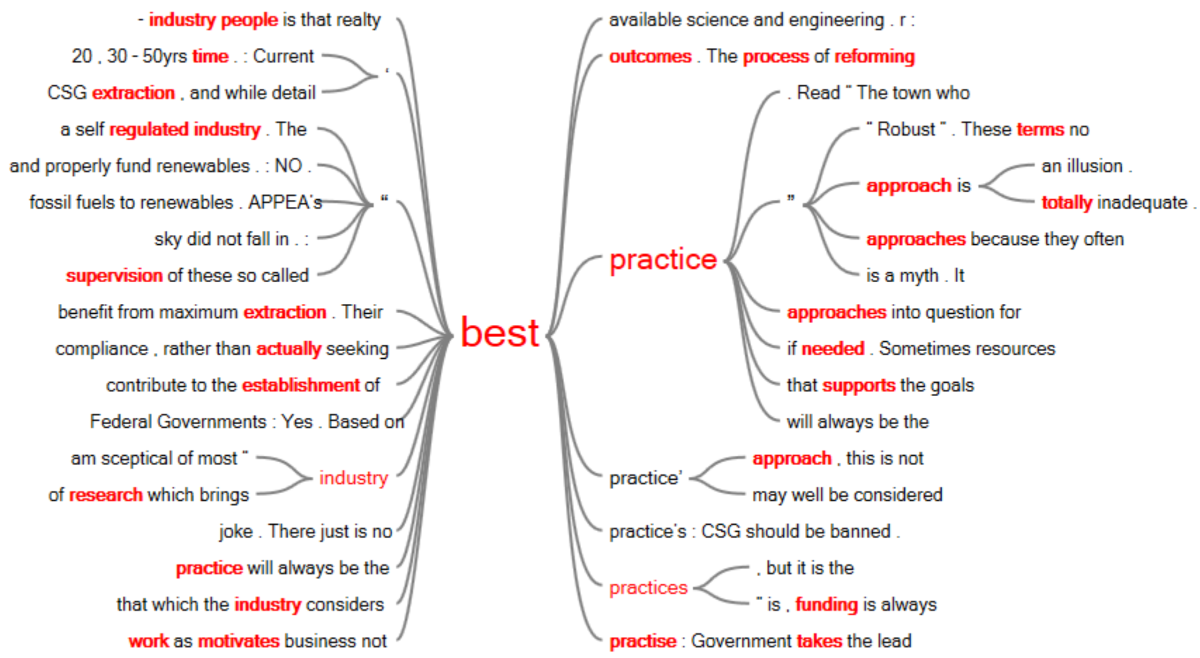


Figure 5.52: Response 12 Groups A, B, C and D

5.14.1 Response 13 Group A

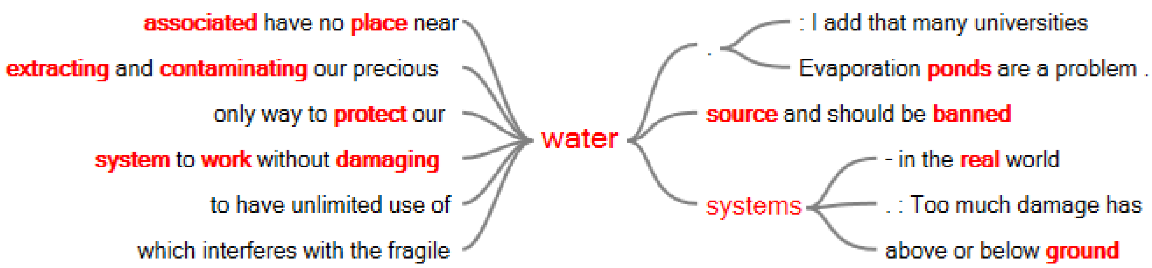


Figure 5.53: Response 13 Group A

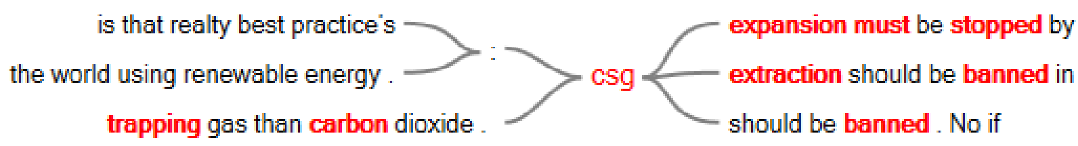


Figure 5.54: Response 13 Group B

5.14.3 Response 13 Group C

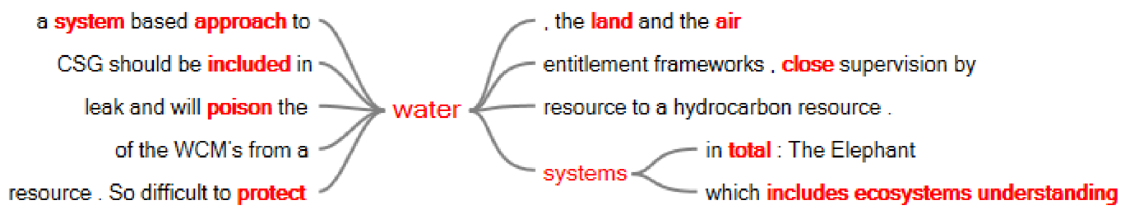


Figure 5.55: Response 13 Group C

5.14.4 Response 13 Group D

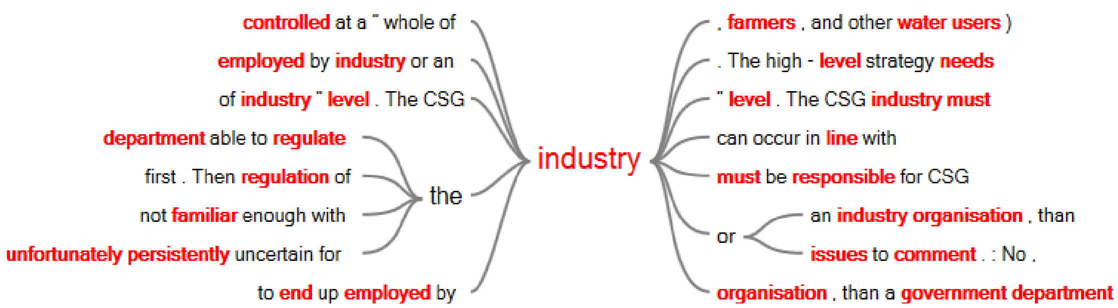


Figure 5.56: Response 13 Group D

5.14.5 Response 13 Groups A, B, C and D

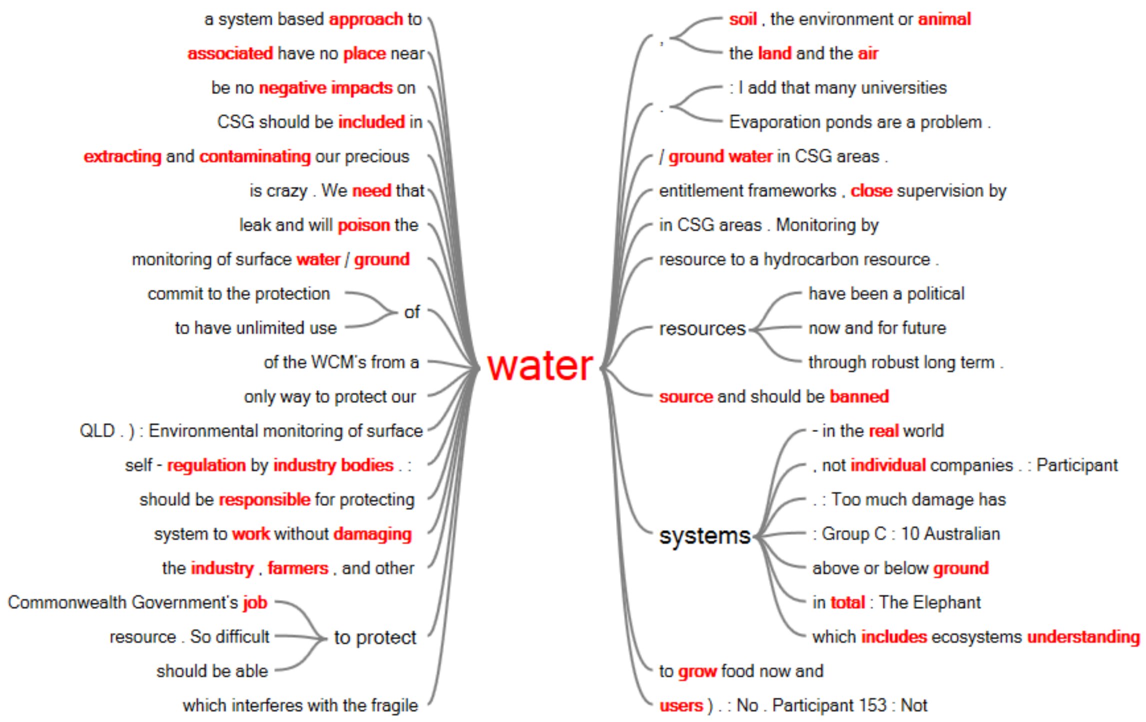


Figure 4.57: Response 13 Groups A, B, C and D

5.15.1 Response 14 Group A

Figure 5.58: Response 14 Group A

5.15.2 Response 14 Group B

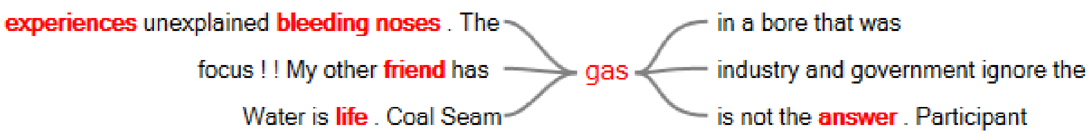


Figure 5.59: Response 14 Group B

5.15.3 Response 14 Group C

Figure 5.60: Response 14 Group C

5.15.4 Response 14 Group D

Figure 5.61: Response 14 Group D

5.15.5 Response 14 Groups A, B, C and D

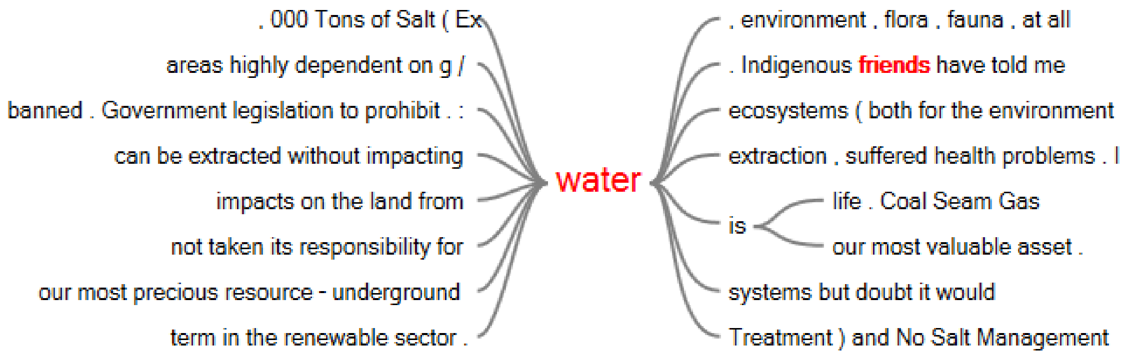


Figure 5.62: Response 14 Groups A, B, C and D

Figure 5.63: Group A: Community Group Member's Word Cloud

Figure 5.64: Group B: Community Individual Participant's Word Cloud

Figure 5.65: Group C: Australian Government Official' Word Cloud

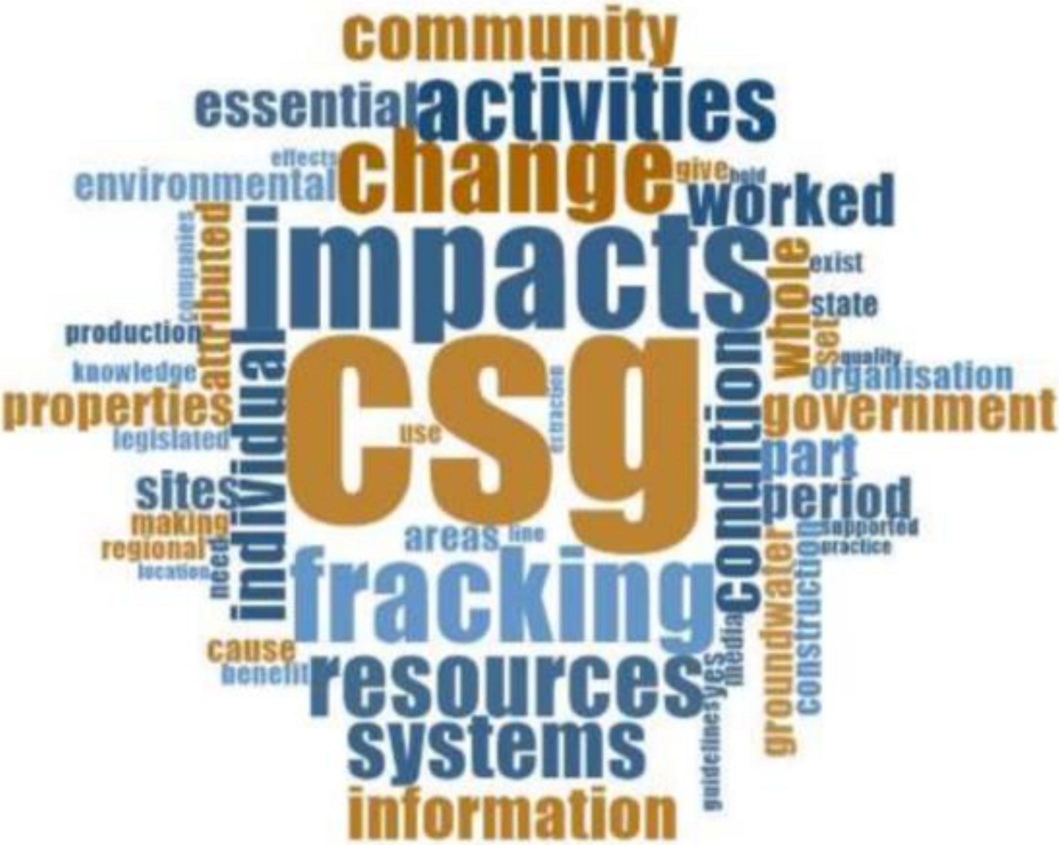


Figure 5.66: Group D: Gas Industry Employees Word Cloud

Figure 5.63: Group A: Community Group Member's Word Cloud

Figure 5.64: Group B: Community Individual Participant's Word Cloud

Figure 5.65: Group C: Australian Government Official' Word Cloud

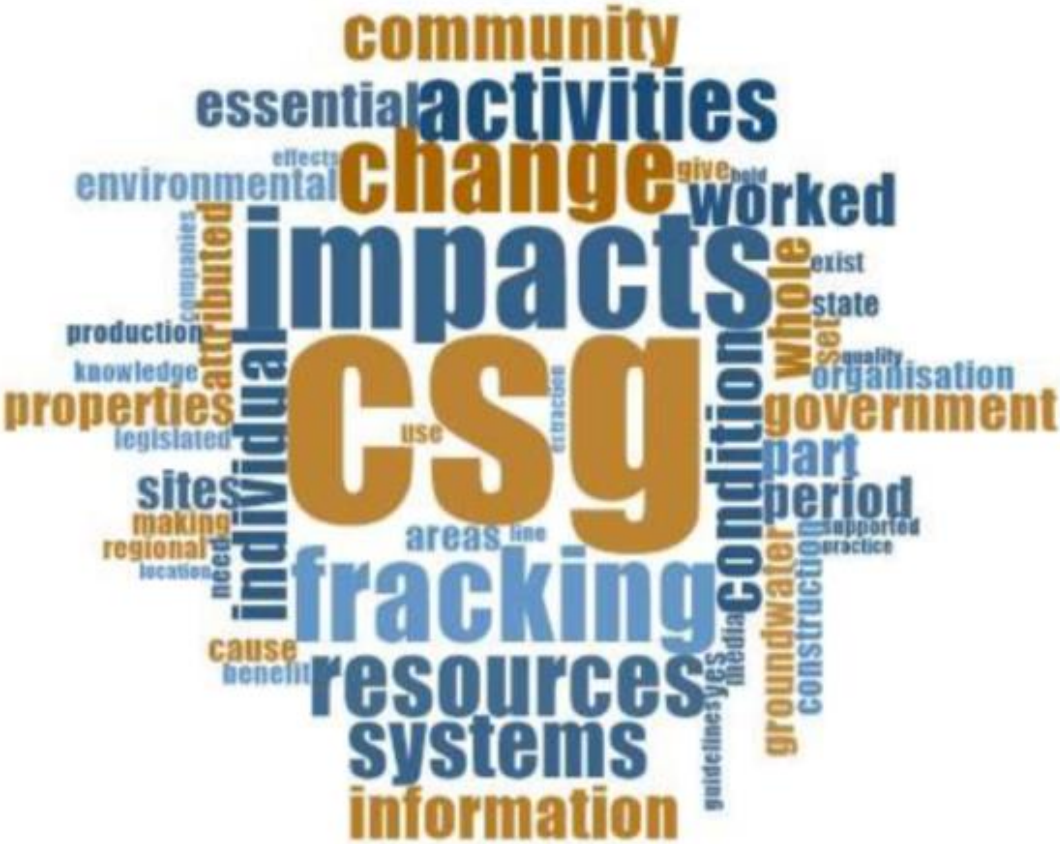


Figure 5.66: Group D: Gas Industry Employees Word Cloud

Figure 5.67: Groups A, B, C and D's Word Cloud

Appendix 11

A Concise Version of the Factiva Data in the Thesis Annex Document

1982 -2004

Factiva data consists of 66 traditional media data entries concerning the exploration, extraction and economic resource development of CSG (EEERDC[1]) at primarily the Western Downs, Queensland.

1982

Dow Jones News Service -Ticker, 8th October 1982. NY -DJ- Basic Resources Corp Said Its Wholly Owned Subsidiary Basco Energy Inc Has Agreed to Join Three Australian Companies in an Oil and Gas Exploration and Development Program. Work Will Proceed Under Petroleum Exploration License…

1989

Sydney morning Herald, 17th February 1989. *'Record Flow From Taylor Field'*. Brisbane: An appraisal well has reported a record oil and gas flow for the Taylor Field in the Surat Basin. The test flow – 1,400 barrels of oil a day and 1.18 million cubic feet (33,440 cubic metres)) of gas a day – is also one of the…

1990

National Business Review, 8th April 1990. *'EldersNZFP to buy out Curtain Bros. Gas Venture'*. Elders NZFP agreed to purchase the stake held by its joint venture partner Curtain Bros in Queensland coal bed methane exploration permit. Under another agreement ERL and Mitsubishi Gas Chemical Co, one of the world's…

Foot note. 1. The acronym EEERDC has been used to minimise the reiteration of the Exploration, Extraction and Economic Resource Development of coal seam gas (CSG). Similarly, 2. RAY has been used for Representative Articles for the Year

1991

The Australian Financial review, 10th October 1991. *'MGC Dilutes Stake in MIM Deal'*. Japan's Mitsubishi Gas and Chemical Company has watered down its stake in a planned $300 million joint venture with MIM Holdings Ltd in Queensland's Bowen basin to extract coal-bed methane gas for conversion to methanol.

1992

Improved Recovery Week Pasha Publications, Inc, 20th July 1992. *'Fracking, horizontals best for Aussie coalgas'*. Hydraulic fracture stimulation and horizontal drilling appear to be the most promising technologies for commercial development of vast coal bed methane deposits in New South Wales, Australia.

Australian Stock Exchange Company Announcements, 29th October 1992, *'Allgas Energy Ltd: Chairman's Address (Part A)'*. 044 – Oil & Gas: Gas Distrib., Pipelines 14000 – Other ASX 29 October 1992 13:12:58 Brisbane (Ref. 009103) Manually entered NATURAL GAS SUPPLIES It is pleasing to report that in recent months we have contracted to…Surat Basin.

1995

5 EEERDC media data entries. Representative articles of the year (RAY[2]):

International Gas Report, 16th February 1995. *'Queensland trials of coalbed methane'*.

BRW, 3rd April 1995. *'Miners Get Taste for Coal-Bed Gas'*. Resources Development of Queensland's huge coal-bed methane resources is a step closer with the recent announcement of a joint venture between the United States energy groups Enron Oil and Gas Company and Dominion Resources Inc to… Australian Gas Industry: Cites Spent $150 Million in Exploration and Research Between 1980s-1992.

Australian Stock Exchange Announcements, 10th November 1995. *'Roma Petroleum NL: VPE Drilling Report – North Cherwondah-1 (part A0'.* 042 – Oil & Gas: Oil/Gas Explorer 11001 – Progress Report ASX 10 November 1995 09:01:31 Brisbane (Ref. 111508) Manually entered DRILLING REPORT FOR NORTH CHERWONDAH- 1 ATP 465P,…

1996

2 EEERDC media data entries. RAY:

The Australian, 25 January 1996.*'BHP plans explosive Proposition'*. BHP is considering its proposed $130 million Queensland ammonium nitrate plant into earner after a detailed study of its worldwide market…using coal-bed methane to produce explosives…Bowen Basin…

1997

2 EEERDC media data entries. RAY:

Australian Stock Exchange Company Announcements, 15th October 1997.*'ASX-Desertstone N>L> (DST.AX) Shareholder Presentation Coal Bed Methane Gas Project Option'*. The Company is to hold a shareholder briefing at 4.00pm om Tuesday 21 October 1997. The briefing is being held to provide shareholders with background information on the Company's Coalbed Methane Gas Project…

1998

4 EEERDC media data entries. RAY:

Eco-Log Week, 30th January 1998.*'Project to cut emissions, enhance production'*. A consortium of Canadian and U.S organisations in the public and private sectors…CBM extraction technology since 1976…

Australian Stock Exchange Company Announcements, 1st May 1998.*'ASX_Desertstone N.L. (DST.AX) Third Quarter Activities & Cashflow Report'*.

The West Australian, 6th July 1998.*'Gas Explorer Keeps Options Open'*. Coal bed methane…Historic lethal hazard for coal mining…

1999

8 EEERDC media data entries. RAY:

The Hindu, 14th January 1999.*'Coal bed methane, fuel of next century'*.

Australian Stock Exchange Company Announcements, ASX-Sydney Gas Company N.L. (SGC.AX) Coal Bed Methane Project – Drilling Report as at 23-2-99.

The Australian, 31st July 1999. *'Coal bed gas fracture costs'*. Coal Bed Methane (CBM) gas now can be obtained through New South Wales pipeline, cutting down on transportation costs from South Australia, using a technique called hydraulic fracturing.

BRW, 1st October 1999. *'Gas bursts at seams'*.

Newcastle Herald, 18th November 1999. *'Licence Fuels Exploration Work'*. Canadian company Sunco Inc has been granted an exploration licence to search for oil and gas near Lismore…Clarence Moreton Basin.

2000

13 EEERDC media data entries. RAY:

The Australian, 24th January 2000. *'Gas warms coal industry hearts / SMALL CAPAS'*.

Australian Stock Market Announcements, 2nd February 2000. *'Australian Mining Investments Limited(AUM.AX)Investment in Coal Bed Methane Development Completed'*.

Hart's Asian Petroleum News, 29th February 2000. *'Aussie Targets for Oil Company of Australia (OCA)'.*

Courier-Mail, 12th June 2000. *'Arrow plans hunt for gas in state'*.

Australian Associated Press, 25 September 2000. *'Qld Gas Co says well advanced in six well drilling program'.* Brisbane Sept 25, AAP – Newly-listed Queensland Gas Company Ltd said today plans for a drilling program, which is set to commence in earl November, were well advanced…QGC partnership with Theiss, Walloon coal seam.

Australian Associated Press, 7th December 2000. *'Arrow boosts coal bed methane holdings through farm-in deal'*. Perth, Dec 7, AAP – Gas explorer Arrow Energy NL today said it has increased its coal bed methane acreage over the Walloon Coal Measures after farming in to a project near Chinchilla in South East Queensland.

2001

11 EEERDC media data entries. RAY:

Herald-Sun, 8th January 2001. *'New Floats'*. Resources newcomer Eastern Star Gas plans to capitalise on the fast-growing natural gas market…

Australian Stock Exchange Company Announcements, 5th June 2001. *'Arrow Energy – Acquisition of ACBM*'. Arrow Energy is pleased to announce that it has entered into an option to purchase 100% of Australian CBM Pty Ltd (ACBM), a privately owned company with substantial interests in several key Walloon Coal Bed Methane (CBM)…Chinchilla, Western Downs.

Australian Stock Exchange Company Announcements, 13th June 2001. *'Arrow Energy N.L. (AOE.AX) Dundee-1 Encounters Gas Flow'*. The Directors of Arrow Energy NL wish to advise that Coal Bed Methane (CBM) drill hole Dundee-1 located approx.. 9km south of Chinchilla in…

Australian Associated Press, 11th July 2001. *'WRAP – Qld Gas Co to commercialise Surat Basin coal seam gas'.*

Australian, 12th July 2001. *'Methane field prospects lift'*. THE Queensland Government has taken 5 per cent equity in listed Queensland Gas Co in a move that suggests the company's coal bed methane finds may soon be commercialised.

2002

6 EEERDC media data entries. RAY:

The Australian, 5th June 2002. *'Coal seam gas to power switch'*.

The Australian Financial Review, 15th June 2002. *'Coal-seam gas starts to generate heat'*.

Australian Associated Press Ralph Wragg Equities News, 18th June 2002.'*(AEQGC) Queensland Gas starts CBM pilot at Berwyndale South'*. Sydney – Tuesday – June 18: (RWE) – Queensland Gas Company Ltd has begun the Berwyndale South pilot project, the second of its planned series of Coal Bed Methane pilot developments.

Australian Associated Press Financial News Wire, 19th December 2002.*'Queensland Gas says its huge resource was taking shape'*. Brisbane, Nov 28, AAP – Queensland Gas Company Ltd said its two pilot coal bed methane operations at Berwyndale South and Aberdeen, Queensland's Surat Basin, were sufficient to meet the state's gas needs for 100 years…near Chinchilla, Western Downs.

2003

3 EEERDC media data entries. RAY:

Australian associated Press Financial News Wire, 28th June 2003.*'Qld Gas Co signs agreements with BHP Billiton & CS Energy'*. Brisbane, June 27, AAP – Queensland Gas Co (CGC) today reached two separate agreements with state utility CS Energy and resources major BHP Billiton Ltd which sets it up to become a coal bed methane producer.

Courier-Mail, 29th July 2003.*'Queensland gas surges ahead'*.

2004

5 EEERDC media data entries. RAY:

Herald-Sun, 8th March 2004.*'Arrow taps gas demand'*.

The Australian Financial Review, 13th April 2004.*'Queensland gas ready to sign first customers'.*

The first Australian media data entries expressing concern regarding CBM/CSG social and environmental impacts.

Daily Telegraph, 22nd October 2004.'*Local fury over gas mining plan'*. 21st October 2004 by Mark Nolan. Hundreds of residents are expected to protest against coal bed methane gas extraction operations in Dooralong and Yarramalong valleys at a public meeting tonight.

Daily Telegraph, 22nd October 2004.'*Gas drilling questions'*. A call on the Australian Government by the Federal Member for Dorbell, Ken Ticehurst to investigate the likely impact of CBM/CSG extraction.

2005

5 EEERDC media data entries. RAY:

Market News Publishing, 17th May 2005.*'Ausam Energy Corp – Spudding of Ungabilla-1 Well'.*

Australian Associated Press Financial Wire, 21st June 2005.*'AGL picks up BHP Billiton's assets for $93million'.*

Ralph Wragg Australian Business News, 21st June 2005.'*(AEAOE) Arrow Energy says Boyne River results positive'.*

EnCompass: Environment, 11th October 2005.'Water quality issues associated with coalbed methane development'. Management of produced water from coal bed methane (CBM) operations poses a significant issue for operators seeking permits to drill and develop CBM resources… challenges of regulatory agencies and the CSG industry managing large quantities of saline water and its effective discharge on surface water systems.

2006

8 EEERDC media data entries. RAY:

The Advertiser, 21st January 2006.*'Gas takeover planned'*. QUEENSLAND Gas Company has made an $88 million takeover bid for the troubled Sydney Gas. This could create the dominant player in Australia's coal-bed methane (CBM) gas industry with a market capitalisation of about $340 million.

Australian Associated Press Financial News Wire, 16th October 2006.*'Coal seam gas to become major source to Eastern market'.*

International oil Daily, 10th November 2006.'Santos Doubts QGC Reserves'.

2007

18 EEERDC media data entries. RAY:

Energy Compass, 5th January 2007.*'Australian firms moot mega-merger'*.

The Australian, 28 April 2007.*'Clean energy search fuels business – coal seam gas – Coal Special Report'.*

The Age, 19th July 2007.*'Gas-price pressure as Santos goes for coal seam'*.

Platts Commodity News, 14th September 2007.*'Australia's Arrow Energy sells CSG to Dyno Nobel plant'.*

Mondaq Business Briefing, 5th October 2007.'Coal Seam Gas and Associated Water Production – An Environmental Perspective'. The last decade has witnessed a rapid expansion in Queensland's ("CSG") production industry. Coal seam gas is held in coal by burial pressure and water. Typically, extracting involves reducing the pressure…at the Queensland Surat Basin. It notes: an average CSG well can extract 140,000-170,000 litres of water per day to de-water the well. Bowen Basin between 80,000-160,000 litres per day. Ordinarily, application for water licences are subject to public notification requirements, however, applications by petroleum tenure holders may be decided without public notification being published. Reports suggest that the life of CSG production is 15 to 20 years…the Environmental Protection Agency (EPA) has draft operational policy…does not have the force of law. Associated water is regarded as regulated waste…if considered beneficial it may be a resource and approval processes are far less onerous.

2008

86 EEERDC and CSG related media data entries. RAY:

Lloyd's List, 25th January 2008.*'Aggressive CSG savours orderbook boomtime'*.

Australian Associated Press Financial News wire, 17th March 2008.*'SunshineGas raises $44 million to fund CSG project'.*

The Courier-Mail, 1st May 2008.*'Origin in 12.9b play'*. THE massive potential of Queensland's coal seam gas resources was emphasised yesterday when BG Group made a $12.9 billion cash bid Origin Energy, Queensland's largest holder of CSG reserves.

The Advertiser, 21st May 2008.*'Mining a fresh seam of untapped resource'*.

Financial Times, 30th May 2008.*'Origin rejects $13.6 Billion BG takeover bid'*.

The Australian Financial Review, 11th June 2008.*'Qld Gas casts net at Roma Petroleum'.*

The Chronicle (Toowoomba), 22nd August 2008.*'Concerns raised over CSG dams'*. Grazier Lee McNicholl is not a fan of the coal seam gas (CSG) industry. Producing cattle and grain across 10,125 hectares at Dulacca and Wallambilla, Mr McNicholl is taking up the fight against what he describes as "the propaganda machine"…

The Financial Review, 12th December 2008.*'Origin boss king of the hill'*. Origin Energy chief executive Grant King is on top of the world. Literally. Few other chief executives can hold a candle to King in terms of Achievement in 2008. After heading into 2008 with a market capitalisation of $7.6 Billion.

Australian Associated Press Financial News Wire, 22nd December 2008.'Pure Energy agrees to Arrow Energy's $489 million Takeover bid'.

Platts International Coal Report, 22nd December 2008.*'CSG company Molopo makes $76 million from Gloucester project sale'*.

The Chronicle (Toowoomba), 22nd August 2008.*'Owners anxious over salt management'.* Wayne Newton will be the lone representative for landholders speaking at this week's Surat Basin Energy Conference-speaking on behalf of AgForce and a group of landholders (including himself) with properties affected by exploration leases…

Dalby Herald, 23rd September 2008.*'Water debate simmers on'*.

5 CSG related media data entries noted concerns regarding CSG associated/co-produced water and water systems in 2008. CSH water evapouration Ponds to be phased out in the Western Downs, Dalby Herald, 4th November 2008.

2009

33 EEERDC media data entries. RAY:

AAP Bulletins, 28th January 2009.*'Santos' oil and gas reserves boosted'*. Santos Ltd's total oil and gas reserves in the proved and probable category have breached one billion barrels, boosted by a lift in coal seam gas (CSG) reserves coupled with solid growth in conventional oil and gas.

Australian Associated Press General News, 6th February 2009.*'Beach Petroleum talks big increase in coal seam gas reserves'*.

Global Insight Daily Analysis, 18th February 2009.*'Arrow Raises Bid for Australia's Pure Energy'*.

Global Insight Daily Analysis, 18th February 2009.*'BG Ups Bid for Australia's pure Energy, Shell May Bid for CBM Assets'*.

BMI Industry Insights – Oil & Gas, Asia, 23rd March 2009.*'Industry News – BG Group (Finally) Bags Pure'*.

International Gas Report, 22nd June 2009.'Shell sees LNG at Gladstone by 2015'.

Ralph Wragg Australian Business News, 1st October 2009.'*(AEBOW) Bow Energy secures rigs for 16 wells in Bowen Basin'*.

Platts Commodity News, 8th October 2009.*'Shell in discussions on consolidating Australian CSG LNG project'*. Singapore (Platts)—8Oct2009/514 am EDT/914 GMT Anglo-Dutch major Shell is in discussions on the possibility of consolidating its proposed Shell Australia LNG project Gladstone in Queensland, Australia, with others at the site, a company…

The Observer (Gladstone), 11th November 2009.*'Region will boom, says securities analyst'*.

International Gas Report, 23rd November 2009.*'Australia Bow beefs up CSG'*.

Tex Energy Report, 8th December 2009.'AP-LNG Project Of Australia's Origin Energy is Delayed; Might be caused by difficulty in securing sale destination and Conoco Phillips being poorly managed'. The development of coal-seam gas LNG project, Australia Pacific LNG (AP LNG), which has been promoted by Australia's Origin Energy and the US Conoco Phillips, is being delayed. Apparently a lack of CSG media data entries regarding CSG water in 2009 in Australia, not so for the USA.

2010

145 EEERDC and CSG related media data entries. RAY

Platts Oilgram News, 1st February 2010.*'APLNG moves ahead on CSG-based LNG project'*. The Australian Pacific LNG joint venture January 29 lodged the draft environmental impact statement for its coal seam gas-based LNG project in Queensland with the state government, the company said.

The Evening Standard, 22nd March 2010. *'Shell Joint Bid Snaps up Arrow for £2 Billion; Standard Reporter'*. Shell today claimed victory in its battle to gobble up Arrow Energy, after the Australian coal-bed methane Producer accepted its sweetened $3.4 billion joint-venture bid with PetroChina.

The Observer (Gladstone), 25th August 2010.'*Government playing catch-up on coal seam gas*' THE Queensland Government is continually scrambling out new legislation on coal seam gas (CSG) extraction in what's been termed a game of "catch-up"…to shore up confidence of farmers and people living in the Surat and Galilee Basins. Mr Robertson said the Bligh Government is creating the Surat Basin CSG Consultation Committee. Mr Robertson said, "It's all about building relationships and trust". Friends of the Earth concerned about CSG impacts.

The Chronicle (Toowoomba), 27th August 2010.*'Group questions CSG mining claims'*. Group questions CSG mining claims ACTIVIST groups in the battle to get more information about coal seam gas mining on the Downs have been stung by statements in the Rural Weekly last week by Matthew Paull of the Australian Petroleum Production and Exploration Association (APPEA)…APPEA representative claims no connectivity between coal seams and water aquifers and CSG mining activity was safe. Group member response "How can an industry be proud of the fact that the Co-ordinator General found 1200 problems in two companies EISs?"

The Chronicle, 3rd September 2010.'*CSG puts aquifer at risk*' CSG puts aquifer at risk A STUDY has found Queensland's largest freshwater aquifer is at serious risk of being drained as a result of coal seam gas extraction…Call for moratorium on CSG development in the area by The Central Downs Irrigators.

The Australian, 3rd September 2010.*'Coal gas industry slams Greens --- ELECTION 2010'*. Lobbyists say the party defies its own principles in trying to impose restraints.

The Chronicle (Toowoomba), 25th September 2010.' *EVERY year, the coal seam gas industry is sucking 350,000megalitres of water…'*.EVERY year, the coal seam gas industry is sucking 350,000 megalitres of water from the underground. That is four times the capacity of

Cressbrook Dam. From that saline water, more than 62,000 tonnes of salt a year will be brought…

Australian Government News, 5th October 2010.*'Ban Petroleum Compounds Containing Benzene, Toluene, Ethylbenzene and Xylenes'*. Brisbane, Qld., Oct 5 – The Honourable Stephen Robertson, Minister for Natural Resources, Mines and Energy and Minister for Trade issued the following Statement:…The Ban of CSG Fracking Chemical use of the Carcinogenic BTEX Group.

Australian Broadcasting Corporation (ABC) News, 25th November 2010.*'Coal seam gas moratorium motion defeated'*. Both parties have rejected Queensland independent MP Aidan McLindon's motion to impose a moratorium on new coal seam gas (CSG) projects.

Australian Associated Press General News, 26th November 2010.*'QLD: Miner's access laws in Qld 'draconian'*'. CSG By Steve Gray BRISBANE, Nov 26 AAP – Laws allowing miners to enter properties in Queensland are "incredibly draconian" and ignored the rights of landholders, the Queensland Council for Civil Liberties (QCCL) says.

Australian Broadcasting Corporation (ABC) News, 26th November 2010.*'Parliament approves new water laws'*. Queensland Parliament has passed water legislation that covers issues including household water bills, the coal seam gas (CSG) industry and Wild River laws.

Further RAY: Western Downs Resources Boom, CSG Companies '*Cutting Corners'*, Large Amounts of CSG Water Released into Rivers Legally, Salt Waste in Land Fill, Aquifers at risk, GAB at risk, Fracking, CSG Mining and Farming, CSG Activities and Unlimited Water Use, Ethical and Responsible Investments, Lobbyists, Election 2010, Community CSG Forums, Safety and Dangers of CSG Activities, Concerned Citizen Hotline, CSG Pipeline, CSG/LNG Project, proposed Carbon Levy, call for CSG Moratorium, Australia in Drought and CSG Water as a Waste Product, Queensland New Water Laws, Minister Warns of Shortfalls in Research on CSG Impacts, Symposium Discusses Effects of CSG Mining on Farming in the Western Downs, No Faith in CSG Industry Self-Regulation, Unanswered Questions Regarding CSG Safeguards in the Western Downs and Hundreds of South East Farmers Lock Their Gates on CSG Mining and Climate Change.

2011

245 EEERDC and CSG related media data entries. RAY:

Queensland Country Life 24th February 2011,'*Simmering tensions between landholders*', mining companies and the State government have reignited after ABC Television's four Corners program showed shocking images of coal seam gas (CSG) mining.

Australian Associated Press General News, 3rd March 2011,*'QLD: CSG laws advantage mining industry'*. CSG by Steve Gray Dalby, Qld March 3rd AAP-Coal seam gas exploration laws in Queensland unfairly advantage the mining industry over individual landowners, a Dalby lawyer says.

Australian Associated Press General News, 7th March 2011,*'QLD: Qld protestors rally against coal seam gas*'. Coal seam gas (CSG) mining constitutes one of the biggest land grabs in Australian history, a Brisbane rally has been told.

The Observer (Gladstone), 7th March 2011,*'Tara Estates protestors are taking gas fight to Parliament'*. Brisbane: Michael Bretherick says he moved to Tara Estates for peace and tranquillity, a good place for those of modest means to raise a family, but now finds it threatened by coal seam gas (CSG) exploration.

Further RAY: CSG Fear for organic Farmers, Queensland Landholders get Training for CSG Negotiation, Tara, Western Downs Resident Bullied and Locked Off His Own Land, 70 year old Great-Grandmother Arrested-Fears for Food, First Meeting for CSG Stakeholders-22/03/2011, Landholders to Administer CSG Wells on Their Land, Pipeline Protests heat up, No Guarantee of Bore Water Protection from New "Cumulative Management Area". Tara Blockade Dismantled by Police, Police Acting Like Paramilitaries, Ag-Force Information Sessions for 134 Farming Families Seeking Quality Independent Information on CSG Industry Juggernaut, "There will be Long Term Impacts", QGC CSG Company Defends CSG Water Disposal Plans, Western Downs- Water Latest CSG Battlefield, Major CSG Leak at Dalby, Queensland on the Verge of a New Gas Age, Western Downs Farmer in the Dark Over CSG Water Release on Her Property, Explosion at Downs Arrow CSG Well, Taroom- 2% of CSG Wells Leaking and a Fire Risk, Queensland Government Rejects Moratorium, First CSG Scientific Alliance Launched by CSIRO, GISERA 14/07/2011, CSG Causes Cancer, CSG Wrecking Farmland, CSG and Farming Don't Work in South Queensland, CSG to Cost 2 Billion in Value from Farmland in South Queensland, Call for Groundwater Checks Before CSG Activity, Queensland Government yet to List all CSG Chemicals, APPEA Rejects Claims on Aquifer Contamination, Group Representing CSG Companies Under Fire for "Fudging"

Results of Study to Downplay the Threat to Underground Water, Council Rejects CSG Mining, Thousands of Farms Bear Anti-CSG Yellow Triangles, Santos Spending $10,000 a Minute on Massive CSG Operation, CSG Carcinogens Found in Arrow Gas Field Bores, CSG Irrigation Water, 3 Million Tonnes of Salt – 10 Metres High and 11 Kilometres Long, Looming CSG Mess, CSG is a Legal Minefield, 500 in a Work Camp, The University of Queensland Walks into a Minefield: UQ-CCSG, IESC Essential and Energy Sector Impacts Local Businesses in Western Downs.

2012

132 EEERDC and CSG related media data entries. RAY:

The Chronicle (Toowoomba), 27th January 2012. '*Negotiating a fair conduct and compensation Agreement (CCA)*'. Landholders will have the chance to access independent information about their rights and responsibilities and how to negotiate a fair CCA when AgForce…

The Conversation, 21st February 2012,*'First job for the new Queensland Government: fix coal seam gas'*. Three little words strike fear into the heart of at least 405 of Queenslanders: coal seam gas. These three seemingly innocuous words have managed to divide a state and become the hottest topic in the Queensland election.

Queensland Country Life, 23rd February 2012,*'I AM waiting for the day I can begin a column'*. I am waiting for the day when I can begin a column satisfied that coal seam gas (CSG) companies are being completely open and transparent in their dealings with landholders.

Daily Telegraph, 23rd February 2012,*'Santos CSG failure'*. Oil and gas giant Santos have admitted an "unacceptable culture" at its recently acquired Eastern Star coal seam gas operations that included "failures in reporting" spills at the company's operations in…

Further RAY: Boom or Bust? Towns on the Downs, The Actions of 'Anti-CSG Vigilantes'- a New label from Metgasco, a Few CSG Wells 700-1000 Metres Apart According to CSG Industry, Politicians Quits-Accusing Party of Stifling Debate on CSG Mining and Hiding its True Intentions, Farmers Fear Drilling Turning Soil Toxic, APPEA Slams Attack, CSIRO - CSG Could Provide Water for Farmers, First Meeting of Lock the Gate, Threatened with Dogs, Workforce Opportunities for Indigenous Australians in the Surat, Methanogens, GISERA, Small Business Solidly Behind the Booming CSG Industry – APPEA, Drilling Fluids

Leak into Condamine River, Short of a War, CSG an issue that has United a Cross-Section of the Australian Community, New IESC Formed Too Late, New QWC – Only 2.5% of Private Bores Affected by CSG in the Surat Basin, 500 Water Bores Affected by CSG Drilling in Southern Queensland, It Will Take 50 Years to Recover Just Half the Groundwater Depletion of CSG Activities, QWC, 2012 – Quality Unknown, Reports of Children with Bloody Noses and Chronic Headaches in the Western Downs, Loop Hole in Federal Environmental Laws Will Not Protect Australia's Groundwater, Good Times Hit Roma, But Farmers Worry About Environmental Impact, Study Hails CSG 2015-2035, Queensland expansion Could Increase Real Australian GDP by 516 Billion, CSG Conduct and Compensation Agreements (CCAs) in Tara, Metgasco Illegally Dump One Million Litres of CSG Water into Sewerage, Unequal Battle: Where Often Government Takes the Side of CSG Companies Has Led to a Plethora of Protest movements, Lack of Transparency, 2600 CCAs Signed, Reports of Symptoms Consistent With Gas Exposure in Tara, Health Minister Accused of Playing Down Health Concerns, New Label – Environmental Activist, Opposition to CSG Costs Billions, CSIRO Rejects Safe CSG Advertising, IESC Passes Senate with Amendments, Jobs in CSG Industry Jump 6674, Miles Community, Western Downs Struggling to Cope with CSG Industry, EIS Process Requires Urgent Review, Unenforceable: UQ, SCU researchers Found Methane Levels Around CSG Operations 10 Times Higher in Air and Water, The Polarisation of Opinion on CSG: The Truth Can be Elusive, CSG Exploration Wells Within 200 Metres of Dwellings and Queensland Government: CSG Water Policy of Use It or Dump It.

2013

177 EEERDC and CSG related media data entries. RAY:

Dalby Herald, 8th January 2013,*'Family blames CSG for hippuric acid finding'*. A Tara family has claimed coal seam gas activity is responsible for high levels of hippuric acid in their son. The Palmer family said the finding from a urine test of their three-year-old Jackson followed a string of medical…

Daily Examiner, 10th January 2013. '*The anti-CSG movement has raised concerns over the failure of CSG concrete well casings…'*

Australian Broadcasting Corporation (ABC) News, 22nd January 2013.*'Battle for hearts and minds in CSG debate*'. The latest controversy in Queensland's coal seam gas industry is not over leaks, pipelines or even water. It's over the hearts and minds of people in the region where gas extraction is taking place.

Daily Examiner, 22 January 2013,*'CSG media 'is bad''*. Glenugie drill reaches 30m above coal seam CONCERNS about CSG's environmental impact are the result of bad media coverage and public furore, according to Metgasco's drilling supervisor Craig Nairn.

Australian Broadcasting Corporation ABC) News, 11th February 2013,*'Claims former Qld government put pressure on gas approvals'*. An industry group has dismissed claims two of Queensland's largest resource projects were approved because of pressure by the former Bligh Labor government.

Further RAY: CSG Firms Reveal Groundwater Study, Crime and Misconduct Commission, CSG Approvals: Wanting, Can Farmers Co-exist with CSG Industry, Doctor Sounds Health Warning, Call for Level Playing Ground for Farmers, CSG: Ban No Protection, Farmer Abused by Anti-CSG Protestors, Economic Pressure on Anti-CSG, CSG: Buying Supporter, Commonsense Water Use: Govt Advice, CSG Well Fields Leaking, CSG and Bio-Security Issues, Elevated Gas Level Horrifying, Radon Emissions, Arrow Will Generate 264 Billion Litres of Water, IESC, CSG: Public Uncertain. Exploration began 1976, Production Began 1995, by 2012 Over 50,000 Abandoned or Decommissioned Bores/Wells. How Many Production Wells Now? Information Not Available, IESC, 2014, Cumulative Impact on Water, Govt Goes to Water, Dalby, Western Downs Unrecognisable in a decade, Australia's 200 Billion CSG Industry, Threat to Quality of Life, 'Dangerous' Industry Tara Western Downs, Titan Energy Services 300% Profit, CSG Compliance Unit Inspects Only 369 of 5,000 Wells (7%), Don't Kill the Golden Goose, 4,000 CCAs signed in Queensland, CSG Critics Don't Get It: Jobs, Investment and National Earnings, UN warning on CSG Extraction, Three People Living Near CSG Activities Contracted Terminal Cancer, 40,000 CSG Wells, Anti-CSG now "Anarchists", CSG Projects now 'One-Stop-Shop' for Approvals, 5,500 Sq/Km CSG Licences Held by $100 Company, Polarised Dispute on CSG Splits Families and Communities, New Research Needed into Potential CSG Health Impacts Western Downs, CSG Royalties Opposed by Industry, Salt Mountains, Co-Produced Water for Drinking and Irrigation, Roma Farmer Earning $250,000 from CSG Wells, 1000s of Abandoned Exploration and Production Bores/Wells, CSG Poses Risk to Groundwater, CSG Contaminated Land has No Value and Unusable, CSG: High Likelihood of Catastrophic Health Risks, Chinchilla: Promised CSG Water Supply Fails, Tara: Black Rain, Lies, Damned Lies…, Santos Fails Contamination Tests, Anti-CSG Environmentalist Label, and CSG Opposition Declining – Realisation of CSG Economic Benefits.

2014

132 EEERDC and CSG related media data entries. RAY:

Australian Associated Press General News, 221st January 2014. *'FED: Arrow says all options on the table in QLD'*. ARROW By Kim Christian Perth, Jan 21 AAP – Arrow Energy says all options are on the table as it sheds jobs and cuts costs at its coal seam gas (CSG) project in central Queensland.

Australian Broadcasting Corporation (ABC) News, 5 February 2014. *'Greens see red over federal CSG taskforce'*. The Greens say the prospect of a federal Government taskforce to sort out community problems with the coal seam gas industry is an outrage. The office of Industry Minister Ian Macfarlane has confirmed the group is being put together.

The Sydney Morning Herald, 7th February 2014. *'CSG and oil giants revealed as major donors to Nationals'*. Donations to the National Party from coal seam gas companies have risen tenfold in four years, but the party is not required to disclose the majority of donations it receives from the gas industry under electoral funding laws.

The Northern rivers Echo, 13th February 2014. *'Health concerns over CSG safety'*. THE KEY question in the CSG debate is whether it is safe to operate gas fields where people live, work and raise children. Gas burns a bit cleaner than coal, but this benefit to consumers is paid for many times over by Australians who are exposed to massive amounts of dangerous pollution where the gas is mined and processed.

Further RAY: CSG: Too Early to Determine Risks in the Long Term – after 19 Years of Production, Santos: CSG Protestors put 15,000 Jobs at risk, Anti-CSG Label – Activists, Anarchists now Lunatics, CSG: Drought Stricken Farmers, CSG Pond Leaks, CSG: Aquifer Poisoned, Santos: Uranium and Arsenic 'Pollution Incident', CSG Opponents 'Scaremongering', EPA on CSG Leak, Origin Energy: Asbestos in Fracking Fluid Scare – Work at 12 Sites Suspended in the Western Downs, Three CSG Myths – 1. Not 100,000 Employees but 9,372 2. More CSG Will Stop Gas Price Rising 3. CSG Can Act as a Low Emission "Bridge" Between Coal and Renewables, CSG Industry Full Steam Ahead While Groundwater Scientists at the Starting Gate, Methane in Drain in Roma Region, Wollongong

University Researcher: Not Enough Knowledge to Proceed with CSG Extraction, Anti-CSG Label – 'Hardened Leftist Eco-Activists' CSG Landholder Concerned, 8,000 CSG Evapouration Ponds in Queensland, CSG: Alkane – University of Queensland: Blinded by Science, CSIRO on Methane Seeps, CSG: Water Trigger Introduction, CSG: Corruption Probe, Researchers Concerned CSG Could Threaten Food and Water Security, *EPBC ACT*: Bilateral Agreements – Removal of the CSG Water Trigger, Pro-CSG Farmers Paid and Happy, Taroom, Western Downs: Facts on CSG Impacts, Tara Cited for Health Fears, Undermining Water Vow, QGC: Tara – Buys Properties to Minimise Impacts, 19 Years of Enviro Laws Wound back, 5,000 CSG Wells in Western Downs, Financial Review Perspective – Ignore Anti-CSG Scare Tactics: Gas Facts v Fiction, Tara QGC Wells Off-Colour, Tara Families in QGC Buy Back, Arrow Energy 4,000 CSG Wells Approved, CSG: Miles - A Model of Co-Existence, 'As a Right of Grant', Roma Residents go to Court – Waste Dumped in Pond, CSG: Try to Reach 'Best Practice' Risk Management, GAB at Risk, Southern Cross University: Tara – CSG Methane Levels High, CSG up to 100x Worse Than CO2 for Climate Change, CSG: Bore Blow Out on Western Downs Farm, CSG: Evidence in Secret – Whistle-Blower and Police Advertise CSG Santos Logo: Sponsorship Deal.

2015

48 EEERDC and CSG media data entries. RAY:

The Chronicle (Toowoomba), 8th January 2015. *'Doctor says CSG fields bad for kids'*. Brisbane GP Geralyn McCarron is urging families with young children or pregnant women not to but lifestyle blocks near Surat Basin coal seam fields.

The Morning Bulletin, 10th January 2015. *'Free bore checks for landowners'*. Rural Law with Melanie Oliver CSG Impact: Go online for an assessment of your bores WHEN coal seam gas wells extract gas, they extract large volumes of water from underground.

The Northern Star, 30th January 2015.'*Web*'. Re: CSG site contamination results will be 'transparent': Coal Seam Gas is a proven disaster on a global scale – it pollutes the water table, it leaks methane into the atmosphere (twice as damaging as CO2), it provides no long-term…

ForeignAffairs.co.nz, 20th February 2015. *'Expert groundwater concerns show need to stop CSG expansion*'. MIL OSI – Source: Australian Green Party – Press Release/Statement:

Headline: Expert groundwater concerns show need to stop Qld CSG expansion The leaked Independent Expert Scientific Committee report on the Santos Gladstone LNG expansion…

Courier Mail, 1st March 2015.*'Industry is our lifeblood'*. You can't blame the greenie protestors for the troubles that have suddenly - and dramatically - beset the state's coal seam gas industry. But the fact that world oil prices have slumped at exactly the same time as the planned end of the…

Australian Associated Press General News, 2nd March 2015.*'QLD: Activist blames CSG fire for Qld soil gas'*. GAS By Christine Flatley Brisbane, March 2 AAP – Environmental activists fear gases found below the soil surface in regional Queensland are the result of a coal seam gas fire burning out of control.

Illawarra Mercury, 25th March 2015.*'From the web'*. Slow learners CSG would appear to be the 21st century's asbestos, First embraced by ignorance, second, misunderstood and third, what have we done?

Further RAY: Biosecurity Significant Concern for Landholders, The Big CSG Player: Royal Dutch Shell, Chinchilla: A town of CSG Extremes, CSG Water Spill Miles, Santos Warned Again on CSG Transparency, CSIRO: Methane Research – Baseline for Thermogenic CH_4 , Chinchilla: Field Day to Look at CSG Impacts, CSG: Australia Probes Funding for Environmental Groups, Farmers Seek level Playing Field, Miles: Locals Struggling Since CSG Companies Departure, CSG Wells Give Farmers 200 million Funding Boost, Family Vows to Continue Fighting Against CSG After Farmer's Suicide, CSG Panel, CSG: Landholders Suspicious and Shell Slices 10,000 Jobs,

2016

42 EEERDC and CSG related data entries. RAY:

Chinchilla News, 31st March 2016.*'Family takes QGC to Land Court'*. After nine years of fighting, the Nothdurfts are taking a CSG company to court IN HINDSIGHT, the kid's nosebleeds and headaches began around the same time as the gas infrastructure went in, Narelle Nothdurft said. It's a story she's told to…

The Chronicle (Toowoomba), 1st April 2016.*'CSG 'eases the drought burden'*. For the first time in his life, Yuleba farmer Brett Griffin has managed to handle a drought with relative ease. It was last year but, thanks to financial compensation for gas wells on the Griffins' 6500-hectare cattle property 54km further…

The Chronicle (Toowoomba). 4th April 2016.*'CSG issue reaches UN'*. The impact of the CSG industry on the Western Downs was one of the focal points at the United Nations' Human Rights Council session earlier this month.

The Chronicle (Toowoomba), 8th April 2016.*'Landholders have say at GasFields Commission*'. It has been a long wait for landholders to be offered an opportunity to have a voice in any decision when it comes to coal seam gas and land access.

Queensland Country Life, 10th April 2016.' *CSG Industry:-bore report not surprising'*. Findings from a report into the potential effects of free gas in bore water supplies in the Surat Basin have been shrugged off as unsurprising by the coal seam gas industry.

Balonne Beacon, 14th April 2016.*'Secret drilling chemical of CSG'*. 15 months on and drilling chemical still a mystery. What is fracking?

Australian Broadcasting Corporation (ABC) News, 23rd April 2016.*'CSG water meetings flooded'*. Ongoing concerns about the impacts of coal seam gas (CSG) on water in the Artesian Basin has resulted in about 250 Surat Basin landholders attending public consultation meetings.

Australian Broadcasting Corporation (ABC) News, 23rd April 2016.*'Condamine River set on fire after Greens MP lights bubbling methane gas, blames fracking*'. Part of a Queensland River bubbling with methane gas burst into flames after being ignited by a Greens MP, who blames nearby coal seam gas operations for the "tragedy in the Murray-Darling Basin".

Further RAY: Queensland Government Commits $7 Million to CSG Compliance Unit, Western Down's CSG Industry Expansion Legal Challenge, 22 Billion Tonnes of Brine into Dawson River, Queensland CSG Industry a Great Success Story, Anti-CSG Lies and Propaganda Killing Australia's Economy, CSG: Wells Devalue Land, Tara Woman Protests About Sickness, CSG: Fugitive Emissions, CSG Farm Impact Revealed at Chinchilla, New Environmental Water Research University Findings, Can Billions of Litres of CSG Water be Safe to be Reinjected into the Ground, Bentley Effect, CSIRO Puts Price on CSG Costs to

Farmers, APPEA: Lock the Gate Misrepresents Important CSG Research, Concerning Health Statistics 'Yet to be Probed", CSG: Local Company 2,150 Sq/Kms Exploration, CSG: Power Supply Scare Tactics and The Bender Inquiry.

2017

74 EEERDC and CSG related data entries. RAY:

The Chronicle, 14th January 2017.*'Dalby hit as 92 Jobs lost'*. Ozcon folds after CSG downturn DALBY has been hit hard after the loss of nearly 100 Jobs as a result of Ozcon Industries closing. The multi-million-dollar manufacturing company was officially placed into liquidation this week by directors…

Australian Broadcasting Corporation (ABC) News, 25th January 2017.*'CSG-rich land in Surat Basin set aside for Australian-only sales'*. A 58-square-kilometre parcel of coal seam gas-producing land in the Surat Basin is set aside exclusively for the Australian market by the Queensland Government.

Global Energy Research, 26th February 2017.*'Australia – Projects – Gas – Pipelines'*. The Bowen Pipeline proposed by Arrow Energy, located in central Queensland, has started the front-end engineering design (FEED) phase at the end of 2014. The buried Arrow Bowen Pipeline (ABP) will transport coal bed methane over 580 km…

Dalby Herald, 24th March 2017.*'Gas project secures jobs'*. Project Ruby expands operations A New Surat Basin gas project will increase domestic supply and secure 350 jobs during its peak 16-month construction period.

Australian Broadcasting Corporation (ABC) News, 27th March 2017. '*A gas company is given federal approval to clear 54 hectares of koala habitat for new coal seam gas wells on Queensland's Western Downs*'.

Dalby Herald, 28th March 2017.*'Joyce slams false claims'*. CSG royalty proposal under fire Deputy Prime Minister Barnaby Joyce has rubbished claims from the Lock the Gate Alliance that his proposed coal seam gas royalty would not benefit farmers.

Foot note. 1. The acronym EEERDC has been used to minimise the reiteration of the Exploration, Extraction and Economic Resource Development of coal seam gas (CSG). Similarly, 2. RAY has been used for Representative Articles for the Year

Northern Daily Leader, 30th March 2017.*'What does the CSG Industry do to the price of nearby houses?*'. Queensland residents have described the coal seam gas industry's impact on local housing prices as "a really short party with the worst and longest hangover".

Central Queensland News, 7th April 2017.*'Miner cuts debt, shrugs off bankruptcy'*. The world's largest private sector coal miner Peabody Energy has emerged from chapter 11 bankruptcy, after reducing its debt by more than $5 billion.

Further RAY: Condamine River Methane Leaks Finally Not Denied by AGL – DNRM: No Clear Signs of Harm – Chief Scientist No Clear Potential Impacts, Queensland Office of Groundwater Impact Assessment (OGIA) Debunks Federal Minister, Queensland Groundwater Monitoring Grant, Arrow Boosts Gas in $500m Project, Arrow to build 180 Wells at Dalby, CSIRO: low Methane Emissions, Anti-CSG Car Stickers, CSG Polarised Feud in the Western Downs – Farmer's Wellbeing, Why CSG Advocates and Activists Both Like CSIRO's New Report, Senex Energy Commences Western Surat Gas Project, CSG Unlimited Water Take Unsustainable, New Landholder Groundwater Survey on Potential Impacts and Biosecurity Risks, CSG: Surat Basin Farmer on Costs to Fix Property, Future is Bright for Balonne, CSIRO – Condamine River Impacts Still Debatable, CSG: Crossbenchers Want Royal Commission, CSG: Life Not All that it Seems, Constant Fight, UQ Ongoing Study: CSG Led to Spikes in Crime Rates, Property Prices, Rents, and Business Income, $45 Billion Spent in Queensland by Gas Industry Since 2011, CSG: 10,400 Jobs and $916 Million Generated in Local Economic Activity in the Western Downs, Shell Kicks Off Charlie CSG Project, Surat Basin Groundwater Flow May be North Eastern Not South Western and CSG Chemicals Dismissed by Gas Industry, But Opinions Still Polarised.

2018

59 EEERDC and CSG related data entries. RAY:

ArabianBusiness.com, 9th January 2018.*'State Gas Bowen Basin Wells Flow as Further Drilling Planned*'. Similar reservoir pressure could indicate connectivity between wells. State Gas Ltd (ASX:GAS), has had gas flows from three of its wells situated in Queensland Bowen Basin.

Crikey, 15th January 2018. *'Gas Industry roll-out linked to startling rise in Darling Downs hospital admissions*'. The rapid expansion of the coal seam gas industry in Queensland's Darling Downs has been accompanied by a startling rise in hospital admissions, according to report published in International Journal of Environmental Studies, pointing to…

Gold Coast Bulletin, 17th January 2018. *'Gas Industry refutes hospital claims'*. The gas industry has hit back at a report suggesting pollutants from Queensland's coal seam gas could explain an increase in hospital admissions, describing it as lacking credibility and pushing a political agenda.

Awareness Times, 31st January 2018. *'Second Round of Meetings for 27-Year Gas Project*'. Arrow Energy will begin a second round of community consultation over its multi-billion dollar Surat Gas Project this week. The upcoming sessions will provide details on Arrow's recent announcement relating to its 27-year gas supply…

The Australian, 1st March 2018. *'Doubts raised over potential of Queensland coal seam gas fields*'. Doubts raised over CSG fields. Gas buyers and sellers have cast doubt on the ability of Queensland's vast coal seam gas fields to supply coming export and domestic demand in the wake of origin Energy's downgrade of reserves at its Ironbark…

Northern Daily Leader, 9th March 2018. *'Web words'*. Just outside Chinchilla there is an entire industrial estate devoted to the care and maintenance of the CSG industry in the region. If Narrabri doesn't want to make the best of such a windfall situation, it's at the community's long-term…

Rural Weekly, 27th April 2018. *'Queensland tells fracking experience'*. Fears of fracking in the Territory could be eased by the Queensland Government, which has revealed the practice has not caused any significant damage to groundwater in the six years of major commercial development of the coal seam gas…

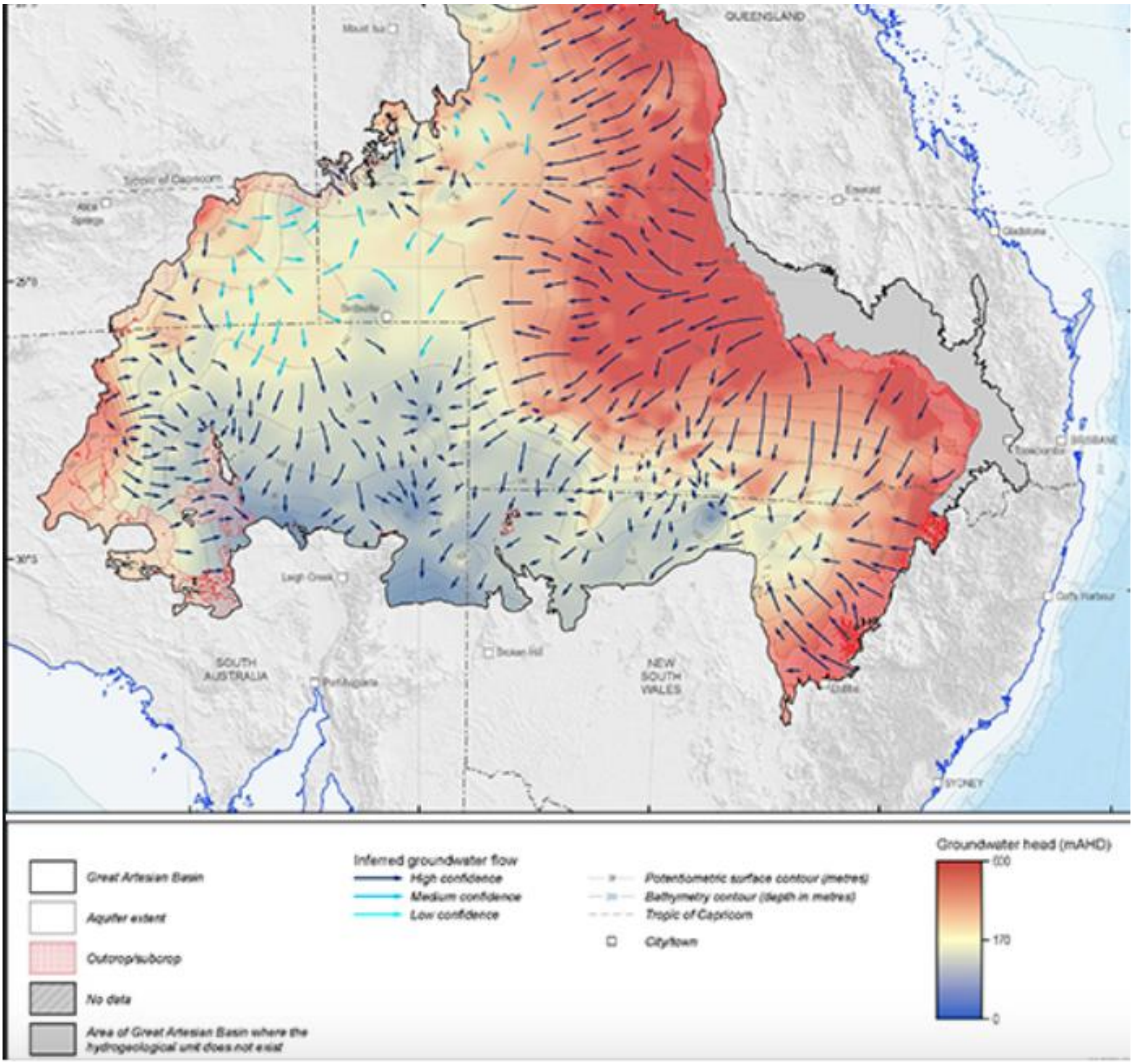
The Western Star, 1st May 2018. *'Horror stats reveal our roads deadliest in state*'. Drivers in regional Queensland are twice as likely to be involved in a fatal vehicle accident as those who live in the state's metropolitan areas, According to data from the Department of Transport and Main Roads.

Further RAY: CSG Impacts in Roma, UQ Holds Meeting to Dissect Social and Economic Changes in Dalby, CSG: Labor to Tighten Regulations to Protect Water, CSG: 3 Companies supply 95%, CSG: CSIRO on Air Quality, CSIRO Stirs Debate, CSG: Average Water Levels Decline in Queensland, CSG: Commissions – CSG Needs More Scrutiny, CSG: Holes from Subsidence Forming Over the Land in Western Downs, CSG: 400-Man Accommodation Camp in Western Downs and CSG: CSIRO.

A total of 1270 EEERDC and CSG related data entries were recorded, from over 2,493 CSG/CBM associated media articles, which relate to the Western Downs between 1982- 2018. Many of the traditional media articles contain pertinent reported information that overlaps multiple research question topics germane to the following media content analysis research.

Foot note. 1. The acronym EEERDC has been used to minimise the reiteration of the Exploration, Extraction and Economic Resource Development of coal seam gas (CSG). Similarly, 2. RAY has been used for Representative Articles for the Year.

APPENDIX 12: Aquifer and Groundwater Flow in the GAB. Considered Questionable by Underschultz *et al*. of the UQ-CCSG and OGIA, 2017.



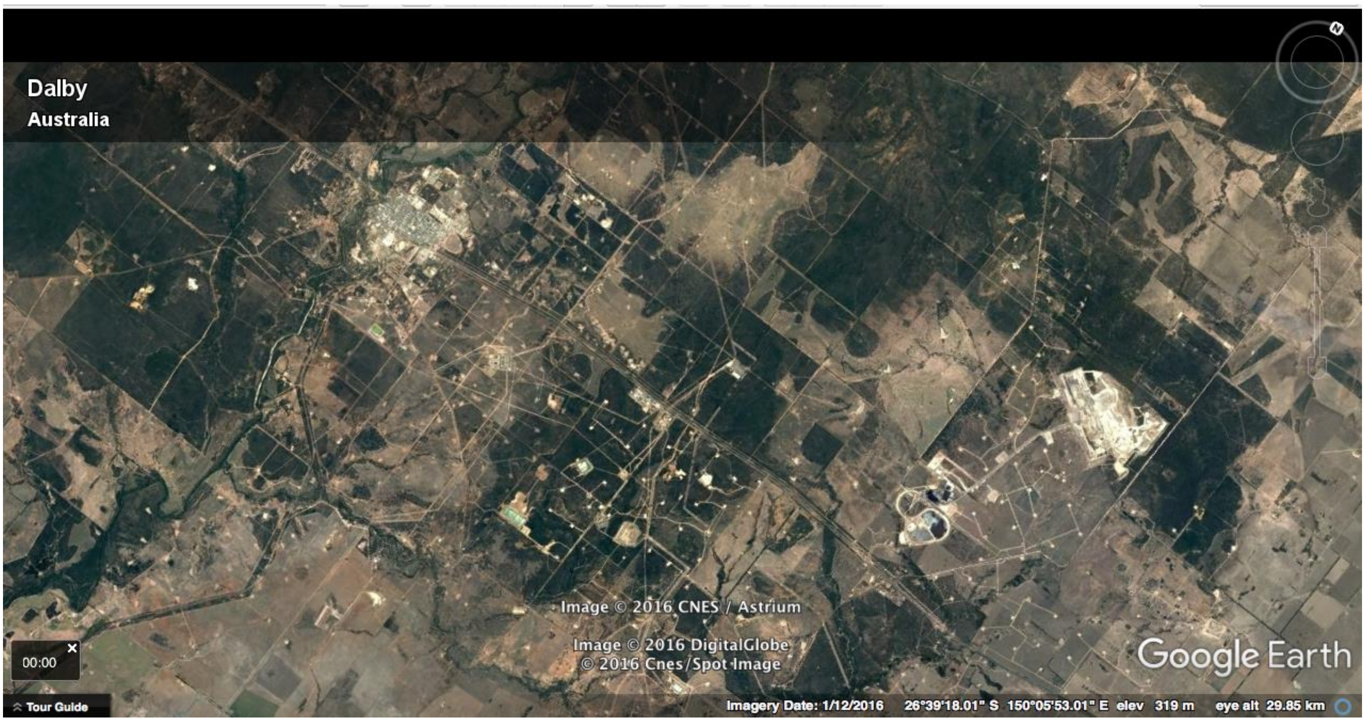
Source: Commonwealth of Australia, Geoscience Australia, (2018) figure, retrieved from http://www.ga.gov.au/webtemp/image_cache/GA21116.pdf Creative Commons Licence CC BY 4.0.

APPENDIX 13: Major Western Downs CSG Well Fields Imagery 2013-2016. (© CNES / Astrium, 2016, © CNES / Spot Image, 2016, © Digital Globe, 2016, © Landsat / Copernicus, © Google Earth, 2017).

Dalby, Western Downs, Queensland

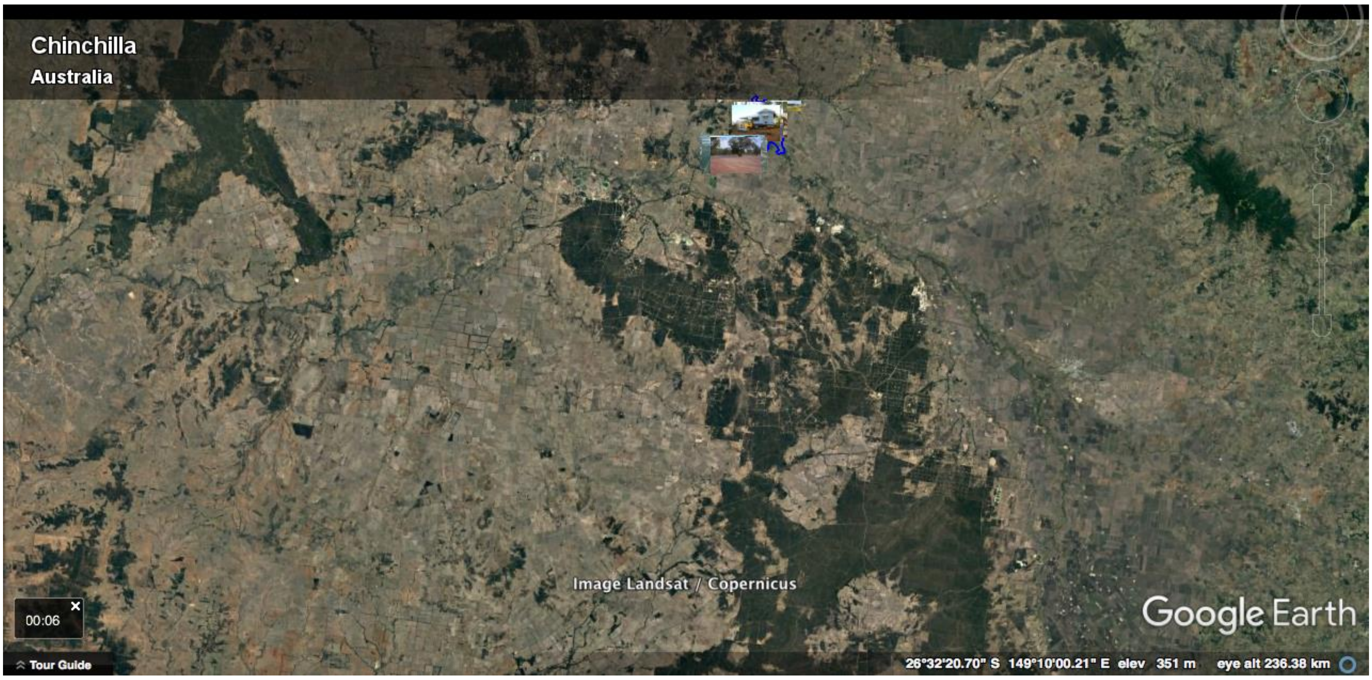
Source: Map data © 2019 Google.

Source: Map data © 2019 Google.

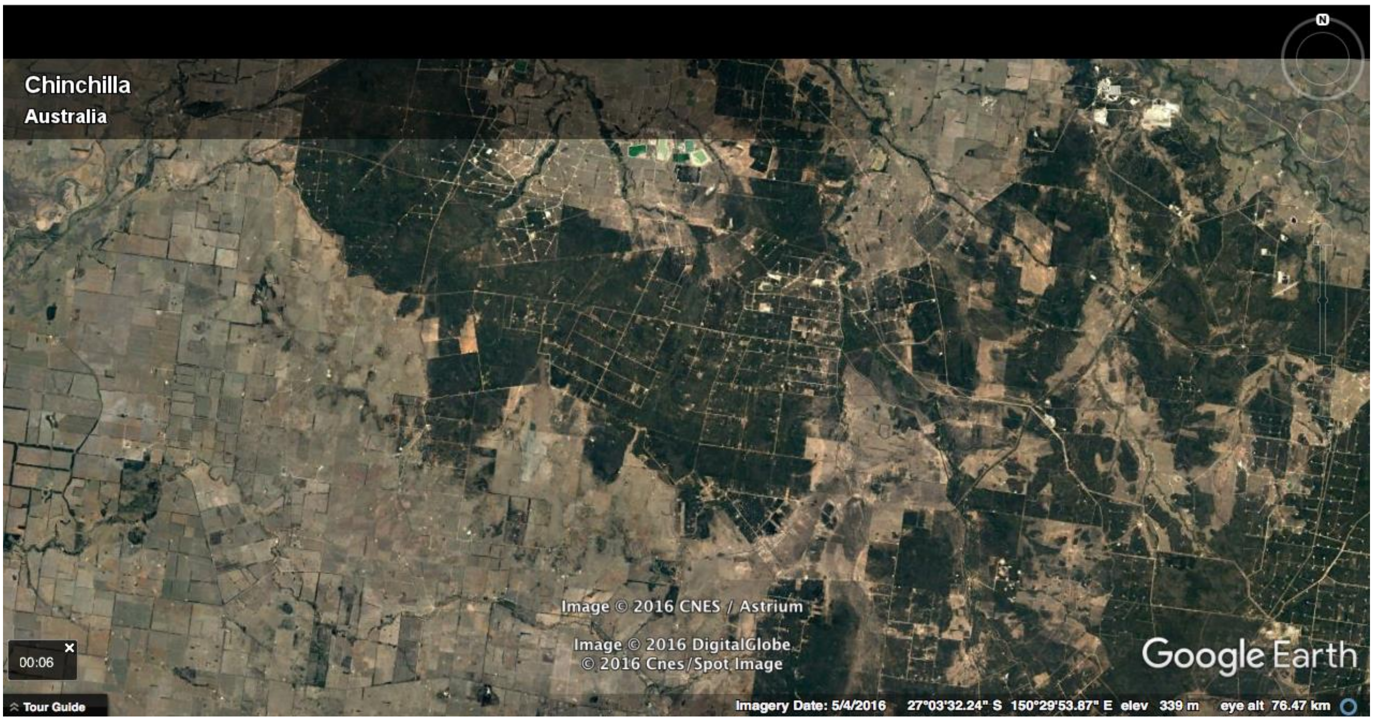


Source: Map data © 2019 Google.

Chinchilla, Western Downs, Queensland

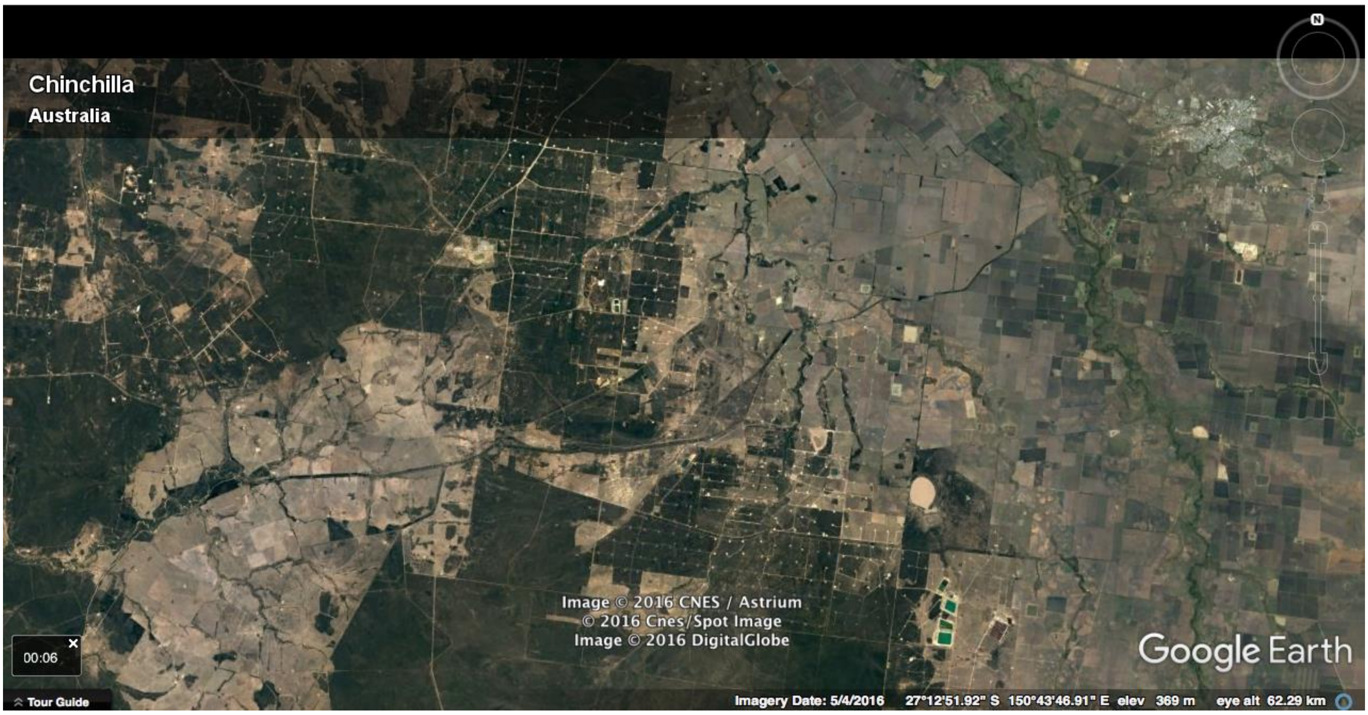


Source: Map data © 2019 Google.



Source: Map data © 2019 Google.

Source: Map data © 2019 Google.



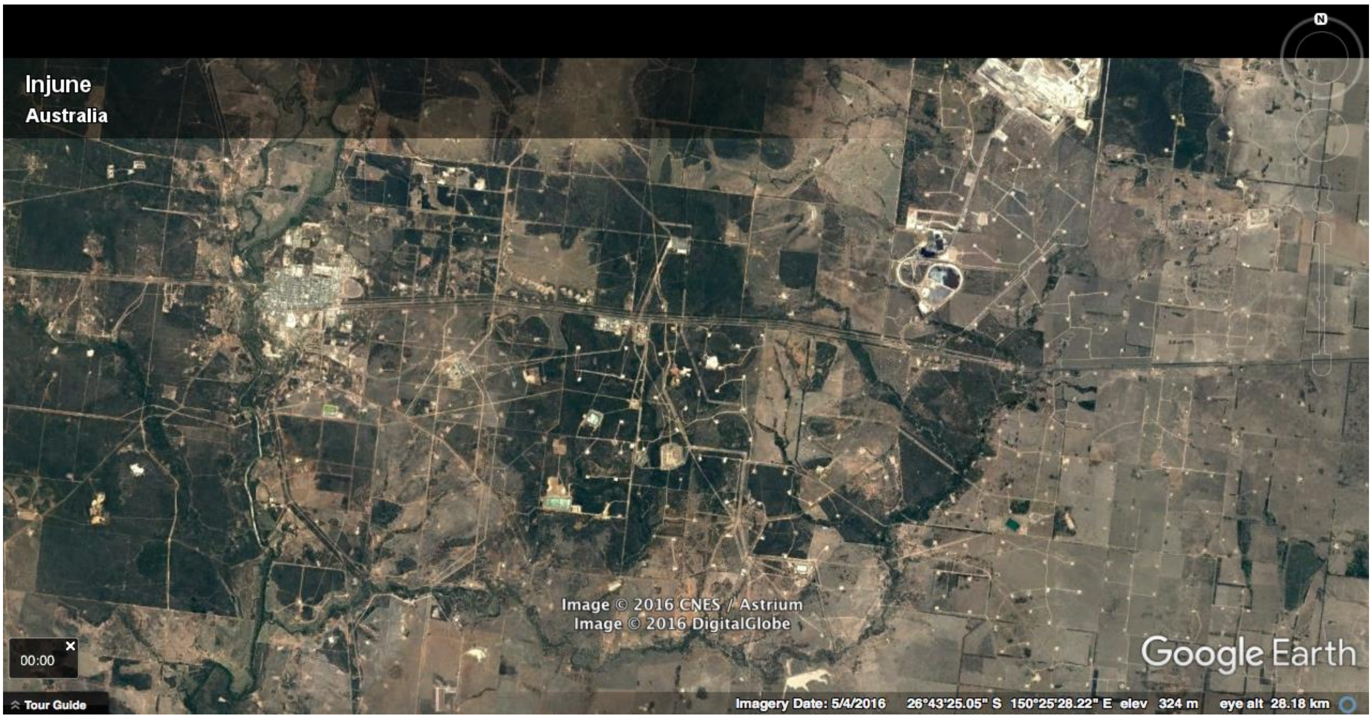
Source: Map data © 2019 Google.

Condamine State Forest, Western Downs, Queensland

Source: Map data © 2019 Google.

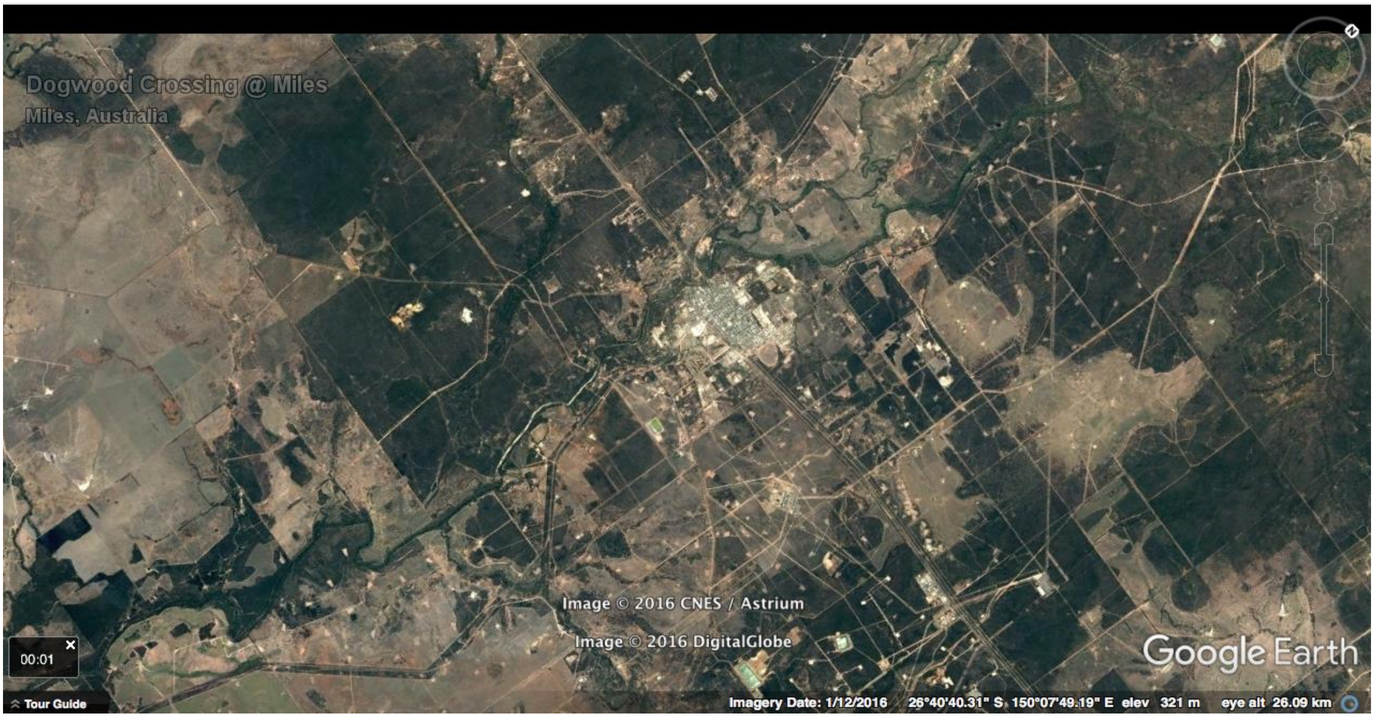
Injune, Western Downs, Queensland

Source: Map data © 2019 Google.

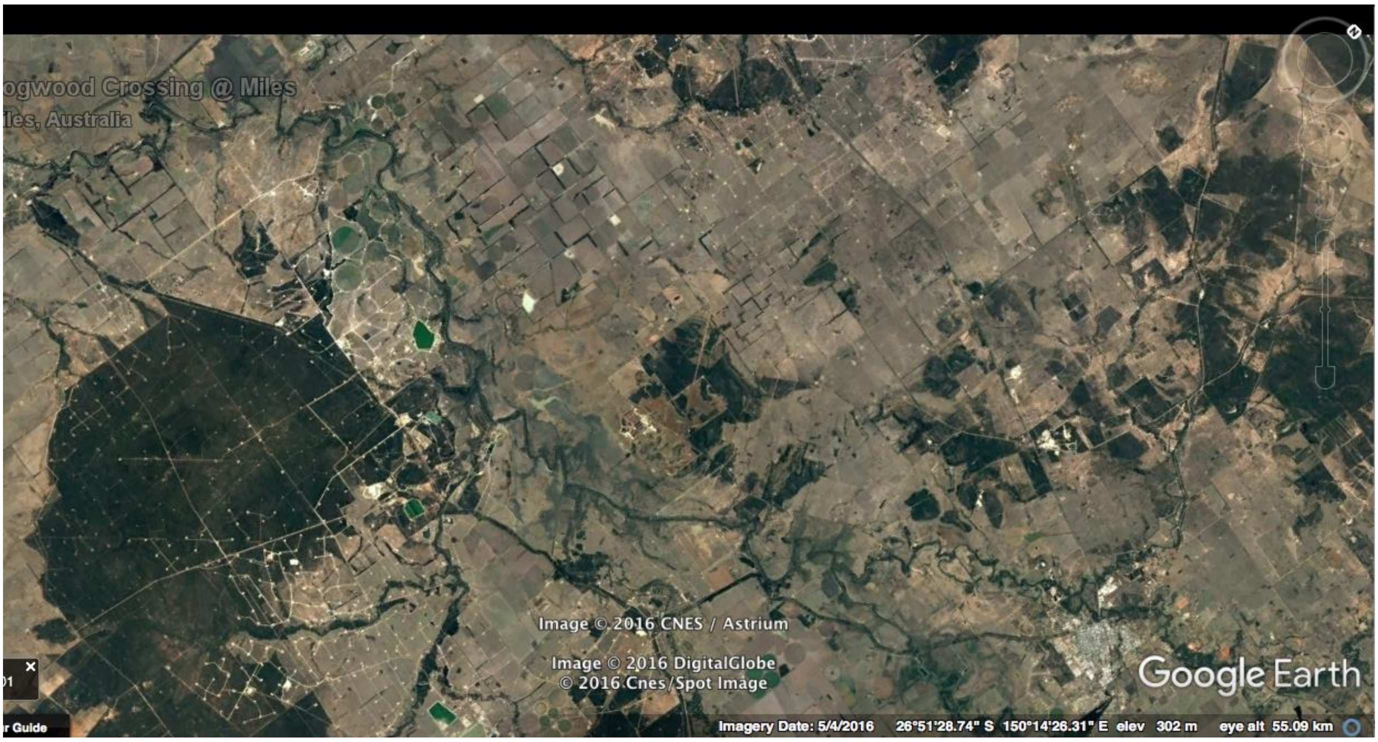


Source: Map data © 2019 Google.

Miles, Western Downs, Queensland



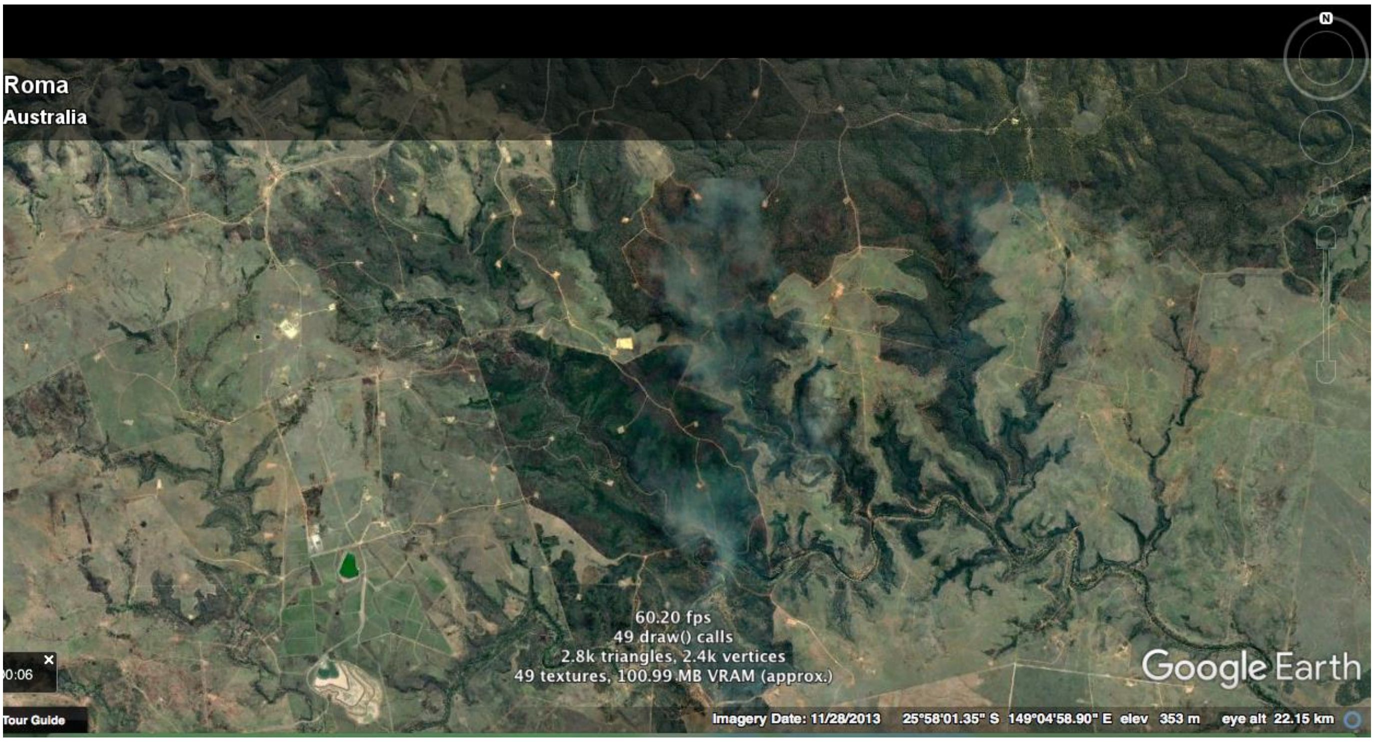
Source: Map data © 2019 Google.



Source: Map data © 2019 Google.

Roma, Western Downs, Queensland

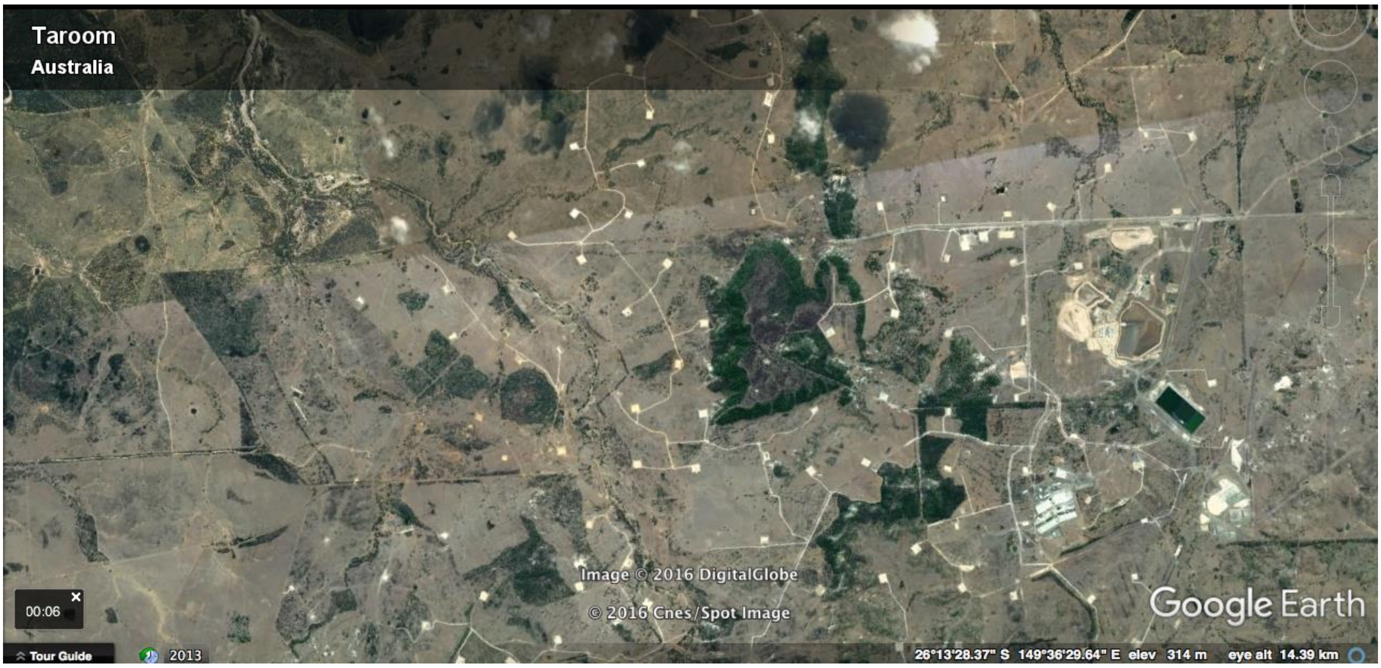
Source: Map data © 2019 Google.



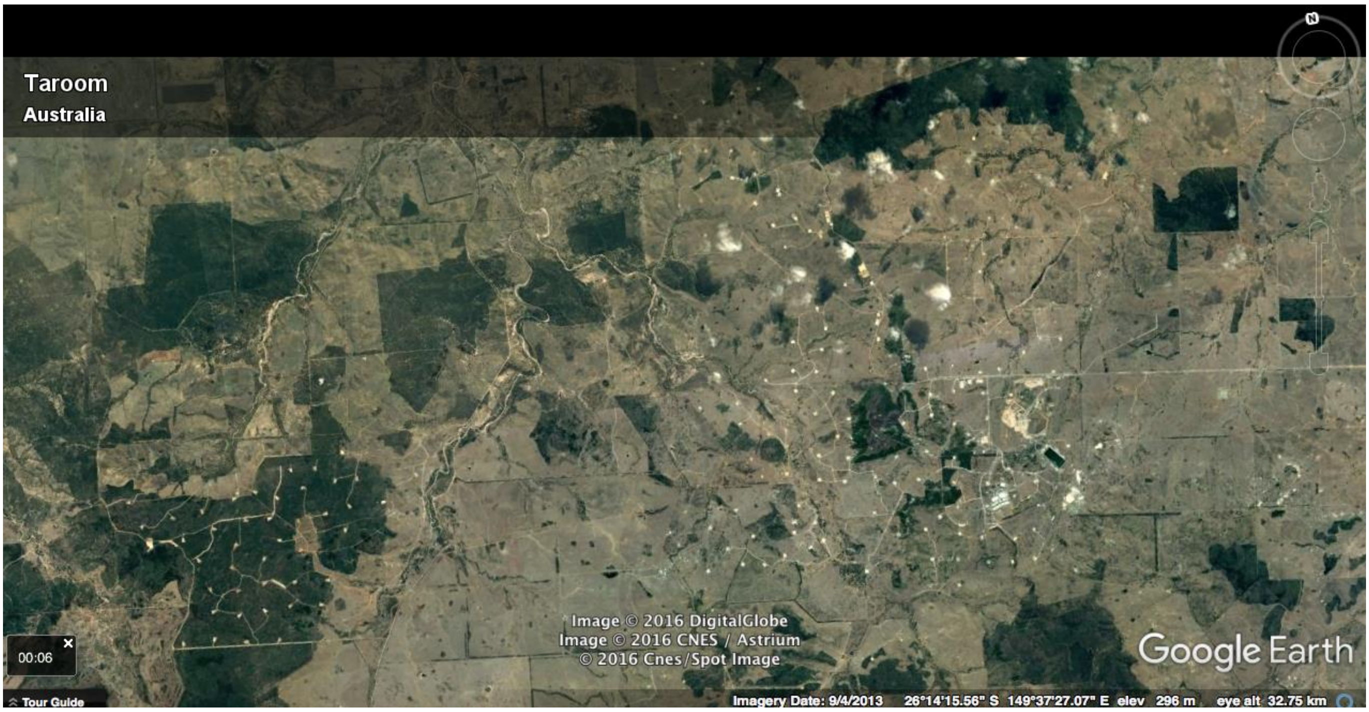
Source: Map data © 2019 Google.

Source: Map data © 2019 Google.

Taroom, Western Downs, Queensland

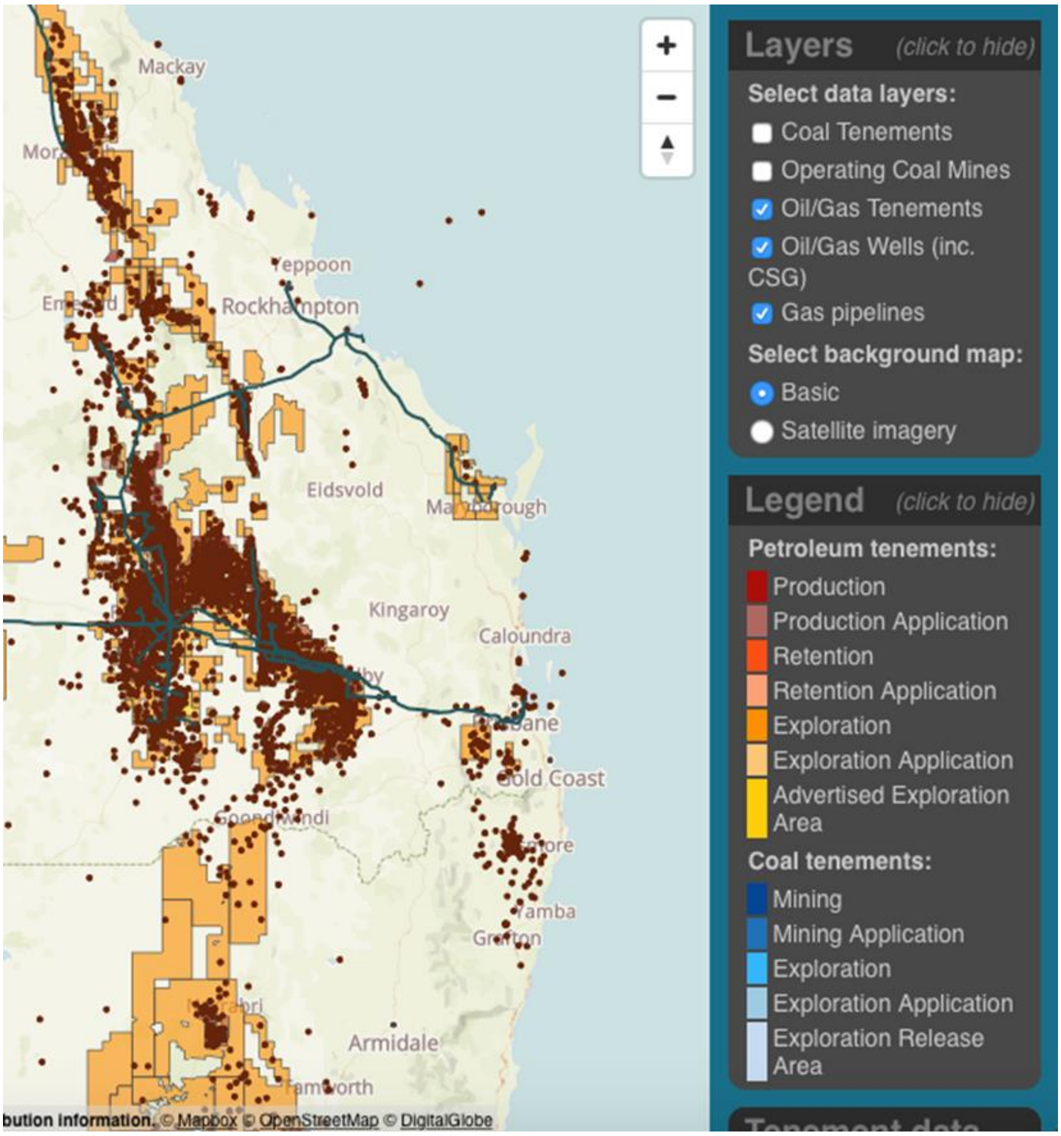


Source: Map data © 2019 Google.



Source: Map data © 2019 Google.

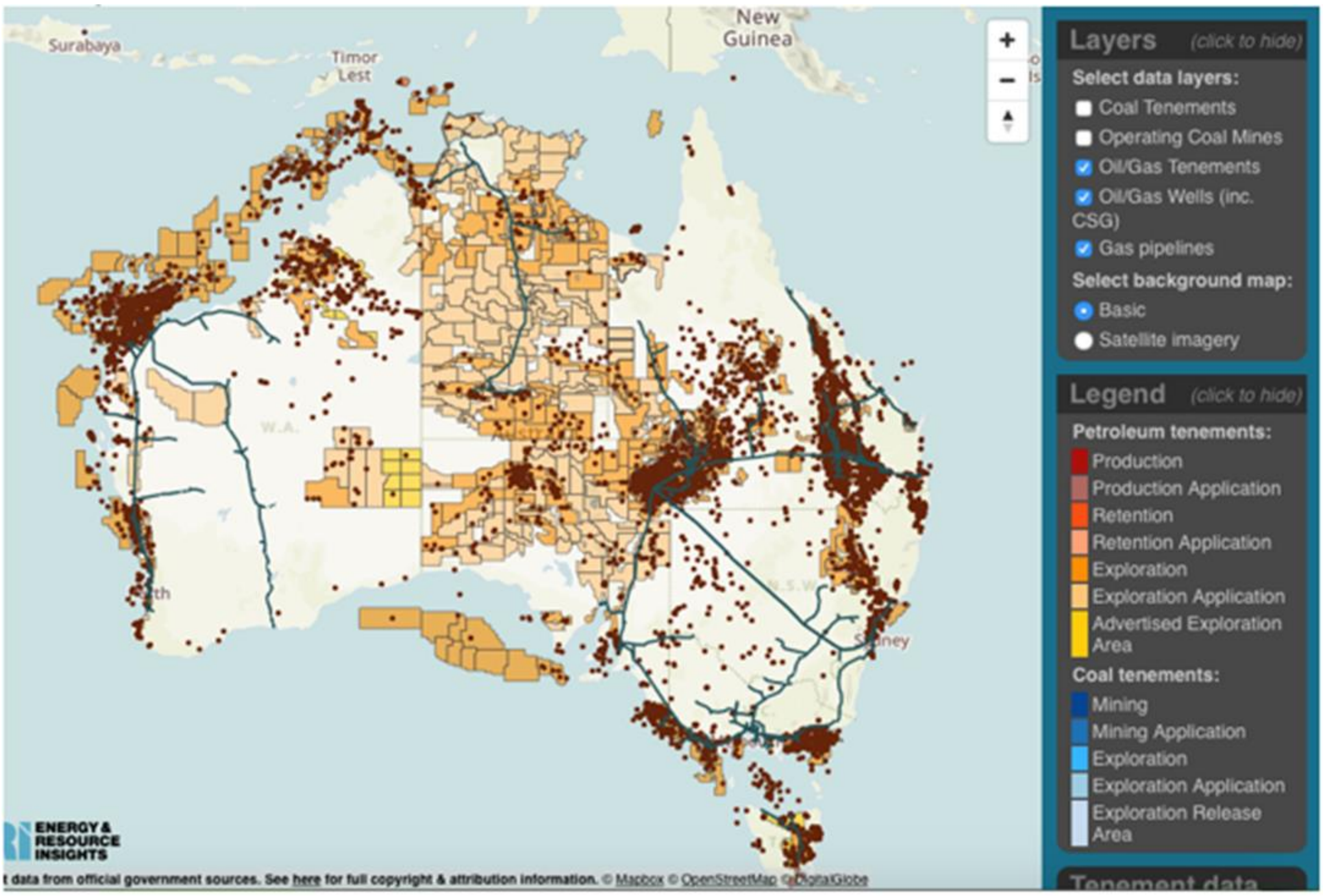
APPENDIX 14: Overview of South Eastern Queensland CSG Tenements (CSG Mining Leases), Gas Wells and Pipelines in Northern New South Wales and Queensland (© Mapbox, © Open Street Map, © Google Globe, 2017).



Source: Map data © 2019 Google

APPENDIX 15: Overview of Australian CSG Tenements

(CSG Mining Leases), Gas Wells and Pipelines in Australia (© Mapbox, © Open Street Map, © Google Globe, 2017).



Source: Map data © 2019 Google

Appendix 16: NVivo Nodes, Sub Nodes and Cases

Chapter 5: NVivo Node Groups A, B, C and D

Nodes

Name	Files	References	Created On	Created By	Modified On	Modified By
Group D APPEA Members (Participants 151-200)	1	140	24/01/2019 8:04 AM	JMS	22/03/2019 9:47 AM	JMS
Group C 10 Australian Government Officials (Participant numbers 101-150)	1	140	24/01/2019 7:01 AM	JMS	22/03/2019 9:47 AM	JMS
Group B 10 Community Individuals (Participant numbers 51-100)	1	140	23/01/2019 12:37 PM	JMS	22/03/2019 9:47 AM	JMS
Group A 10 Community Group Members (Participant numbers 1-50)	1	140	23/01/2019 11:27 AM	JMS	22/03/2019 9:47 AM	JMS

Node Group A and Sub Node Participants

Group A 10 Community Group Members (Participant numbers 1-50)	1	140	23/01/2019 11:27 AM	JMS	22/03/2019 9:47 AM	JMS
Participant 9	1	14	23/01/2019 12:42 PM	JMS	28/03/2019 9:23 AM	JMS
Participant 8	1	14	23/01/2019 12:41 PM	JMS	28/03/2019 9:23 AM	JMS
Participant 6	1	14	23/01/2019 12:40 PM	JMS	28/03/2019 9:23 AM	JMS
Participant 49	1	14	23/01/2019 12:47 PM	JMS	28/03/2019 9:23 AM	JMS
Participant 42	1	14	23/01/2019 12:47 PM	JMS	28/03/2019 9:23 AM	JMS
Participant 34	1	14	23/01/2019 12:46 PM	JMS	28/03/2019 9:23 AM	JMS
Participant 30	1	14	23/01/2019 12:49 PM	JMS	28/03/2019 9:23 AM	JMS
Participant 29	1	14	23/01/2019 12:43 PM	JMS	28/03/2019 9:23 AM	JMS
Participant 22	1	14	23/01/2019 12:45 PM	JMS	28/03/2019 9:23 AM	JMS
Participant 2	1	14	23/01/2019 12:40 PM	JMS	28/03/2019 9:23 AM	JMS

Node Group B and Sub Node Participants

Group B 10 Community Individuals (Participant numbers 51-100)		1	140	23/01/2019 12:37 PM	JMS	22/03/2019 9:47 AM	JMS
Participant 78		1	14	24/01/2019 6:06 AM	JMS	28/03/2019 12:21 PM	JMS
Participant 77		1	14	24/01/2019 6:06 AM	JMS	28/03/2019 12:21 PM	JMS
Participant 73		1	14	24/01/2019 6:05 AM	JMS	28/03/2019 12:21 PM	JMS
Participant 72		1	14	24/01/2019 6:05 AM	JMS	28/03/2019 12:21 PM	JMS
Participant 71		1	14	24/01/2019 6:04 AM	JMS	28/03/2019 9:23 AM	JMS
Participant 70		1	14	24/01/2019 6:04 AM	JMS	28/03/2019 9:23 AM	JMS
Participant 69		1	14	24/01/2019 6:03 AM	JMS	28/03/2019 9:23 AM	JMS
Participant 56		1	14	24/01/2019 6:03 AM	JMS	28/03/2019 9:23 AM	JMS
Participant 54		1	14	24/01/2019 6:02 AM	JMS	28/03/2019 9:23 AM	JMS
Participant 51		1	14	24/01/2019 6:01 AM	JMS	28/03/2019 9:23 AM	JMS

Node Group C and Sub Node Participants

Group C 10 Australian Government Officials (Participant numbers 101-150)		1	140	24/01/2019 7:01 AM	JMS	22/03/2019 9:47 AM	JMS
Participant 138		1	14	24/01/2019 7:07 AM	JMS	28/03/2019 12:21 PM	JMS
Participant 128		1	14	24/01/2019 7:07 AM	JMS	28/03/2019 12:21 PM	JMS
Participant 125		1	14	24/01/2019 7:07 AM	JMS	28/03/2019 12:21 PM	JMS
Participant 120		1	14	24/01/2019 7:06 AM	JMS	28/03/2019 12:21 PM	JMS
Participant 114		1	14	24/01/2019 7:06 AM	JMS	28/03/2019 12:21 PM	JMS
Participant 110		1	14	24/01/2019 7:05 AM	JMS	28/03/2019 12:21 PM	JMS
Participant 104		1	14	24/01/2019 7:05 AM	JMS	28/03/2019 12:21 PM	JMS
Participant 103		1	14	24/01/2019 7:04 AM	JMS	28/03/2019 12:21 PM	JMS
Participant 102		1	14	24/01/2019 7:03 AM	JMS	28/03/2019 12:21 PM	JMS
Participant 101		1	14	24/01/2019 7:03 AM	JMS	28/03/2019 12:21 PM	JMS

Node Group D and Sub Node Participants

Group D APPEA Members (Participants 151-200)		1	140	24/01/2019 8:04 AM	JMS	22/03/2019 9:47 AM	JMS
Participant 174		1	14	24/01/2019 8:10 AM	JMS	28/03/2019 12:56 PM	JMS
Participant 171		1	14	24/01/2019 8:09 AM	JMS	28/03/2019 12:56 PM	JMS
Participant 170		1	14	24/01/2019 8:09 AM	JMS	28/03/2019 12:21 PM	JMS
Participant 165		1	14	24/01/2019 8:08 AM	JMS	28/03/2019 12:21 PM	JMS
Participant 158		1	14	24/01/2019 8:07 AM	JMS	28/03/2019 12:21 PM	JMS
Participant 156		1	14	24/01/2019 8:07 AM	JMS	28/03/2019 12:21 PM	JMS
Participant 155		1	14	24/01/2019 8:06 AM	JMS	28/03/2019 12:21 PM	JMS
Participant 153		1	14	24/01/2019 8:06 AM	JMS	28/03/2019 12:21 PM	JMS
Participant 152		1	14	24/01/2019 8:05 AM	JMS	28/03/2019 12:21 PM	JMS
Participant 151		1	14	24/01/2019 8:05 AM	JMS	28/03/2019 12:21 PM	JMS

Cases and Children Cases: Questions 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 and14

Cases

Name	Files	References	Modified On	Modified By
Question 2	1	39	28/03/2019 12:56 PM	JMS
Q2 Group A	1	9	28/03/2019 9:27 AM	JMS
Q2 Group B	1	10	28/03/2019 12:21 PM	JMS
Q2 Group C	1	10	28/03/2019 12:21 PM	JMS
Q2 Group D	1	10	28/03/2019 12:56 PM	JMS

Question 4		1	40	28/03/2019 12:56 PM	JMS
Q 4 Group A		1	10	28/03/2019 9:55 AM	JMS
Q 4 Group B		1	10	28/03/2019 12:21 PM	JMS
Q 4 Group C		1	10	28/03/2019 12:21 PM	JMS
Q 4 Group D		1	10	28/03/2019 12:56 PM	JMS

Question 5		1	40	28/03/2019 12:56 PM	JMS
Q 5 Group A		1	10	28/03/2019 10:13 AM	JMS
Q 5 Group B		1	10	28/03/2019 12:21 PM	JMS
Q 5 Group C		1	10	28/03/2019 12:21 PM	JMS
Q 5 Group D		1	10	28/03/2019 12:56 PM	JMS
Question 6		1	40	28/03/2019 12:21 PM	JMS
Q 6 Group A		1	10	28/03/2019 10:27 AM	JMS
Q 6 Group B		1	10	28/03/2019 12:21 PM	JMS
Q 6 Group C		1	10	28/03/2019 12:21 PM	JMS
Q 6 Group D		1	10	28/03/2019 12:56 PM	JMS
Question 7		1	40	28/03/2019 12:56 PM	JMS
Q 7 Group A		1	10	28/03/2019 10:43 AM	JMS
Q 7 Group B		1	10	28/03/2019 12:21 PM	JMS
Q 7 Group C		1	10	28/03/2019 12:21 PM	JMS
Q 7 Group D		1	10	28/03/2019 12:56 PM	JMS
Question 8		1	40	28/03/2019 12:56 PM	JMS
Q 8 Group A		1	10	28/03/2019 12:17 PM	JMS
Q 8 Group B		1	10	28/03/2019 12:23 PM	JMS
Q 8 Group C		1	10	28/03/2019 12:27 PM	JMS
Q 8 Group D		1	10	28/03/2019 12:56 PM	JMS

Question 9			1	40	28/03/2019 12:56 PM	JMS
Q 9 Group A			1	10	28/03/2019 12:38 PM	JMS
Q 9 Group B			1	10	28/03/2019 12:48 PM	JMS
Q 9 Group C			1	10	28/03/2019 12:53 PM	JMS
Q 9 Group D			1	10	28/03/2019 12:57 PM	JMS

Question 10		1	39	28/03/2019 12:56 PM	JMS
Q 10 Group A		1	10	28/03/2019 1:07 PM	JMS
Q 10 Group B		1	10	28/03/2019 1:11 PM	JMS
Q 10 Group C		1	10	28/03/2019 1:15 PM	JMS
Q 10 Group D		1	10	28/03/2019 1:18 PM	JMS
Question 11		1	40	28/03/2019 12:56 PM	JMS
Q 11 Group A		1	10	28/03/2019 1:24 PM	JMS
Q 11 Group B		1	10	28/03/2019 1:27 PM	JMS
Q 11 Group C		1	10	28/03/2019 1:30 PM	JMS
Q 11 Group D		1	10	28/03/2019 1:33 PM	JMS
Question 12		1	40	28/03/2019 12:56 PM	JMS
Q 12 Group A		1	10	28/03/2019 1:37 PM	JMS
Q 12 Group B		1	10	28/03/2019 1:40 PM	JMS
Q 12 Group C		1	10	28/03/2019 1:43 PM	JMS
Q 12 Group D		1	10	28/03/2019 1:45 PM	JMS
Question 14		1	40	28/03/2019 12:56 PM	JMS
Q 14 Group A		1	9	28/03/2019 2:03 PM	JMS
Q 14 Group B		1	7	28/03/2019 2:04 PM	JMS
Q 14 Group C		1	8	28/03/2019 2:06 PM	JMS
Q 14 Group D		1	4	28/03/2019 2:07 PM	JMS
Question 13		1	40	28/03/2019 12:56 PM	JMS
Q 13 Group A		1	10	28/03/2019 1:52 PM	JMS
Q 13 Group B		1	10	28/03/2019 1:54 PM	JMS
Q 13 Group C		1	10	28/03/2019 1:57 PM	JMS
Q 13 Group D		1	8	28/03/2019 2:00 PM	JMS

Chapter 6: Factiva NVivo Media Content Analysis Nodes

Nodes

Name	Files	References	Created On	Created By
Water Impacts	1	457	2/01/2020 12:39 PM	JMS
Water benefits of CSG	1	21	2/01/2020 12:40 PM	JMS
Social impacts	1	494	2/01/2020 12:44 PM	JMS
Social benefits	1	101	2/01/2020 12:45 PM	JMS
Human health impacts	1	399	2/01/2020 12:41 PM	JMS
Human health benefits	0	0	3/02/2020 6:43 AM	JMS
Environmental impacts	1	383	2/01/2020 12:43 PM	JMS
Environmental benefits	0	0	3/02/2020 6:44 AM	JMS
Economic growth and development of Queensland CSG Industry	1	638	2/01/2020 12:35 PM	JMS

Appendix 17: The Anonymous Questionnaire Participant

Name	Description
Group A 10 Community Group Members (Participant numbers 1-50)	Possible Anti-CSG Lobby Groups
Participant 2	
Participant 6	
Participant 8	
Participant 9	
Participant 22	
Participant 29	
Participant 30	
Participant 34	
Participant 42	
Participant 49	
Group B 10 Community Individual Participants (Participant numbers 51-100)	Possible Anti-CSG Individuals
Participant 51	
Participant 54	
Participant 56	
Participant 69	
Participant 70	
Participant 71	
Participant 72	
Participant 73	
Participant 77	
Participant 78	

Name	Description
Group C 10 Australian Government Officials (Participant numbers 101-150)	Possible Anti and Pro-CSG Government Officials
Participant 101	
Participant 102	
Participant 103	
Participant 104	
Participant 110	
Participant 114	
Participant 120	
Participant 125	
Participant 128	
Participant 138	
Group D APPEA Members (Participants numbers 151-200)	Possible Pro- CSG APPEA Members
Participant 151	
Participant 152	
Participant 153	
Participant 155	
Participant 156	
Participant 158	
Participant 165	
Participant 170	
Participant 171	
Participant 174	

Appendix 18: Research Questions 1 and 3 Word Excel Data

Question 1 Word Excel Data

Question 1 Group A Data

Group A	1 to 5
Question 1	**Answer**
P2	3
P6	3
P8	3
P9	2
P22	3
P29	3
P30	1
P34	3
P42	3
P49	3

Question 1 Group B Data

Group B	1 to 5
Question 1	**Answer**
P51	3
P54	1
P56	1
P69	2
P70	3
P71	1
P72	1
P73	1
P77	2
P78	3

Question 1 Group C Data

Group C	1 to 5
Question 1	**Answer**
P101	3
P102	3
P103	3
P104	3
P110	1
P114	3
P120	1
P125	1
P128	3
P138	1

Question 1 Group D Data

Group D	**1 to 5**
Question 1	**Answer**
P151	3
P152	3
P153	3
P155	3
P156	3
P158	3
P165	3
P170	3
P171	3
P174	3

Question 1 Groups A, B, C and D Data

All Groups (A, B, C, and D)	1 to 5
Q1	Ans
P2	3
P6	3
P8	3
P9	2
P22	3
P29	3
P30	1
P34	3
P42	3
P49	3
P51	3
P54	1
P56	1
P69	2
P70	3
P71	1
P72	1
P73	1
P77	1
P78	3
P101	3
P102	3
P103	3
P104	3
P110	1
P114	3
P120	1
P125	1
P128	3
P138	1
P151	3
P152	3
P153	3

P155	3
P156	3
P158	3
P165	3
P170	3
P171	3
P174	3

Question 3 Word Excel Data

Question 3 Group A Data

Group A	1 to 6
Question 3	**Answers**
P2	12345
P6	13456
P8	123456
P9	12456
P22	2345
P29	123456
P30	123456
P34	23456
P42	2345
P49	13456

Question 3 Group B Data

Group B	1 to 6
Question 3	**Answers**
P51	12345
P54	12345
P56	1245
P69	12345
P70	345
P71	12345
P72	12345
P73	123456
P77	123456
P78	1345

Question 3 Group C Data

Group C	1 to 6
Question 3	**Answers**
P101	123456
P102	3456
P103	46
P104	134
P110	346
P114	46
P120	134

P125	125
P128	34
P138	1235

Question 3 Group D Data

Group D	1 to 6
Question 3	**Answers**
P151	136
P152	2345
P153	4
P155	6
P156	34
P158	4
P165	36
P170	1346
P171	34
P174	4

Question 3 Groups A, B, C and D Data

All Groups (A, B, C, and D)	1 to 6
Question 3	**Answers**
P2	12345
P6	13456
P8	123456
P9	12456
P22	2345
P29	123456
P30	123456
P34	23456
P42	2345
P49	13456
P51	12345
P54	12345
P56	1245
P69	12345
P70	345
P71	12345
P72	12345
P73	123456
P77	123456
P78	1345
P101	123456
P102	3456
P103	46
P104	134
P110	346
P114	46
P120	134

P125	125
P128	34
P138	1235
P151	136
P152	2345
P153	4
P155	6
P156	34
P158	4
P165	36
P170	1346
P171	34
P174	4