

# Coal Seam Gas Mining: An Assault on Farming Land, Water Resources and Property Rights

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## A. GLOSSARY

**ATP.** Authority to Prospect.

**BTEX.** Benzene, toluene, ethylbenzene, xylene. These chemicals are highly carcinogenic and are found in coal seams, crude oil, natural gas, volcanic emissions and forest fires, as well as being industrial chemicals (Leusch & Bartkow, 2010; DES, 2012).

**Business Queensland.** Queensland Government. <https://www.business.qld.gov.au/>

**CCA.** Conduct and Compensation Agreement between landholder and resource company, required as a legally binding agreement before the company can enter private land and carry out advanced activities. <https://www.business.qld.gov.au/industries/mining-energy-water/resources/landholders/accessing-private-land/landholder-agreements>.

**CSG.** Coal seam gas is mined from coal seams (US term: ‘coal bed methane’). The main components, methane and carbon dioxide, occur with water in pores in the coal. CSG is held tightly in a series of ‘cleats’ within coal beds well below the surface and held in place in the porous coal seam by hydraulic pressure. This pressure is sometimes sufficient to enable flow to the wellhead, allowing the methane to be extracted by pumping both water and gas to the surface. Typically, large volumes of water are extracted before the gas begins to flow. This ‘associated produced water’, as it is termed, is of variable salinity and variable chemical composition but is usually not sufficiently pure, because of the salts and sometimes concerning levels of toxic aromatic hydrocarbons, to discharge without consequence to nearby waterways. This variable quality and the temporal variability in volume likely to be available give rise to questions as to whether the extracted water is waste or a resource. CSG, shale gas and tight gas are regarded as ‘unconventional gas’ to differentiate them from conventional or natural gas, also mainly methane, which is pumped from the earth where it is found free, in contradistinction to unconventional gas which requires technology to unlock.

**CRAA.** Condamine River Alluvial Aquifer is an aquifer overlying much of the Surat Cumulative Management Area. Bores drilled into it support agriculture, town and house water supplies. Often abbreviated as the CA Condamine Alluvium.

**DEHP.** Queensland Department of Environment and Heritage Protection, now transformed into the Department of Environment and Science. <https://environment.des.qld.gov.au/>

**DES.** Queensland Department of Environment and Science. <https://environment.des.qld.gov.au/>

**EA.** Environmental Authority to perform an environmentally relevant activity (ERA) which has potential to release contaminants into the environment that will or may cause environmental harm. Mining, geothermal activity, greenhouse gas storage and petroleum activities are considered resource ERAs. <https://www.business.qld.gov.au/running-business/environment/licences-permits/applying>

**EDO.** Environment Defenders Office is an NGO that uses the law to protect the environment and help communities understand their rights and responsibilities.

**EIA.** Environmental Impact Assessment, a tool to evaluate likely environmental impacts of a proposed project or development.

**EIS.** Environmental Impact Statement, required for resource activity projects under the *Queensland Environmental Protection Act 1994*. [https://environment.des.qld.gov.au/\\_data/assets/pdf\\_file/0026/208079/eis-gl-environmental-impact-statement-process.pdf](https://environment.des.qld.gov.au/_data/assets/pdf_file/0026/208079/eis-gl-environmental-impact-statement-process.pdf); <https://www.qld.gov.au/environment/pollution/management/eis-process>

**EPA.** Queensland Environmental Protection Agency was a Department but is now within the Department of Environment and Science. Queensland does not have an independent EPA, unlike other states. <https://environment.des.qld.gov.au/>

**GasFields Commission Queensland (GFCQ).** Established under the *Gasfields Commission Act 2013* as a statutory authority to facilitate onshore gas industry stakeholder relationships, review implementation of regulatory frameworks and advise on sustainable co-existence and management of the industry. <https://www.gfcq.org.au/about-us>

- GISERA.** Gas Industry Social and Environmental Research Alliance, an entity of CSIRO (the national Commonwealth Scientific and Industrial Research Organisation), with four gas-producing companies as members, established to research the environmental, social and economic impacts of the onshore gas industry. <https://gisera.csiro.au/>
- Hydraulic Fracturing**, or ‘fracking’ or ‘fracing’. “A wellbore completion method that is used to improve the recovery of hydrocarbons from unconventional oil and gas reservoirs (such as low-permeability rocks). Injection of high-pressure fluids, usually a water–sand slurry, is used to create an open fracture network that enhances fluid flow within porous but otherwise impermeable strata” (Atkinson et al., 2020, p. 264; and see Dart et al., 2022).
- MDB.** Murray-Darling Basin. Note its Condamine-Balonne water resource management plan: <https://www.mdba.gov.au/publications/mdba-reports/condamine-balonne-water-resource-plan>
- National Water Commission.** Independent statutory authority of the Australian Government, established under the *Water Commission Act 2004* to implement the National Water Initiative agenda. Abolished by the Abbott Government in 2014.
- OGIA,** Office of Groundwater Impact Assessment. An entity of the Queensland Government. <https://www.business.qld.gov.au/industries/mining-energy-water/resources/environment-water/ogia>
- PAH.** Polyaromatic hydrocarbons. There is a long list of these found in coal; some, such as naphthalene, are eye and skin irritants; many are believed to be carcinogenic (CDC, 2022).
- P&G Act.** *Petroleum and Gas (Production and Safety) Act 2004*. Successor to *Petroleum Act 1923*, sections of which remain in force.
- QCL.** *Queensland Country Life*. A weekly newspaper. <https://www.queenslandcountrylife.com.au/>
- RIDA.** Regional Interests Development Approval. <https://planning.statedevelopment.qld.gov.au/planning-issues-and-interests/areas-of-regional-interest/regional-planning-interests-applications>
- RO.** Reverse osmosis, a water purification process in which contaminated water such as CSG-produced water is pumped under high pressure through semipermeable membranes which selectively remove salts.
- RPI.** *Regional Planning Interests Act 2014*.
- Salinity.** Salt level in water or soil. CSG-produced water contains different levels, mainly of sodium chloride and sodium bicarbonate, varying from 200 to more than 10,000 mg/L. Salinity levels greater than about 5 dS/m (electrical conductivity level, ca. 3.3 g salt/L) inhibit growth of many agricultural plants.
- Sunwater.** A Queensland Government-owned corporation providing bulk water services from 19 dams. <https://www.sunwater.com.au/about/>
- Surat Cumulative Management Area.** Declared under the *Water Act 2000* to enable the biennial Underground Water Impact Report(s) undertaken by the independent Office of Groundwater Impact Assessment (OGIA).
- USGS.** United States Geological Survey, established in 1879, operating under the Department of the Interior. The agency monitors, analyses and predicts current and evolving human and natural earth-system interactions. <https://www.usgs.gov/about/about-us/who-we-are>
- Void.** Used in the technical sense, a zone of reduced pressure, below the surface and surrounded by strata subject to greater hydraulic or geomorphic pressure. It does not connote an empty vacuum.

## B. NOTES

### 1. Australian Domestic Gas Security

#### Mechanism

If the relevant Minister determines there will be a supply shortfall year, they may institute controls on exports of liquefied natural gas (LNG) not presently contracted, i.e. gas exports to the spot market, to ensure sufficient domestic supply. The Commonwealth Government has an agreement on this with the east coast of Australia LNG exporters until 2023.

### 2. Anecdotal Reports from the Darling Downs

Landholders' concerns have resulted in several recent reports in the media, e.g. an ABC *Landline* (Morris, 2021c) report, press articles by the ABC (Morris, 2020, 2021a,b,c), *Queensland Country Life* (Long, 2022a,b), *Guardian Australia* (Cox, 2021; Smee, 2022a,b), *Country Caller Regional News* (Clarke, 2022), *Australian Financial Review* (MacDonald-Smith, 2022), *Courier-Mail* (2021), *Courier-Mail* (2022), *InQueensland* (McCarthy, 2022), TV reports on Channel 7 Toowoomba (2021a,b), *The Project* (Channel 10, 2021) and *Rural Queensland Today* radio interview broadcast with an affected landholder (2022). The Lock the Gate Alliance (2022) publishes a series of case studies relating to coal seam gas extraction. It "is a national grassroots organisation made up of over 120,000 supporters and more than 260 local groups who are concerned about risky coal mining, coal seam gas and fracking" (see Lock the Gate Alliance website).

### 3. Land Tenure

Various leases for grazing purposes from the Crown (State) under the *Land Act 1994* cover about 60% of Queensland, some for a fixed period of time (commonly 30 years) and others perpetual. As with freehold, such leases do not cover the underground mineral or gas resources. Leaseholders have a duty of care for the land, as specified in s. 199 and explained in *Managing Grazing Lands in Queensland* (DERM, 2011) and the Long Paddock website (Queensland Government, 2022). However, the state as landlord also has an (inadequately defined or acknowledged) duty of care and residual responsibility for managing activities outside the scope of the lease.

### 4. Petroleum Tenure

Coal seam gas and shale gas activities are administered under the P&G Act and *Petroleum Act 1923*, although they draw upon a coal resource that otherwise could be administered under the regime for allocating coal (*Mineral Resources Act 1989* (Qld)).

### 5. Hydraulic Fracking

Hydraulic fracking is explained in the Glossary. Coal seams can lie between water-bearing aquifers; and once a well intercepts the coal seam, gas and associated water under pressure from the overlying strata can be accessed. In conventional coal seam gas production, the initial process generally involves dewatering of the coal seam. To achieve this, downhole pumps are used to carry water to the surface, where the produced water is usually piped to a storage dam before regulated disposal as a waste under Queensland's *Environmental Protection Act 1994* (EP Act) and the *Waste Reduction and Recycling Act 2011* (Waste Act) (IESC, 2014). This dewatering process then allows gas to be released from the coal seam through a reduction in hydrostatic pressure. Each well will have varying amounts of water and gas and contained chemicals (e.g. dissolved solids, salt as sodium chloride and bicarbonate, hardness chemicals, silica, a large variety of organic chemicals including polyaromatic hydrocarbons and BTEX), often making the water brackish and needing purification before disposal. Salt levels range from 300 to 10,000 mg/L or occasionally more (Leusch & Bartkow, 2010; Apte et al., 2017, 2020; DES, 2012). In Queensland, more than 90% of associated water is treated before being made available for beneficial use.

In a hydraulic fracking process the fracking fluid is pumped at high pressure into the well to initiate a 'fracking' of the near-wellbore formation. After the pressure is released, the fracking fluid, along with any associated or produced water in the coal cleats, is produced back (and out of the wellbore) before the gas can readily flow. The produced-back fracking fluid can often be of significant volume and is often contaminated with chemicals used in the fracking process.

## 6. Energy Consumption of Reverse Osmosis

The energy used in a seawater water reverse osmosis (RO) treatment plant is 3.5–4.5 kWh/m<sup>3</sup> (Kim et al., 2019). CSG-produced water varies in its concentration of salts but can be as much as, or occasionally greater, than 10,000 mg salt/L with a high SAR, about a third of sea water concentration. RO energy use will be usually less than that for treatment of sea water to drinking water. However, much of the energy in the RO process is expended by the pumps, which will be similar for produced water across salt concentrations. Gas companies do not release this information, e.g. for the large-capacity QGC (Shell) Kenya Treatment Plant near Chinchilla.

## 7. Licence Applications

Petroleum licence applications are not required to be published, nor are they on a public register which would require them to remain available to members of the public, and they are not subject to any public notification under Queensland's petroleum legislation. The only official way to view these applications and to find out where CSG well-drilling activity is proposed is to apply for them under the Right to Information framework, a convoluted and time-consuming process. Once production licences are granted, they may be available on the GeoResGlobe which “provides an online, interactive experience to view Queensland's mining and exploration data to assist in the administration of permits and assessment of mineral potential in Queensland. Users of GeoResGlobe can access over 600 spatial data layers that include themes such as exploration, production and historical resource authorities, geological and geophysical data, native title areas, administrative boundaries and more” (Business Queensland, 2021).

Tenures for gas activities cover approximately 11.5% of Queensland and are comprised of 3.6 million ha under petroleum lease production and 16 million ha under authority to prospect, a total of 19.6 million ha (GasFields Commission, 2022). On the Darling Downs, these gas resources are overwhelmingly on privately held agricultural land (Taylor & Hunter, 2019); yet gas proponents are generally not required in their assessment materials to state where specifically on the landscape they will be undertaking their activity;

nor is this generally provided for in conditions. The behaviour of the industry in moving through good-quality agricultural land without sufficiently transparent government oversight or interaction with landholders is seen as improvident, stirring up community uncertainty and perceptions of exposure to high risk because of an inability to plan and predict satisfactorily (Everingham et al., 2013, 2016; Epsig, 2021) and as repeatedly documented in the Senate Select Committee on Unconventional Gas Mining Interim Report (Parliament of Australia, 2016).

## 8. Compensation

The *Mineral and Energy Resources (Common Provisions) Act 2014* also provides for allocation of appropriate compensation to landowners as claimants and specifies how this will be undertaken under requirements for CCAs. The Act also lays out a path forward if the CCA negotiations stall – via mediation, conciliation and arbitration – and specifies how parties assisting with or undertaking these processes can be jointly appointed. Far from the ‘level playing field’ described in the Code, the only effective avenue landholders have for redress is to take the CSG company to court or via alternative dispute resolution, where the landholders' costs are considerable and often prohibitive.

Lack of information on compliance activities limits public transparency of operator activities. New South Wales has set up a dedicated Coal Seam Gas Office and the Environment Protection Authority which regulate compliance with the environment protection licences for gas exploration and production, and which have legally enforceable, site-specific controls. These include the requirement for a water access licence if the gas extraction activity uses/produces more than 3 megalitres per year. The Independent Pricing and Regulatory Authority provides benchmark compensation rates for landowners to use in their negotiations with resource companies for access.

## 9. Land Access Code Requirements

Mandatory conditions for resource authorities detail the training required of staff and specify that operatives must, where possible: use existing access points and minimise dust and road damage, disturbance to livestock and people and property;

prevent pest spread; negotiate camp sites; manage rubbish; not bring livestock animals or alcohol without landholder's consent; and close gates, repair any cut fences or add stock-proof gate or grid (DNRM, 2016).

### 10. The Darling Downs

The Darling Downs is characterised by deep, fertile, black-clay vertosols, which now support productive agriculture comprising cropping, horticulture and grazing, particularly for cattle. The CSG mining area extends further into the South West region of Queensland, which has poorer soils, lower rainfall and more grazing than cropping. Combined, the vertosols cover >390,000 km<sup>2</sup> (Regional Development Australia, 2022). Sustainable agroecosystem management has ensured that the Darling Downs is now one of the most productive areas in Australia, in part based on management of water for irrigation and control of erosion. The Downs as a geographical construct occupies part of the Surat sedimentary basin, which includes the surficial Condamine Alluvium and deeper, mainly sandstone aquifers, but also includes the Walloon coal seams.

After moving through the Bowen Basin, west and south-west of Dalby, Queensland, Australia, Arrow Energy, a CSG extraction company jointly funded by Shell and PetroChina, is now commencing to establish mines on arable alluvial soils on the Darling Downs Condamine region east of the Condamine River (Arrow, 2022). This evolution of the industry from operating mainly in pastoral country of variable fertility to highly fertile cropping land has generated distrust in landholders of both authorities and resource industries (Taylor & Hunter, 2019). This distrust is heightened by a lack of publicly accessible data, including plans for where activities are to be undertaken, potential and realised groundwater impacts, and baseline monitoring of soil levels to assess impacts of subsidence.

Farmers on the Downs commonly have been ready to adopt modern precision and conservation agricultural technology including:

- laser levelling fields for cropping efficiency, especially irrigation;
- GPS-controlled traffic guidance of machinery;
- equipment for irrigating crops efficiently and

scientific matching of irrigation to crop water requirements;

- ring (surface) tanks to store overland flow for irrigation, topping up from aquifers and waterways, as licensed to do, whenever the creeks and rivers are flowing adequately;
- management of erosion, especially in severe weather events; and
- minimum tillage and crop rotations, including legumes.

Articles in support of this statement are: Jha et al. (2022), Dang et al. (2020), Murray et al. (2020), Tennakoon & Milroy (2003), and Freebairn et al. (1996).

Farmers adopting some or all of these technologies, all requiring significant capital investment, are sensitive to changes in the profile of the soil and water resources on which their productivity depends. Farmers are not unanimous in their opposition to the industry: some pastoralists, particularly in the districts of lower farm productivity, have welcomed the payments made to compensate for the drilling infrastructure (Morris, 2021d). Even so, we are aware of many cases where graziers have found their bore water has become depleted by CSG companies well beyond a government-mandated level of allowed extraction from immediately affected area bores (OGIA, 2022), and therefore these bores are no longer a resource for use by these landholders. For this reason, the extension of the industry to cropping lands has raised widespread and increasing concern over the past 10 years.

### 11. The Walloons

The geological stratigraphy of the Walloon Coal Measures lies at depths varying typically from 300 to 600 m, but in parts it is only 60 m deep below the farms. Lying above this stratum are the Condamine Alluvium and the Springbok Sandstone aquifers (OGIA, 2016) which supply quality bore water for irrigation and drinking. The Walloon coal measures are tapped for CSG, coal and water. The Walloon coal seams were formed by sedimentary deposition in the Jurassic period and lie beneath other sedimentary layers, usually including aquifers and aquitards, and good-quality agricultural soils that are often very deep, particularly in the Condamine Alluvium.

## 12. Inadequacies of Regulatory Regimes – CSG Legislation

Given that ownership over mineral and petroleum resources is retained out of land title by the state, the stage is set for conflict between incoming holders of tenure over mining resources and the holders of tenure over the land surface. Legislation attempts to minimise the damage caused to the land surface or the landowner's assets and provides for compensation where damage is done, but it does not give landholders the right to refuse access (Taylor & Hunter, 2019). A series of actions has been taken by government to support the coexistence of the gas industry with agriculture:

- A GasFields Commission to manage and improve “the sustainable coexistence of landholders, regional communities and the onshore gas industry in Queensland” (CFCQ, 2022, p. 8).
- An Office of Groundwater Impact Assessment (OGIA), an independent office responsible for assessing managing impacts of groundwater extraction from resource activities in cumulative management areas (see Glossary).
- Extensive statutory reform of the regulation of water impacts under the *Water Act 2000* and the *Environmental Protection Act 1994*.
- Reform and review of CSG wastewater management, including recent establishment of a CSG Brine Management Targeted Stakeholder group.
- Attempts to reconcile gas extraction with the protection of good-quality agricultural land, including via the *Strategic Cropping Land Act 2011* which was repealed and replaced by the *Regional Planning Interests Act 2014*.
- The CSG industry is subject to an extensive and complex network of statutory provisions, broadly clustered into the following:
  - *Gas tenure*, a transfer of ownership of CSG from the Queensland Government to the applicant company under the P&G Act or the *Petroleum Act 1923*.
  - *Environmental authority*, which provides conditions of operation to seek to minimise environmental impacts, regulated under the *Environmental Protection Act 1994*. The inconsistencies in the way these

conditions operate in practice is outlined in the paper *Falling Through the Cracks: Issues with Integrity in Environmental Assessment of Gas Activities in Queensland* (EDO, 2021).

- *EPBC Act assessment*, particularly under the ‘water trigger’, which requires that significant impacts to water resources by CSG companies must be referred for assessment under the Commonwealth’s *Environment Protection and Biodiversity Conservation Act 1999* (EPBC, 1999).
- *Private contracts*, including Conduct and Compensation Agreements and commitments to ‘make good’, contracts being notionally voluntary between landholders and the companies but legitimised by and in some cases required by statute.

## 13. Inadequacies of Regulatory Regimes – Adaptive Management

Adaptive management is the preferred model of the Queensland Government for managing the impacts of the burgeoning CSG industry (DES, 2022b). The concept “is an iterative, hierarchical organisational process for undertaking natural resource planning activities” (Pressland et al., 2004, p. 1). It provides a conceptual vehicle for continually integrating new knowledge and science into planning to achieve desired outcomes. It is a structured decision-making process that can accommodate quite difficult and contentious trade-offs but is based on a trust and willingness to change by the partners/stakeholders involved as part of a shared responsibility. This process is supported by a systems analysis of the biophysical, socio-economic and institutional environments. The process should lead to a set of performance indicators and independent review which determine management actions, but this is often not routinely undertaken.

On-shore unconventional gas extraction activities are generally regarded as having a temporary effect on the land and the atmospheric greenhouse gas content. Royalties are usually required to be paid to the government for the resource but rarely cover costs of the negative externalities.

A major issue with the administration of this plethora of Acts and regulations is that

sorting out how they might operate (and redress for non-compliance) requires multiple submissions by landholders to regulators and occasionally, where legal rights exist, court cases. There is little apparent collaboration between the Department of Resources and the Department of Agriculture and Forestry on clarifying the situation for landholders.

#### 14. Queensland Audit Office's Red Flags

This is a precis of the findings in the Audit *Managing coal seam gas activities* (Report 12: 2019-20) (Queensland Audit Office, 2020):

1. The Acts involved did not specify designated regulatory activity for the CSG industry, leading to numerous issues that were inadequately or not at all addressed, and to inconsistent application across agencies, especially regarding the irreversible effects on agricultural land.
2. Compliance issues and outcomes are recorded on different databases across agencies and by limited data sharing. Non-compliance is approached first through attempting to educate and guide operators to return them to compliance; however, there are too few experienced staff to do this adequately and competently. An increased level of training and establishment of supporting staff is "recommended" (p. 8). There is limited enforcement, and no register of the number of non-compliant events and how many operators were brought back into compliance. "The regulators cannot provide government with a collective understanding of regulatory effectiveness and industry compliance" (p. 5). There is no separate database for CSG activities, meaning that manual extraction and manipulation of data from within the petroleum and gas database is required.
3. Stakeholders and, particularly, landholders are confused and frustrated by the number of entities and their roles (including the regulators and other Departments, the Commission, the Land Access Ombudsman and the Land Court). Hence, there is confusion over whom to ask for information about rights, entitlements, obligations of industry and stakeholders – and how to deal with inconsistencies

and conflicting advice. Industry and government can access assessments and baseline data, but this is often not shared with landholders because gas companies regard it as 'commercial in confidence'.

4. Four Departments are involved in the regulation of productive, priority agricultural land, leading to inconsistencies in land classifications and the procedures by which Departments deal with land use conflicts, the ostensible reason for establishment of the GasFields Commission. This is coupled with conflict about adequacy of reporting off-site impacts such as the drilling of deviated bores under land for which a CCA has not been signed, let alone the effects on community health and workplace safety obligations under Queensland's *Human Rights Act 2019*.
5. The databases and data use need to be improved. The regulators do not have a full list of the environmental authorities and leases issued for CSG activities. The industry operators do not have consistent database structures, and there is no agency with custodianship over a complete set of industry data. This issue and the consequences were clearly spelt out at the start of the modern era (post-2010) of the CSG industry, including by government agencies, but not addressed. This was to be addressed by the industry-funded Coal Seam Gas Centre (now 'Centre for Natural Gas') at The University of Queensland and the CSIRO's GISERA, but was not.
6. There is a perception by key stakeholders of a lack of independence of the GasFields Commission.

#### 15. Good-quality Agricultural Land

The land resource mapping underpinning the original *State Planning Policy 1/92* (1992) was deemed inadequate, and this led to the *Strategic Cropping Land Act 2011* which outlined technical support required for assigning land to classes such as prime agricultural land and strategic cropping land. The government provided maps of the designated land classes, and gas companies responded in their EIS for access to such land with maps which their consultants had prepared with varying levels of technical input and spatial cover. Landholders were



unhappy with this, alarmed that the companies wanted access to their high-value land and concerned that this would affect farm operations (see Supplementary Report to the Surat Gas Project Basin EIS Submission responses; and Arrow, 2012; Espig & Rijke, 2016; Espig, 2021).

By declaring quality agricultural land to be of ‘regional interest’ and requiring a Regional Interests Development Approval (RIDA) to operate a resource activity, unless exempt, the Regional Planning Interests (RPI) Act is arguably intended to minimise loss of farmland in priority agricultural areas of great commercial value from damage caused by CSG extraction. This can be inferred since the Act declares these areas to be of “regional interest”, requires either an agreement with landholders or a RIDA with criteria to assess likely impacts – *and* confirmation that no damage is to be caused to neighbouring land. Unfortunately, the Act is aimed primarily at managing competing interests (companies, local governments, landholders, Departments) in order for the CSG mining to proceed smoothly.

A major issue with the administration of the plethora of Acts and regulations over time is that sorting out how they might operate and clarifying avenues for redress for non-compliance requires multiple submissions by landholders to regulators and, occasionally, where legal rights exist, court action. There is little apparent collaboration between the Department of Resources and the Department of Agriculture and Forestry on clarifying the situation for landholders.

## 16. Conclusions

Given the accelerating rate of change towards decarbonisation of the national economy and the significant climate impacts of the gas industry, attention must shift to the ability of the companies and the statutory regime to remediate the impacts on the subject landscapes, but serious questions remain as to the practicability of remediation, even if adequate funds were available to a body with the engineering skills. No feasible path towards securely stabilising in perpetuity the thousands of wells being drilled and closed is visible.

The dewatering and depressurisation of the Walloon coal seams and aquifer in the Great

Artesian Basin has the potential to result in leakage from overlying aquifers into this zone. As well, large ring tank dams may leak as the hydraulic support for maintaining the integrity of the base of the dam is also drained, especially where the coal seam is relatively close to the surface. These dams, along with the aquifers, are a critical component of some of the most productive farming systems in Australia and have enabled continued production on the Darling Downs through very severe recent droughts.

While purified CSG-produced water is a bonus for some farmers and towns supported by the Sunwater Chinchilla Weir dam, it is available only during the possible 30-year horizon of the CSG mining in the Surat Basin (Monckton et al., 2017). The RO treatment creates an egregious, unsolved problem of what to do with the brine produced. As currently stored, in very large dams, it poses a threat to the salinity profile and integrity of the Murray-Darling system.

Depleting the aquifers on which this agricultural production depends will have a horrendous effect on the ability of landholders to irrigate, especially when compounded with the effects of climate change. Rainfall is projected to decrease, with an increase in the intensity of extreme rainfall events, leading to increased surficial flooding, an increase in the time spent in drought, and an ongoing increase in temperature and extreme hot days (CSIRO, 2021). These changes will affect crop requirements for water, along with reducing yields (Australian Academy of Sciences, 2021).

We have shown how the creation of depressurised zones by extraction of water from a coal seam aquifer can lead to subsidence through seismic poroelastic, hydrological load processes, a phenomenon occurring worldwide. Subsidence poses an existential threat to the way the vertosols of the Condamine Alluvium can be managed and the consequent productivity.

The current InSAR method of measuring subsidence used by OGIA has limitations in assessing the onset of subsidence induced by the CSG extraction. Satellite-based geodetic measures over the last decade show that there is “significant land subsidence across the southern part of the Surat Basin in Queensland which is spatially consistent with the declining of coal bed methane

and groundwater storage” (Pan et al., 2022, p. 9). Coupled with ongoing issues regarding insurance, lack of knowing with any precision where the gas wells are bored, especially those underdrilled, has created anxiety in the farming community about the effect of subsidence and leakage on the integrity of the land they use and their ability to continue with current sustainable and productive farming systems. The GasFields Commission was established to ensure that coexistence could occur without acrimony but has not quelled the current disquiet throughout the whole body politic about the effects of CSG mining. Conduct and Compensation Agreements are negotiated often under the duress of an enormous power differential between the gas companies and the landholders. The abrogation of the precautionary principle and adoption of an adaptive management paradigm by the government has led to many confusing changes to governance of land planning laws and oversight of regulations, which the Queensland Audit Office found to be very wanting.

No amount of ‘make-good’ compensation can rectify the loss of agricultural functionality and landscape integrity over this vital link in Australia’s supply chain for its food and fibre staples. The potential loss of land productivity on lands covered by the Surat Cumulative Management Area also

has considerable intergenerational equity issues. Without adequate pre-assessment being required of gas projects by the government, including baseline assessments, landholders and the government are greatly hindered from being able to prevent or address concerns about environmental impacts, such as loss of water from aquifers and subsequent subsidence.

On 4 March 2022, only five years after he had advocated the building of new coal-fired power stations, the Chief Executive of the Queensland Resources Council, Ian MacFarlane, publicly conceded that coal-fired electricity generation could cease within a decade (Bevan et al., 2022). It would be a brave analyst who would dismiss the likelihood that the CSG industry will also face a more rapid phase-out than its advocates have predicted. Superimposed upon an emissions challenge analogous to that of coal, the CSG industry faces an additional raft of landscape disruption and hydrological and salinity challenges. Even an orderly phase-out will generate a large and technically complex remediation task. From the evidence available to the authors, it is highly likely that neither the companies nor the Queensland Government seem prepared to accept responsibility for an incalculably great cost of remediation, even assuming that remediation were possible.

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