**Submission No 552**

# INQUIRY INTO COAL SEAM GAS

**Organisation**: Stop Coal Seam Gas Illawarra

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# Submission to the General Purpose Standing Committee No. 5 Inquiry into Coal Seam Gas (CSG) Mining in NSW

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7 September 2011

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# 1. EXECUTIVE SUMMARY

**This submission is made by Stop Coal Seam Gas Illawarra** (**SCSGI**) and addresses the Inquiry Terms of Reference 1a, 1b, 1c, 1f and 1g.

SCSGI is an incorporated, politically independent, community group of about 2,000 members, We organized the beach sign protest at Thirroul beach on May 29 2011, which attracted over 3,000 protesters.

**SCSGI calls for urgent action and requests the General Purpose Standing Committee No. 5 Inquiry into Coal Seam Gas Mining in NSW, support the following goals:**

- a Royal Commission into all aspects of coal seam gas mining
- a moratorium on coal seam gas mining pending the outcome of the Royal Commission
- a ban on fracking and similar coal bed 'stimulation' technologies and techniques.

While research remains limited there is mounting evidence that coal seam gas mining poses substantial risks. This submission details these risks within the context of the Terms of Reference for this enquiry and specific concerns for the Illawarra region. We call on the Inquiry to exercise the Precautionary Principle.

**<u>Contaminated water</u>**

CSG mining always involves contaminated water that poses unacceptable risks to water supply, the environment and human health. This is demonstrated by international research and documented adverse impacts, some of which is referenced in this submission.

- Water must be drawn out of the coal seam to access gas. This 'produced water' is highly saline and can contain toxic and radioactive compounds, and heavy metals.
- CSG mining will also be a major user of water. The CSG industry states that a single well takes approximately 3 million gallons or 13.5 million litres of water to fracture.
- Drilling and fracking and similar coal bed simulation techniques can involve a large number of toxic chemicals (over 750 identified) that are released into the environment through underground migration or through discharge during drilling or from storage dams or containers.

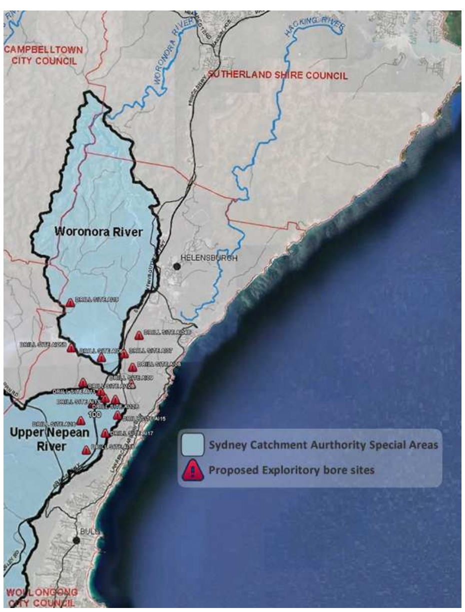
- Contaminated water is generally stored in ponds near wellheads.

**Map image overlay of the 15 CSG exploration wells approved for PELS 442 & 444**


Fifteen exploration wells have been approved in the Northern Illawarra and the 140-190 production wells that may follow are in highly sensitive areas. They are in and around critical water catchments for both Sydney and the Illawarra.

- Seven of the 15 approvals are in Sydney Catchment Authority Special Areas, which have restrictions on land use and access to protect our water supply.

**Map overlay showing locations of the exploration wells in relation to SCA water catchment 'Special Areas'**




- The approved wells are adjacent to upland swamps that feed and clean the adjacent water catchments, including the Georges and Hacking river systems, and contain endangered ecological communities.

- The approved wells are in Hawkesbury Sandstone. This has an extensive aquifer system that is considered highly valuable, due to its high quality potable water. It soaks up rainfall and discharges water into the creeks and underground fissures that drain the escarpment. It feeds upland swamps and the groundwater sustains rainforest along the escarpment.

- The coal seams of the Illawarra are much shallower than those in the Queensland Surat Basin. Thus there is much more potential for contamination of water that people, plants and animals are exposed to.

**Fracking and other 'stimulation' methods**

Hydraulic fracturing or 'fracking' is a stimulation process used in CSG mining. It involves the high-pressure injection of large volumes of water, sand and undisclosed chemicals into the ground to fracture coal. Fracking expands fissures in the coal seams, which allows gas to flow much faster and from a wider area. Originally used to tap deep earth oil and gas formations, the use of fracking has been expanded to coal seams, which sit much closer to the surface. This brings contaminated water and geological disruption close to water catchments and aquifers, and the above ground natural and built environment. As a result it poses unacceptable risks.

- The experience of CSG mining in the USA is that the commercial viability of CSG mining is dependent on extensive use of stimulation, such as hydraulic fracturing, and horizontal drilling that extends the reach of stimulation.

- The Northern Illawarra has already been extensively mined for coal. Stimulation in an environment of geological instability, cavities and subsidence, would greatly increase the risk of fugitive methane emissions, the distribution of contaminated water, and seismic activity.

**Leaking methane**

Not all of the previously trapped methane is captured during the CSG extraction process. Substantial fugitive methane escapes into the atmosphere: pipelines, well heads and processing plants leak; methane is carried to the surface in water drawn out of the coal seam; and any un-captured gas that is released will migrate through underground systems to the surface.

- Unlike oil or traditional gas wells, where extraction rates from reservoirs generally exceed 98%, extractions rates for with CSG ('unconventional gas') mining are as low as 65% . This means that up to 35% of the methane mined will find its way back to the surface in the form of fugitive emissions.

- Both fugitive methane and methane storage pose explosion and fire risks. The content of methane in produced water can be so high that the water becomes flammable. The Northern Illawarra is already prone to severe bush fires.
- Methane is a potent greenhouse gas, forcing warming at 105 times the rate of carbon dioxide over a 20 year period. Reports suggest that the global warming potential of unconventional gas is as bad or far worse than coal, over its lifecycle.

**Above ground industrialisation**

Production fields usually require a well head every 400-900 metres, all connected by pipelines and roads to get wastewater and gas out. As a result of this the above ground footprint of CSG mining is enormous.

- CSG exploration and mining will require extensive land clearing for the construction of infrastructure. This includes roads capable of handling heavy vehicles and equipment, pipes, wells, storage tanks and containment ponds.
- In the Illawarra this is on land that, until 2009, had a high conservation zoning.

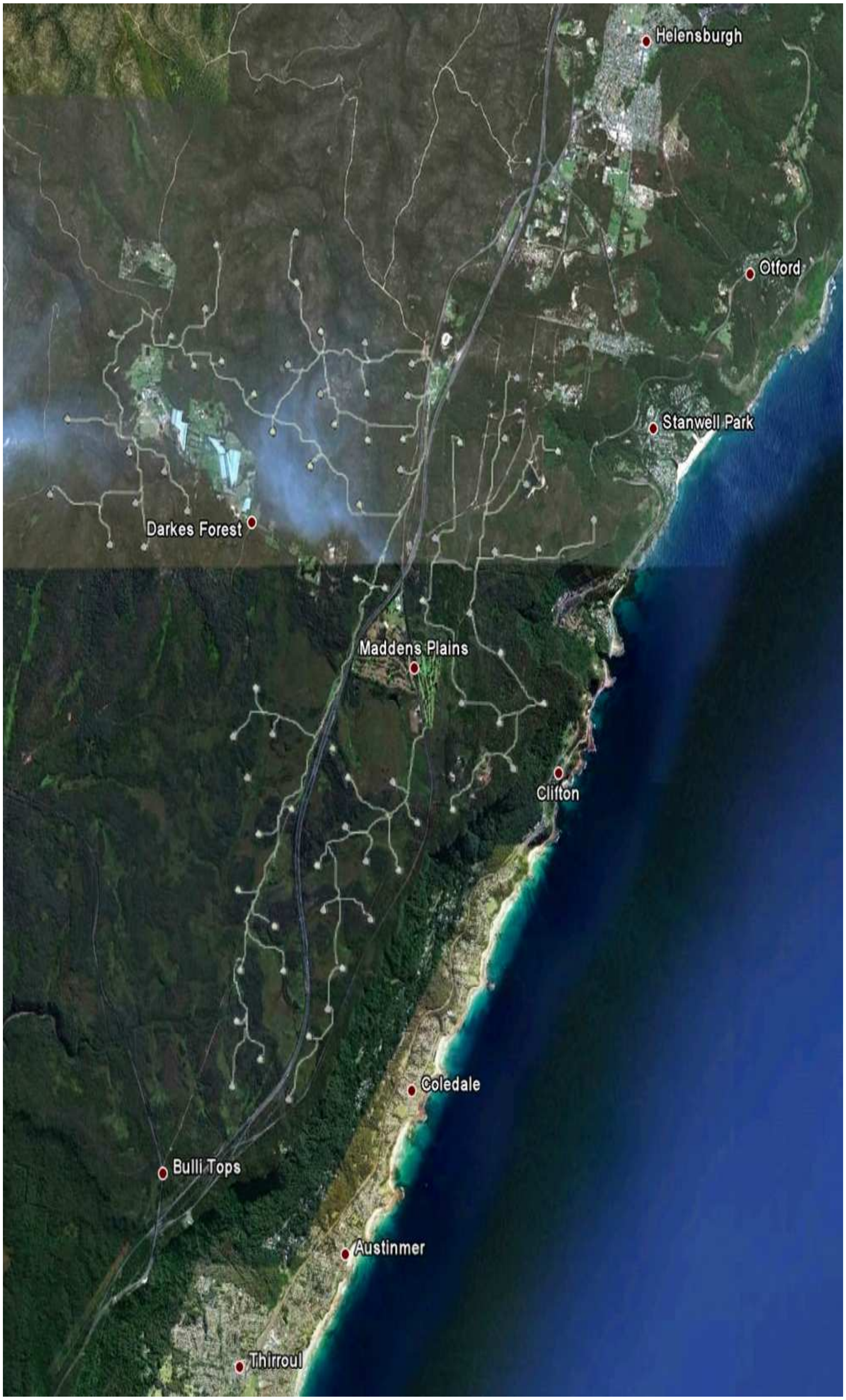
**Approval process**

Insufficient consultation and research has preceded approvals around the world. Very little independent research has been conducted on the risks associated with CSG mining, particularly its cumulative impacts.

- In the Northern Illawarra approvals were granted before the vast majority of residents knew what CSG mining was or that there was a proposal to mine locally.
- These were granted under Part 3A of the Environmental Planning and Assessment Act, under which the Minister for Planning deemed the site of 'state significance' and bypassed environmental and local planning controls.

The Northern Illawarra and Woronora Plateau were zoned ‘high conservation’ until 2009. The Department of Primary Industries pressured state government appointed Wollongong City Council Administrators to downgrade the zoning. Against the advice of Wollongong City Council (WCC), the then Department of Environment and Climate Change (DECC) and Sydney Catchment Authority (SCA), the Administrators complied. **The state breached its obligations to protect drinking water supplies.**

**PHOTO:** Image of the potential environmental impact of production wells on PELs 442 & 444.



# 1. Introduction

This submission is made by the Executive Committee of Stop Coal Seam Gas Illawarra (SCSGI), an incorporated, non aligned community group.

While SCSGI believes that the substantial risks posed by, Coal Seam Gas Mining are relevant throughout NSW, this submission focuses on the particular circumstances and risks in the Northern Illawarra and adjacent region.

The Northern Illawarra commences approximately 50 km south of Sydney, stretching from the Royal National Park in the north to the Cataract Dam in the south http://g.co/maps/z8k5. It encompasses the Garrawarra State Recreational Area, the Woronora Dam water catchment, the Dharawal State conservation area, **two drinking water catchments**, the upland swamps of the upper escarpment and the Illawarra Escarpment State Conservation Area, together with their associated coastal beaches. It is an area of vital importance to Sydney's drinking water security, as well as a bio diverse region with outstanding areas of special interest and natural beauty **- David Attenborough refers to it as New South Wales' Kakadu**. With over 1,000,000 visitors per year it is an important tourist destination.

## 1.1. Goals of SCSGI

SCSGI's goals are aligned to a growing body of evidence from around the world indicating that **unconventional methane gas mining** (such as CSG and shale gas) **poses a significant threat** to the environment, drinking water sources, food supply and public health. For example a report by the Tyndall Centre For Climate Change calling for a moratorium on shale gas mining in the UK states that:

> *'The dismissal of any risk as insignificant is even harder to justify given the documented examples that have occurred in the US, seemingly due to poor construction and/or operator error. These examples have seen high levels of pollutants, such as benzene, iron and manganese, in groundwater, and a number of explosions resulting from accumulation of gas in groundwater '*[1].

Similar evidence is emerging in Australia, with confirmed incidents of CSG well blow outs, leakage and contamination in NSW[2] and Queensland[3]. During a recent public meeting in Sydney on CSG mining the Australian Petroleum Production and Exploration Association's (APPEA) official spokesman, Ross Dunn[4] was quoted as saying*, 'drilling will to varying degrees impact on adjoining aquifer*s'.

Consequently, SCSGI believes that the NSW State Government should **adopt The Precautionary Principle regarding CSG mining in Aus**tralia by:

- **establishing a Royal Commission** into all aspects of coal seam gas mining, with recommendations supported by independent research based on the particular conditions applying in the Australian regions where CSG mining is proposed

- **introducing a moratorium on all Coal Seam Gas Mining** pending the outcome of the Royal Commission

- **banning fracking and similar coal bed gas 'stimulation' technologies and techniques** used in CSG exploration and production operations. The evidence of risk with this practice is so compelling that no other action is deemed appropriate.

SCSGI also asserts that the invasive techniques used in exploration are those used in production extraction and therefore **any restrictions placed on CSG mining should include both production and exploration activities**.

The above goals form the basis of the STOP CSG petition, which can be viewed at http://stop-csg-illawarra.org/Stop_CSG_petition.pdf. Over 6,500 signatures have already been added to this petition and SCSGI shortly expects to present Premier O'Farrell with at least 10,000 signatures. More information about SCSGI can be found on its website http://stop-csg-illawarra.org/.

## 1.2. About this submission

This submission is based on wide ranging research and where available, extracts from (or web linkages to) independent research papers, government reports, media articles and/or general commentary are included. However, **SCSCI wishes to bring to the attention of the Standing Committee, the absence of independent scientific research on the environmental impact of CSG mining in Australia.** Consequently, much reliance is placed on overseas research, including research from world renowned universities such as Cornell, Duke and Manchester. It is a similar situation with documented CSG mining safety incidents, water and air contamination, hazard alerts and seismic events. 'Unconventional' methane gas has been mined in the USA on a large scale for a decade and as a result the environmental impacts are more apparent.

However, there is direct evidence that **adverse impacts to the environment and public health, similar to those experienced in the USA and elsewhere, are beginning to materialise in Australia**:

- O**n June 23 2011** there was **a blow out at an** Arrow Energy **CSG well head near Dalby in Queensland[5].** Methane and water spewed up to 90 metres in the air for two days before being capped. This is one of several incidents with Arrow, which has since been fined by the Queensland Government.

- **On 17 May 2011 a blow out occurred at AGL's CSG well head at** Camden North **in NSW** during routine maintenance. This incident released plumes of contaminated water and foam into the atmosphere in the vicinity of housing and a water catchment feeder stream. AGL, which failed to report the incident for two days until the leakage was shown in TV, has been formally warned by the NSW government[6].

**Despite these incidents CSG exploration drilling and production gas mining activities continue unabated throughout NSW,** including in and around the Northern Illawarra water catchment and Royal National Park, Camden Valley (which also abuts the same catchment), the inner west of Sydney (within 3kms of the CBD), the Hunter Valley area (where new drilling works commenced on Sunday August 14 2011), the Northern Rivers region and a number of areas in rural NSW.

### 1.3. Recommendation to the Standing Committee

**SCSGI calls for urgent action and recommends the General Purpose Standing Committee Inquiry into Coal Seam Gas Mining in NSW, support its three principal goals as stated in 1.1 above.**

## 2. Coal seam gas mining in the Northern Illawarra

While the potential risks posed by Coal Seam Gas mining are applicable to any area of Australia, this submission examines these major risks in the context of the particular circumstances of the Northern Illawarra - the community that SCSGI seeks to represent.

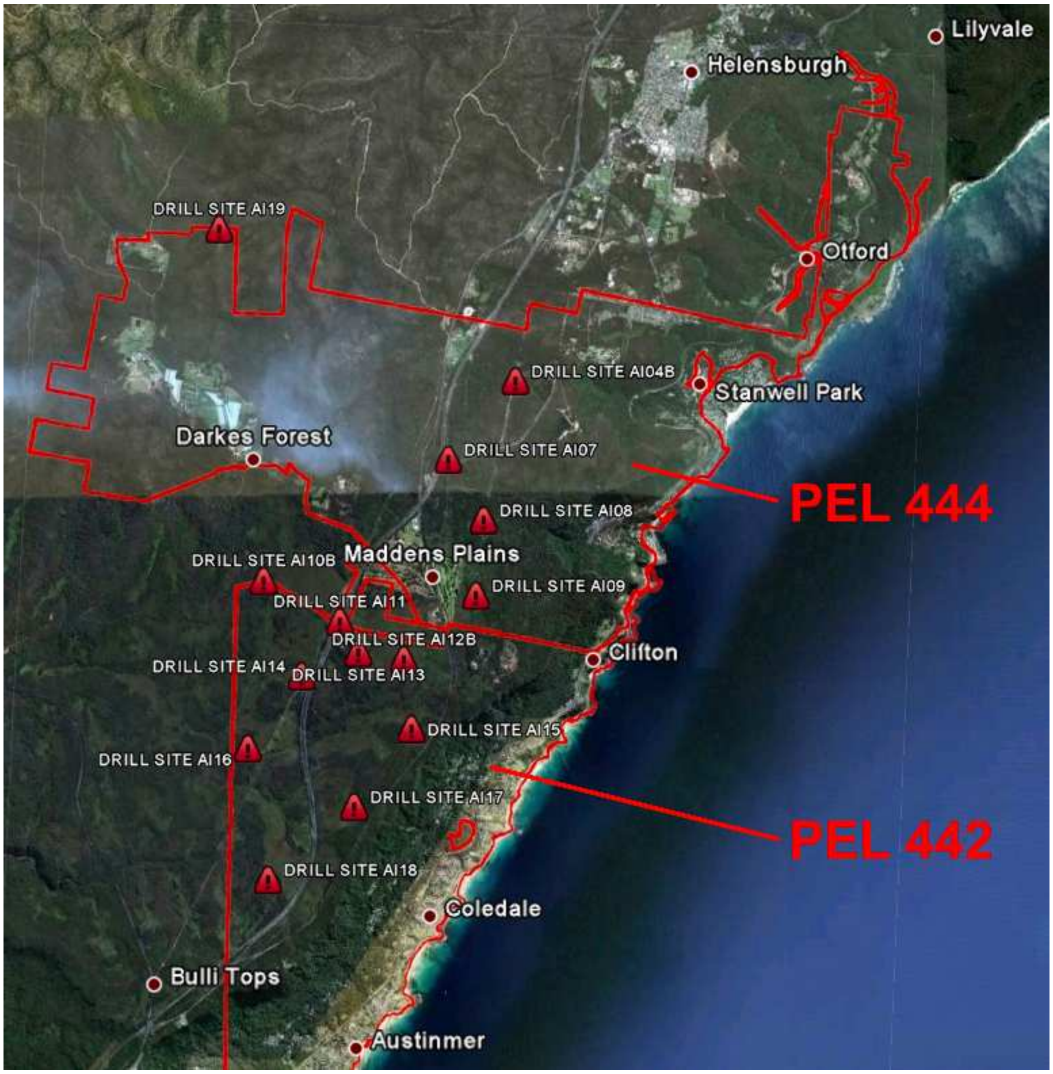
### 2.1. Areas covered by the PELs

Coal Seam Gas Mining is administered under the Petroleum Exploration Act of 1991, which was originally intended to regulate deep earth/water exploration (below 3,000 metres) of oil and natural gas reserves, rather than CSG. CSG is found at much shallower depths – in the Illawarra as close to the surface as 250 – 300metres. CSG mining drilling areas are defined in NSW Petroleum Exploration Licenses or PELs.

Two CSG PELs cover the Northern Illawarra (PEL442 and PEL444), both owned by APEX Energy NL. Fifteen (15) CSG exploration wells have been approved for development under these PEL numbers[7], although further wells are being discussed and applied for in the region. Please note that these approvals are for exploration wells only and according to APEX Energy management, **production CSG extraction would involve 140-190 wells over the same area**.

The areas covered by PELs 442 and 444 are illustrated in Figure 1 below, along with the approximate location of the 15 approved exploration sites. This information has been extrapolated from information provided by APEX Energy in its applications

**FIGURE 1 : MAP IMAGE OVERLAYS OF AREAS COVERED BY PELS 442 & 444**



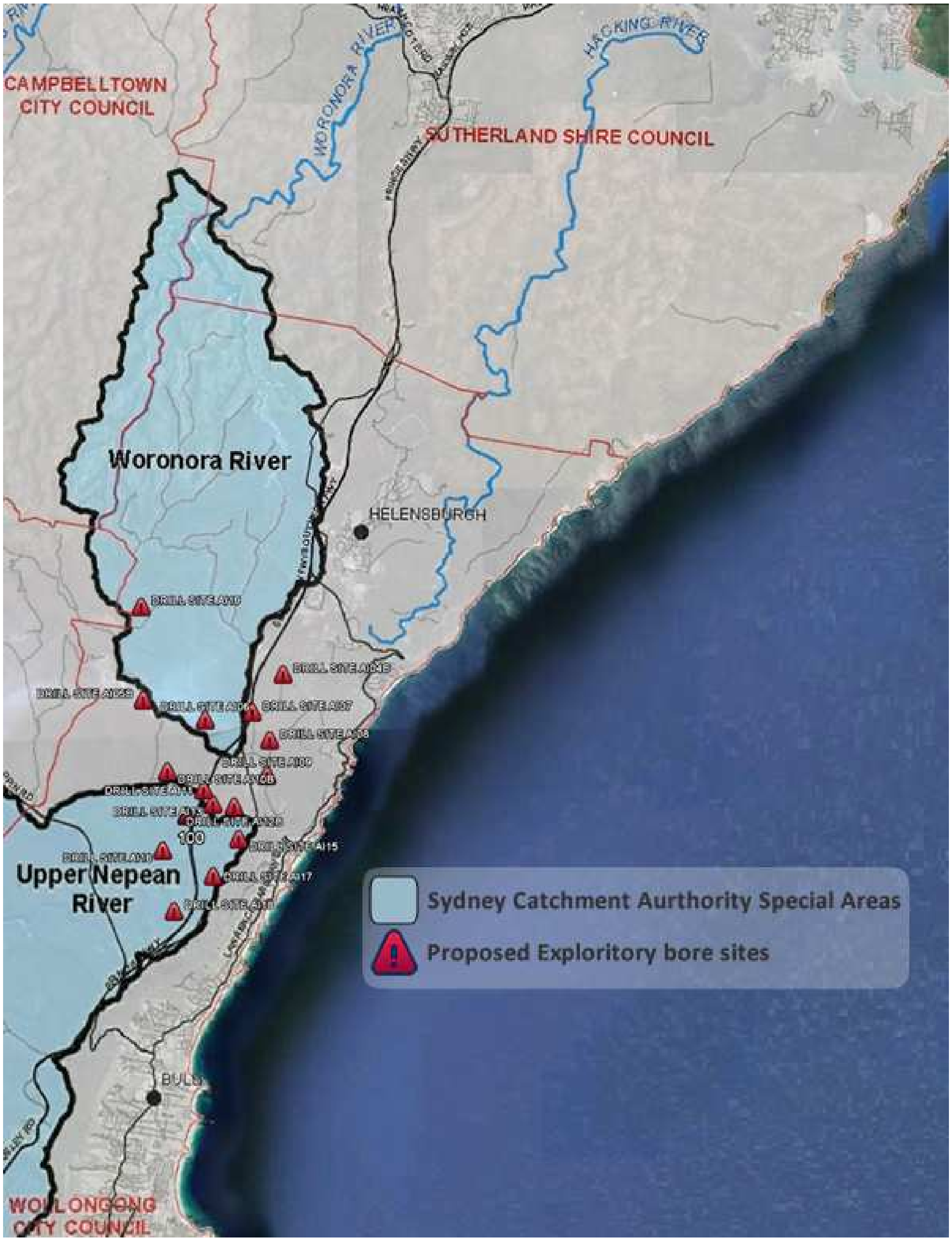

**Note:** FIGURE 1 MUST BE PRINTED IN COLOUR IN ORDER TO BE LEGIBLE

## 2.2. APPROVED PELS IN AND ADJACENT TO THE SYDNEY WATER CATCHMENT

PELs 442 and 444 are in and adjacent to, the Woronora and Upper Nepean water catchments administered by the Sydney Water Catchment Authority (SCA).

Figure 2 shows the 15 sites for CSG exploration drilling sites currently approved under PELs 442 and 444, in relation to the Sydney Water Catchment Special Areas.

FIGURE 2 PROPOSED EXPLORATION WELLS IN RELATION TO WORONORA AND UPPER NEPEAN SPECIAL AREAS




**<u>Note 1:</u>** this map does not depict the full extent of the catchment, which is considerably larger

**<u>Note 2:</u>** <u>the map</u> depicts 15 exploration wells only. Production could involve up to 190 wells across PELS 442 & 444.

**The Sydney Water Catchment Special Areas protect our water supply** by acting as a buffer zone to help stop nutrients and other substances that could affect the quality of water entering the storages[8].

Under the Sydney Water Catchment Management Act 1998 **there** are two water quality protection zones:

- **Schedule One** (land close to the water storages)
- **Schedule Two** (second tier buffer zone, adjoining Schedule One).

These zones are known as SCA Special Areas[9] and they are heavily restricted to protect water quality, with strict controls on land use, development and access. For example**, fines of up to $11,000 can be imposed for simply** walking in the Special Areas[10].

Figure 2 shows that **all 15 of the approved CSG exploration wells are in, or abut, SCA Special Areas**.

## 2.3. Significance of the Areas Proposed for CSG Mining in the Illawarra

### 2.3.1. Overview

The area within and around PELs 442 and 444 and the 15 approved CSG exploration sites are in a highly sensitive and biodiverse region of special environmental significance. It is of vital importance to Sydney's drinking water security, as well as a major recreational zone. This is reflected in the fact that:

- it spans **two vital NSW drinking water catchments** (Woronora and Nepean) and their associated Special Areas
- it includes **a number of State Conservation Areas**, State Reserve Listings and National Parks. These include the Garrawarra State Recreational Area, the Dharawal State Conservation Area, Dharawal Nature Reserve, the unique upland swamps of the upper escarpment and the Illawarra Escarpment State Conservation Area and associated coast lands
- the Illawarra Escarpment is the **most extensive area of rainforest** in the Sydney Basin Bioregion[11], supporting many vegetation communities that are only found in the Illawarra[12]

- **The NSW Government has committed to legislate** to establish the Dharawal National Park[13] which will contain some 26 swamps, with **over 200 km of watercourses that are little disturbed and collect water of very high quality**. The Plan of Management for the Dharawal Nature Reserve and Dharawal State Conservation Area states that:

  > *'…the volume and quality of the water discharged from the reserves is significant to the health of the Georges River…tributaries, are classified as Class P (Protected Waters), and…Class S (Specially Protected Waters), under the Protection of the Environment Operations Act 1997 and Regulation.* ***No effluent may be discharged into Class S waters and discharges of effluent into Class P waters are limited to those with a quality similar to that required as a raw source of potable water.'*** [Emphasis added] [14]

  > '*These swamps are considered exceptional because equally high levels of richness have not been encountered in similar communities elsewhere*.' [15]

**Commercial CSG mining puts the protection of these water sources at considerable risk.**

In addition, the upland swamps contain particularly flammable vegetation and are a high risk location for fire ignition[16]. Fire risks increase as a result of CSG exploration and mining activities (see section 4.6), and this is a particular concern in water catchments.

In June 2011, the NSW Scientific Committee recommended that the region's coastal upland swamps be listed as an endangered ecological community. The preliminary findings of the report recognise the threat posed by coal seam gas mining[17].

The cultural and environmental significance of the area and its significance as a water catchment were also recognised by the Member for Heathcote, Lee Evans, in his inaugural speech to the NSW Parliament:

*'I was proud to walk Dharawal State Reserve with Barry O'Farrell when we made the commitment to make it a national park. This will preserve the headwaters of the Georges River and priceless Aboriginal rock carvings. It is the water catchment area for the Woronora Dam.* ***This area, with its natural swamplands, filters our drinking water. The whole area needs careful management****. I look forward to again joining Barry O'Farrell at the commitment ceremony.* ***Many of my constituents have great concerns with methane gas exploration in our electorate. The water source for the Illawarra and Sutherland shire must be protected****. I will represent the many concerns of my constituents and make their voices heard. My focus as the member for Heathcote is to encourage economic growth and environmental sustainability. These tasks are not taken lightly.'* [18]

The figure below illustrates the great beauty of the Northern Illawarra region, and the location of the 15 approved exploration wells.

FIGURE 3 MAP IMAGE OVERLAY OF NORTHERN ILLAWARRA ESCARPMENT SHOWING LOCATION OF THE 15 EXPLORATION WELLS


2.3.2. Sydney Water Catchment

**More than four million (4,000.000) people - about 60 per cent of the NSW population rely on the catchments of** the Warragamba, **Upper Nepean**, Blue Mountains, **Shoalhaven, and Woronora river** systems to supply their drinking water.

**These catchments are the source of the raw bulk water stored in** SCA dams**.** Keeping the catchments healthy, and improving our understanding of how we impact on them, is essential to protecting water quality in these areas.[19]

At present, **the water catchment areas are largely pristine, as a result of the extremely strict controls that have protected these important water source and habitat areas**. The controls have been so strict that **even bush walking is prohibited in the Catchment, with a fine of up to $11,000 for any breach.**

**Prior to the changes in Zoning by the Wollongong City Council in 2009**, which occurred at the request of the NSW Department of Primary Industries (DPI) to enable the approval of all 15 exploration wells in PELs 442 and 444, the **Sydney Catchment Authority (SCA) would only allow** access to Special and Controlled Areas **if the activity met all of the following requirements**:

- it cannot be carried out elsewhere
- it will provide some benefit to the SCA management of the Special Areas
- it will not adversely affect the SCA's interests
- it will not be a security threat to the SCA's infrastructure, water supply or Special Areas.[20]

The NSW Government needs to explain **why planning zones were amended to allow CSG mining on PELs 442 and 444, when it meets none of the above requirements.**

It is the view of SCSGI that by influencing WCC to change zoning restrictions to allow CSG mining activities to commence on PELS 422 and 444, **the Government exerted inappropriate and undue pressure on the WCC's planning department, whilst it was under its administration, and in doing so may have breached its obligation to** protect drinking water supplies**.**

SCSGI is concerned that under the Onshore Petroleum Licensing Act 1991, the legislation under which PELs are authorised, **SCA does not have the same 'owners rights' in opposing CSG mining as it does with (say) conventional coal mining**.

**PHOTO: Looking South West across SCA Special Area, from the 10A fire Trail, Dharawal Nature Reserve**

### 2.3.3. State Environmental Planning Policy and Water Catchments

The Drinking Water Catchments Regional Environmental Plan No 1 was replaced by The State Environment Planning Policy (Sydney Drinking Water Catchment 2011 (The SEPP) commencing 1 March 2011. The SEPP aims to:

- provide for healthy water catchments that will deliver high quality water while permitting development that is compatible with that goal
- provide that a consent authority must not grant consent to a proposed development unless it is satisfied that the proposed development will have a neutral or beneficial effect on water quality
- support the maintenance or achievement of the water quality objectives for the Sydney drinking water catchment.

The SEPP **requires all proposed development in the Sydney drinking water catchment to have a neutral or beneficial effect on water quality** and the SCA is currently working in partnership with councils in the catchment area to help them fulfil their responsibilities under The SEPP.

**The SEPP also requires that all land development and other activities in the Sydney drinking water catchment incorporate the SCA's current recommended practices and standards**. These are best practice guidelines to protect water quality and cover many key areas of planning and development.

**SCSGI contends that CSG mining in PELs 442 & 444 does not meet the requirements of either the current or former policies**, both clearly designed to protect drinking water catchments into the future.

# 3. CSG MINING – A DESCRIPTION

## 3.1. THE BASIC PROCESS

Coal seam gas is accessed by drilling vertically into strata until a coal seam is reached, at which point horizontal drilling is likely to occur in order to extend the reach of the well. Horizontal drilling may reach 1.5 -2 kilometres from the base of the well. Drilling involves the injection of a number of chemicals to optimise drilling efficiency. The bore of the well is lined with concrete to prevent leakage of gas and contaminated water into the subsurface. Methane, which is physically trapped in the coal structure with water under pressure, is released by reducing the pressure in the seam. This is initially done by pumping out water but **almost always some form of additional 'stimulation' is need needed to extract the methane on a commercial basis. Hydraulic fracturing ('fracking) is one common type of stimulation technique**.

Figure 3 below is a simplistic representation of a vertical well. In many cases horizontal **bore holes will radiate from the initial bore hole for several hundred metres and potentially several kilometres. In** the Northern Illawarra this means wells could reach far into the water catchments and under the escarpment and beachside communities. Figure 3 does not indicate how thin and fragile the drill line is in relation to its length. Most importantly, it does not show the many fissures and fractures in the surrounding rock, into which concrete can be lost when the casing is being cemented. **These gaps and fractures can make it extremely difficult and in some cases almost impossible to completely seal the**

**casing, leading to the types of contamination and gas migration events that are detailed later in this submission.**

FIGURE 4 ILLUSTRATION OF A CSG EXTRACTION WELL[21]

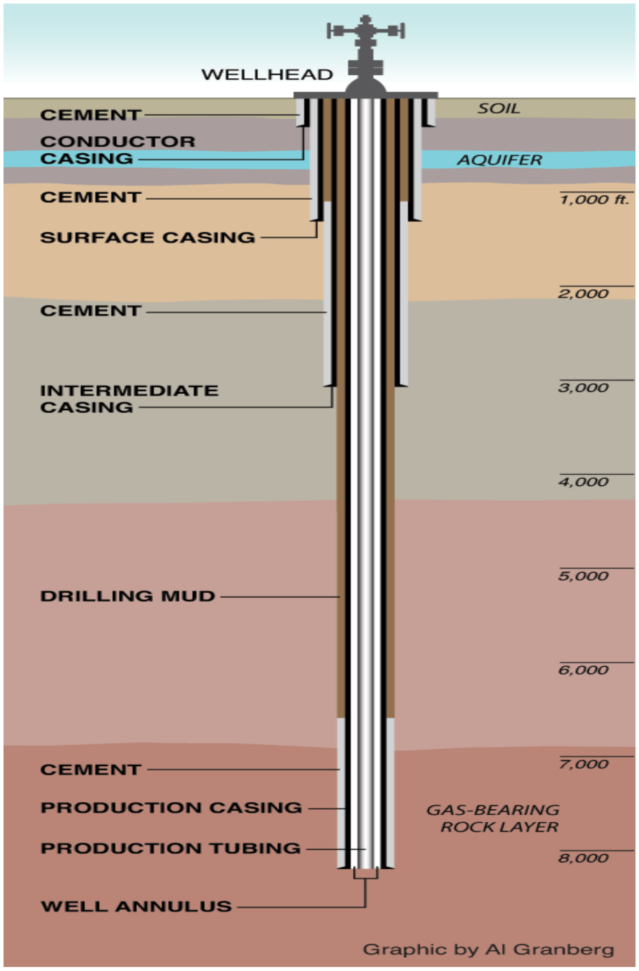



PHOTO: the impact of CSG well heads on the landscape

There are risks associated with CSG drilling operations that need to be considered:

- The drilling rigs are large and heavy, transported to the well head on large trucks of more than 30 tonnes displacement. Roads must be developed for this purpose and platforms laid down to support the rigs. Large ponds for holding contaminated water brought to the surface, chemical tanks, gas pipes and storage tanks make up the rest of the necessary infrastructure, which **disturbs at least 1 hectare of land per well**.
- **CSG drilling operations involve a large number of toxic chemicals**, including diesel to drive the equipment, and there is a high risk of spillage and soil contamination.
- Drilling operations disturb and connect the disparate geologic strata, either temporarily or permanently. This disturbance, in combination with high water and gas pressures, can and does result in **migration of contaminated water and gas either underground, or in the case of methane, to the surface.** This migration is certain but not predictable: depending on geological structure it can take a short time, or even decades (long after the well has been shut down).
- The concrete and steel well liners are subject to high stress, and may fracture or corrode, **resulting in the leakage of methane and contaminated water.**
- If the coal bed has low permeability, the well will be 'fracked' to release the methane (see Section 3.2). **Drilling the strata, fracking the coal seam and pumping out the water liberates gases and hydrocarbons**, not only for the commercial life of the well but for many years to come.

## 3.2. Hydraulic fracturing

Hydraulic fracturing or 'fracking' uses high-pressure pumps to inject **large volumes of water, sand and undisclosed toxic chemicals into the ground** at very high pressures of up to 5000psi **to fracture coals**

**seams** and release the trapped **gas. Fracking expands fissures (cleats) in the seams allowing gas to flow much faster and from a wide**r area. **CSG wells are likely to be fracked multiple times throughout their life**.

Originally used to tap deep earth oil and gas formations, the use of fracking has been expanded to geologic formations, such as coal seams which reside geologically much closer to the surface, water catchments and aquifers.

**FIGURE 5 ILLUSTRATION OF HYDRAULIC FRACKING**[22]

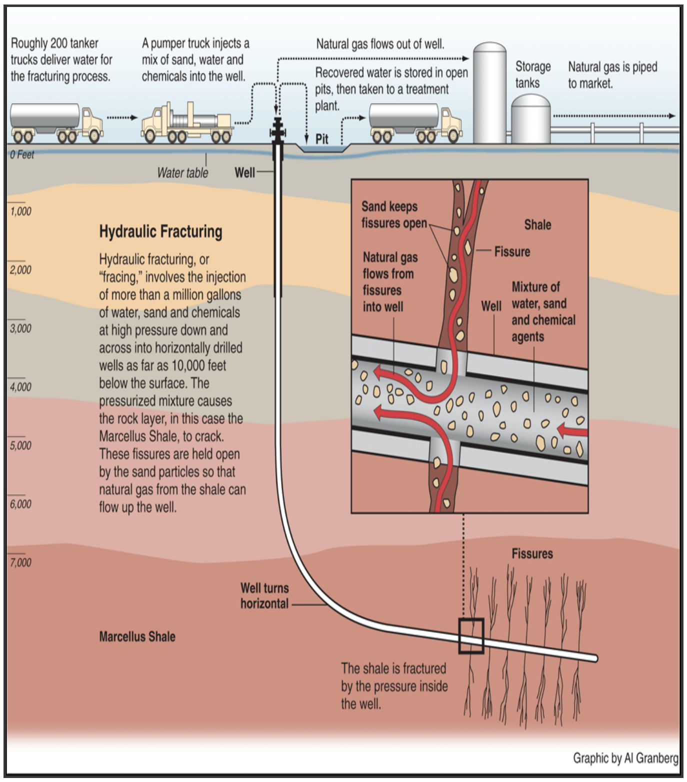



**PHOTO: Closed system hydraulic fracturing of a vertical well PA (*Source: ALL Consulting, September 2008)***

The experience of CSG mining in the *USA is that* ***the commercial viability*** **of CSG mining is dependent on extensive use of stimulation, such as hydraulic fracturing, and horizontal drilling** that extends the reach of stimulation.

A February 2011 National Toxics Network briefing paper **said fracking will be used in up to 80% of Australian gas wells** in the next ten years[23]. **The public assurances of APEX Energy not to frack throughout the life of these wells are therefore not credible**, especially given their refusal to enter into a binding agreement with the community through SCSGI.

**The coal seams of the Illawarra are much shallower** than those in the Queensland Surat Basin, with minimal separation between upper and lower level coal seams being tapped for CSG, therefore there is **much more potential for contamination of water and land**.

The Northern Illawarra has already been extensively mined for coal and is suffering significant subsidence as a result of long wall mining[24]. **Stimulation, in an environment of geological instability, cavities and subsidence, would greatly increase the risk of fugitive methane emissions, the distribution of contaminated water and** seismic activity similar to that experienced in the UK[25].

A 2011 submission to the US Congress identified **over 750 different chemicals and compounds that are known to have been used in fracking.** Most are not disclosed by operators and none of have yet undergone CSG hazard testing and clearance. The following is a partial list of the different types of additives that are used in fracturing operations, as indicated by the New York State Department of Environmental Conservation.

**TABLE 1 CHEMICALS USED IN FRACKING**

| Classes of Additives | Purpose | Examples |
|---|---|---|
| Acid | Facilitates entry into rock formations | hydrochloric acid |
| Biocides | Kill bacteria and reduce risk of fouling | glutaraldehyde, 2,2 Dibromo-3-nitrilopropionamide |

| | | |
|---|---|---|
| Breaker | Facilitate proppant entry | peroxodisulfates |
| Clay stabilizer | Clay stabilization | salts, ie tetramethylammonium chloride |
| Corrosion inhibitor | Well maintenance | methanol |
| Crosslinker | Facilitate proppant entry | potassium hydroxide |
| Friction reducers | Improve surface pressure | sodium acrylate, polyacrylamide |
| Gelling agents | Proppant placement | guar gum |
| Iron control | Well maintenance | citric acid, thioglycolic acid |
| Scale inhibitor | Prevention of precipitation | ammonium chloride, ethylene glycol, polyaccrylate |
| Surfactant | Reduction in fluid tension | methanol, isopropanol |

There is currently no requirement for CSG companies in Australia to disclose the constituents in their fracking fluids and only 20 of the 750 are listed by APPEA as known to be used in Australia[26]. **Given their proximity to drinking water catchments, fracking fluids are unsuited for use in PELs 442 and 444.**

# 4. Risks posed by CSG mining

## 4.1. Introduction

**SCSGI contends that the findings and recommendations of this Inquiry should be based on the best independent scientific research, conducted in Australia**. To do otherwise, would be to put at risk our water, our health and our environment.

Unfortunately, there is **an alarming absence of independent scientific research on the environmental impacts of CSG mining in Australia**. Consequently, a fair amount of the information cited in this submission is based on research, government reports and other evidential materials sourced from overseas, where unconventional gas mining has occurred for a decade or more and where adverse environmental impacts are more apparent. Some proponents of CSG mining in Australia claim that much of the US and European research on shale gas mining is irrelevant to Australia. This claim only holds if there is Australian research that demonstrates the irrelevance of the US research, which requires a comprehensive independent scientific assessment of the inherent risks within an Australian context.

## 4.2. The threat to our water

A common conclusion of independent research is that unconventional mining poses a potential threat to water supplies. For example, researchers at Duke University's Nicholas School of the Environment argued that *'systematic and independent data on groundwater quality, including dissolved-gas concentrations and isotopic compositions, should be collected before drilling operations begin in a region..'* [27]

This view is almost identical to the conclusions drawn in similar research at Cornell and Manchester Universities. The reason for this is that CSG always produces water contaminated by:

- entrained methane and chemicals brought to the surface in the production process
- fracking fluids injected but not retrieved
- chemicals/toxins released naturally from the coal seam with the water.

The acting chief executive of the National Water Commission, James Cameron, noted recently that while the CSG industry has potential to deliver significant economic benefits 'there are also **significant potential risks to water and our water management as a result of the scale of the development of the sector'**.[28]

In a recent public meeting in Sydney, a spokesman for the Australian Petroleum Production and Exploration Association (APPEA) was quoted as saying '**drilling will to varying degrees impact upon adjoining aquifers'**[29]**.**

The National Water Commission estimated in a recent position paper entitled 'The Coal Seam Gas and Water Challenge', that the Australian CSG industry will extract around 7,500 gigalitres (GL) of co-produced water from ground water systems over the next 25 years, equivalent to around 300 GL per year. They also note that the **potential impacts of CSG development on water systems**, particularly the cumulative effects of multiple projects, **are not well understood**. [30]

**Given Australia's limited water resources and propensity to drought, any activity that threatens our water security must be considered against the Precautionary Principle.** Yet in the vital water catchment areas of the Northern Illawarra 15 exploration wells have been with an anticipated 140-190 production wells required for production. These are in and around critical water catchments serving both Sydney and the Illawarra. **Seven of the 15 drilling sites are on land so protected that public access is prohibited**, with fines of up to $11,000 applied for breaches of these restrictions. In addition to this:

- They are in or adjacent to Sydney Catchment Authority Special Areas that supply more than four million affecting two the major catchments of Woronora Cataract, which have restrictions on land use and access to protect drinking water supply.
- They are adjacent to upland swamps that feed and clean the water catchments and St George and Hacking river systems. These have been recommended by the NSW Scientific Committee for listing as an endangered ecological community.
- The coal seams of the Illawarra are much shallower than those in the Queensland Surat Basin, with **minimal separation between the upper coal seams being mined and the surface and between these upper and lower level coal seams, also being tapped for CSG.** The area also has underground fissures that naturally drain towards the local coastline and community. As a consequence there is much more potential for cross over contamination
- Water must be drawn out of the coal seam to access gas. This 'produced water' is highly saline and can contain toxic and radioactive compounds and heavy metals[31], as highlighted in the recent report by Doctors For The Environment Australia (DEA).
- Drilling, fracking and similar coal bed simulation techniques can involve a large number of toxic chemicals. These can find their way into the environment through underground migration or discharge during operations (contaminated water recovered from underground is generally stored in open surface evaporation ponds near the wellheads, or shipped offsite for treatment and disposal).
- The Illawarra escarpment provides a ready exit point for ground water along its base and below the shore line. Around 75,000 people live along the base of the scarp.

### 4.2.1. Drilling and fracking fluids

Many of the chemicals used in fracking are known to be toxic to humans and there are numerous documented cases of the health consequences to families who live in close proximity to CGS wells.

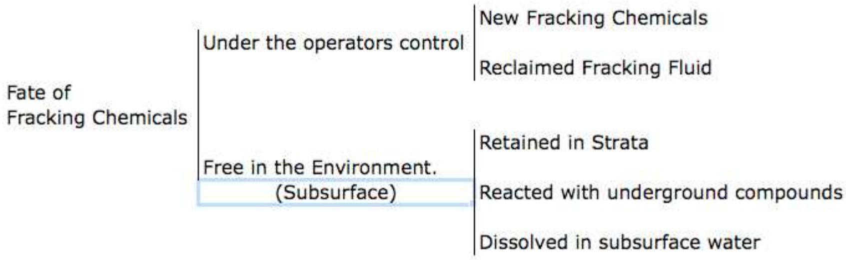
In February 2011 a briefing paper on fracking by National Toxics Network called for **a moratorium on the use of fracking fluids until health risk are better understood[32].**

**The United States EPA has also raised concerns about the potential public health risks** posed by diesel fuel used in hydraulic fracturing fluids. In a 2004 report, EPA stated that the 'use of diesel fuel in fracturing fluids poses the greatest threat' to underground sources of drinking water. Diesel fuel contains toxic constituents, including benzene, toluene, ethylbenzene, and xylenes (collectively known as 'BTEX' compounds). **BTEX compounds are also found naturally in coal seams and may be released by CSG drilling and fracking**.

The US Government it has found it virtually impossible to identify the exact combination of chemicals used by CSG companies, as they are listed as 'proprietary' or 'trade secret'. The Committees of Congress have been unable to penetrate this secrecy, with requests to gas mining companies to disclose the contents of their fracking fluids met with the response that *'they did not have access to proprietary information about products they purchased "off the shelf" from chemical suppliers. The proprietary information belongs to the suppliers, not the users of the chemicals'* [33]. In effect, these companies are saying '**we don't know what we are using and we, therefore, don't care whether there are adverse consequences to water, air or public health.'**

When fracking fluids are injected into the wells under high pressure, the chemicals interact with other compounds found naturally underground – including BTEX chemicals. Most of them are retained underground in the gelling compounds. After the fracking operation the fluids are pumped from the well under considerably less pressure. According to research from Duke University, **recovery of the fracking fluids varies between 15 - 80% depending on conditions in the well[34]**.

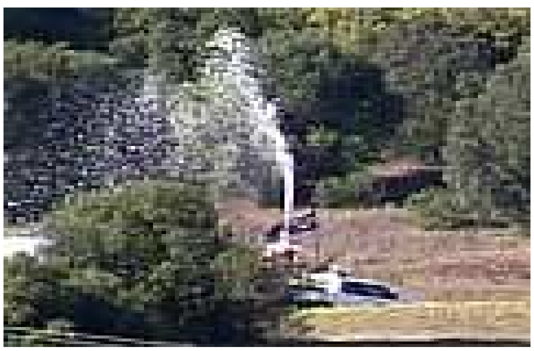
FIGURE 6 THE FATE OF FRACKING CHEMICALS




**Given the toxic nature of fracking fluids and the close proximity to vital water catchments, allowing their use within PELs 442 and 444 would be an act of negligence and irresponsibility.**

### 4.2.2. Water and land contamination

**PHOTO: Blowout at an AGL CSG wellhead at north Camden NSW in June 2011**



**CSG mining always involves contaminated water**, even if fracking does not occur. This is because that in order to extract gas, pressure within the seam must be reduced by pumping water from cleats in the coal seams, allowing the methane to be desorbed from the coal pores. **This dewatering results in a significant drawdown of water levels in overlying and underlying aquifers in the region during CSG production**. According to a study by the Sustainable Metals Institute[35] the *'spatial extent of the drawdown is expected to extend beyond the boundary of the gas field production area and recovery of the groundwater systems is expected to extend significantly beyond cessation of CSG operations'*.

The integrity of impermeable strata is compromised by local defects such as fault lines and local stress cracking, which are then further stressed by extraction and stimulation activities. This **creates many channels through which fugitive fluids and gases can flow.** The well casings, which are located at frequent intervals during the production phase, also provide a clear pathway for exchange of gas and water between the rock layers and the surface. Whilst CSG engineers go to some lengths to avoid this, the configuration of the structure make it difficult to ensure integrity, or even detect a problem. **This risk is far greater in the Northern Illawarra given the geology of the region and damage caused by extensive coal mining**.

The large amount of 'produced water' that is drawn out of the coal seam during the drilling process is usually highly saline and contains various other pollutants. The process of drilling often involves the use of Potassium chloride (KCl) and the Environmental Assessment for the Illawarra CSG exploration drilling indicates that **the salinity of the water produced will severely impact the surrounding water if a release occurs**[36].

The produced water can contain toxic and radioactive compounds, endocrine disruptors, heavy metals and BTEX compounds, all of which are found naturally in coal seams. Therefore any produced water requires long term containment (open evaporation ponds commonly used for this purpose- see below) or purification – which requires trucking large volume of contaminated produced water offsite to desalination or other specialist treatment facilities. These are both areas of potential spillage. According to AGL's 2010 Annual Report, such an incident occurred at the Gloucester Gas project in NSW in 2009:

> *'A reportable incident occurred on 29 June 2009 after an accidental overflow of drilling water from a tank. Approximately 5,000 litres of drilling liquid overflowed and some left the AGL site and flowed onto adjacent paddocks. Due to the off-site impact, AGL was required to notify the Department of Primary Industries of the incident. No enforcement action was taken.'* [37]

There have been a considerable number of reported water contamination incidents around the world. Recent examples include:

- contamination at Parson's Well in New York caused by migrating fracking fluids[38]
- carcinogens found by the Queensland Government in 14 CSG wells operated by Arrow Energy[39].

The latter incident is not an isolated one for **Arrow Energy, who were fined earlier this year for breaching their permits**. **AGL has also experienced multiple incidents** at its NSW CSG operations resulting in **censure by the NSW Government**.

**Apex drilling hole A105, which is located close to an Upland Swamp, presents a significant risk to the water catchment area.**

T**he Woronora Plateau is an area of extreme rainfall events[40],** with the swamps acting like large sponges that soak up water and release it slowly. The Hawkesbury sandstone acts like a groundwater aquifer at times of extreme rainfall events.

In an attempt to reduce the risk of overflowing storage ponds, the use of excavated sumps to retain water, and bunds (earth retaining walls) is recommended in Appendix 1 of the Environmental Assessment. The height of the earth retaining walls is specified as 660 mm in the original Environmental Assessment. However, according to the records from the Darkes Forest rain gauge, there have been a number of rainfall events in the area which exceed 500mm (for example 573mm in 3 days in 1992). This means there is **a very high risk of a release of contaminated saline water spreading via groundwater into the adjacent upland swamp lands and water catchment.**

The fact that **Overland water flow causes significant damage to farmland** over a wide area is well demonstrated in the following extracts from the official Minutes of Arrow Energy's Intensively Farmed Land Committee Meeting on February 10 2011[41]. This flooding occurred during last summer's excessive rainfall.

| ITEM | DETAILS | ACTIONS |
|---|---|---|
| | . | |
| ITEM 4 | Updated – Land Owner Issues | |
| | Overview of the impact of the flood<br>Overland water flow causes significant damage.<br>- There was significant erosion around above ground infrastructure (approximately 20% the Condamine floodplain impacted)<br>- Flood water flow cut gullies on properties approximately 3-5 km long and 0.5-1.0 m<br>deep.<br>- Minor changes in the flood plain had significant impact during this flood event.<br>- The landowners believe that these issues could be addressed by Arrow Energy working with landholders.<br>Council road formation diverted the Brigalow flood plain water course:<br>- Small changes to the height of a council gravel road of approx. 200mm caused overland flow diversion.<br>- Diverted water travelled between catchments and created 7 km of new water cause downstream.<br>- Resulted in loss of 500 acres of cotton for one landholder.<br>- Impact area of approximately 20km downstream. | Non listed |
| | | |

The Queensland government has since banned the use of evaporation ponds[42].

According to a study by Atkinson, **AGL has disposed of produced water at Camden by adding potable water to it until the discharge reaches regulatory limits**. This method is a poor use of water resources. Gastar reported that they produced about 100,000L of saline water every day (about five water tankers) from each of their six Bohena pilot wells in Queensland.[43]

If the produced water on the Woronora Plateau is to be trucked out of the area for treatment, as suggested by APEX management at a recent public meeting, then it will require the building of a substantial trail and road infrastructure within the SCA catchment and upgrading of local feeder roads, once production commences.

### 4.3. Fugitive emissions from CSG Mining

Fugitive emissions from CSG mining can result from:

- leaking pipelines, well heads and processing plants
- entrained methane in produced water
- methane escaping through underground systems.

#### 4.3.1. Leaking pipelines, well heads and processing plants

Recent conducted at Cornell University[44] found that between 3.6% and 7.9% of methane from shale gas production escapes to the atmosphere in venting and leaks over the lifetime of a well. This leakage occurs during hydraulic fracturing and during drill out following fracking. The study refers to modeling that indicates methane has a far greater impact on global warming than previously believed when the indirect effects of methane on atmospheric aerosols is taken into account. Over 20 years, **methane has a 'global warming potential' 105 times that of an equivalent amount of carbon dioxide, reducing to 33 times over a 100 year timeframe[45].** Therefore the warming impact of the methane that escapes from the wells, produced water, fittings and pipelines is considerable. Over a 20-year period, means that **leakage of even 1% more than doubles the environmental cost of CSG fired power**. The **credible leakage figures for CSG start at about 4%.**

A study by Atkinson on the hazards of coal seam gas mining supports this assertion by stating[46]:

'*In September 2004, within a fortnight of the beginning of gas testing, a coal bed methane well north of Newcastle, NSW, was shut down as several boreholes up to 300m away began to blow off methane gas. This was the first reported case of a serious migration of methane gas from coal bed methane operations in New South Wales.'*

Atkinson also notes that[47]:

> *'…long experience in the USA, and more recent experience in New South Wales shows that once the head of water is removed, the coal gas, mainly methane, is mobile and can migrate by uncontrolled pathways to the surface, or to nearby openings such as water wells. In surface*

*methane seepages through soil, the methane displaces the soil oxygen, the soil becomes anoxic leading to total death of the vegetation.'*

Blow outs and seepage at AGL and Dart Energy CSG drilling sites, referred to earlier, add to this body of evidence. The AGL incident resulted in a warning letter from the NSW DECCW[48].

### 4.3.2. Entrained methane in produced water

CSG extraction requires water to be pumped from the well throughout its operating life. This produced water, generally saline and laced with contaminants, also contains methane, mostly "entrained" as gas bubbles. In Australia, the usual practice is to pipe this water to evaporation ponds. How much methane reaches the atmosphere this way? **Engineers working on CSG technologies in Wyoming have found that the amount lost as entrained gas varies from 2% to 30% of total well yield**[49].

### 4.3.3. Methane in underground systems

When coal seams are de-watered and gas is released, any that is not captured 'can migrate by uncontrolled pathways to the surface, or to nearby openings such as water wells'[50]. This can happen along groundwater aquifers, fractures in bedrock and through permeable soils[51].

## 4.4. Air pollution

CSG mining generates air pollution from the earliest stages of extraction and this continues throughout the extraction and processing cycle. This is graphically illustrated in the photos below.

**PHOTOS: blow outs at an AGL production CSG wellhead in Camden NSW (left) and an Arrow Energy CSG wellhead near Dalby, Queensland (right) in 2011**

In April 2011, the United States House of Representatives Committee on Energy and Commerce reported that:

> *'Between 2005 and 2009, the hydraulic fracturing companies used 595 products containing 24 different hazardous air pollutants. Hydrogen fluoride is a hazardous air pollutant that is a highly corrosive and systemic poison that causes severe and sometimes delayed health effects due to deep tissue penetration. Absorption of substantial amounts of hydrogen fluoride by any route may be fatal. One of the hydraulic fracturing companies used 67,222 gallons of two products containing hydrogen fluoride in 2008 and 2009. Lead is a hazardous air pollutant that is a heavy metal that is particularly harmful to children's neurological development. It also can cause health problems in adults, including reproductive problems, high blood pressure, and nerve disorders. One of the hydraulic fracturing companies used 780 gallons of a product containing lead in this five-year period. Methanol is the hazardous air pollutant that appeared most often in hydraulic fracturing products. Other hazardous air pollutants used in hydraulic fracturing fluids included formaldehyde, hydrogen chloride, and ethylene glycol.'*[52]

**Given the concentration of water catchments and other state protected zones in the Northern Illawarra, and CSG mining's potential to generate air pollution, this is an unsuitable activity for the region.**

## 4.5. Threats to the above ground environment

**SCSGI is also very concerned about the above ground impact of CSG mining in PELs 442 and 444.**

### 4.5.1. Exploration

The 15 approved drilling sites for PELs 442 and 444 will result in significant deforestation and damage to the protected environment of the Northern Illawarra. Each exploration well will require a large area of forest to be cleared, as show in the photo below. We estimate the footprint per well head to be at least one hectare, with further substantial forest clearing required for the construction of access roads, pipelines and fire breaks.

**PHOTO: Example of a CSG exploration wellhead site**

It is the view of SCSGI and other interested local stakeholders, such as Otford Eco, that such **clearing for CSG mining will irrevocably damage and most likely destroy the native bush and swamp lands of the upper escarpment, which are so vital to local water supplied and eco systems**.

### 4.5.2. Production

If CSG production mining is allowed in the Northern Illawarra there will, according to APEX Energy, be **between 140 and 190 wells across PELs 442 AND 444 at intervals of approximately 400-800 metres**. Given the topography of the area, well locations (and the distance between them) will be greatly influenced by the terrain of the area, with a likely concentration of wells along ridge lines.

Each wellhead will have a pipeline for gas and either a storage pond (or tank) to hold produced water, a wide, underpinned road capable of handling vehicles heavily laden with plant and equipment (such as drilling rigs and associated machinery such as mud pumps, separators, generators and booster compressors) and frequent daily truck movements to remove the separated water. There will be a need for gas compressor and pumping stations throughout the area that will operate continuously and emit noise (and possibly methane gas).

Figure 5 below shows how the 190 production well pads could be distributed across the Northern Illawarra, given its topography. Each white dot represents one well head with a cleared area of approximately 100m x 100m (excluding roadways gas pipelines and fire trails). **Clearing well beyond the perimeters of the pad, which is likely to protect the wellheads from bush fires, could result in the loss of up to four hectares of forest per pad**.

**FIGURE 7: OVERLAY IMAGE SHOWING POTENTIAL IMPACT OF PRODUCTION WELLS ON PELS 442 & 444**


*Note:* This model was compiled from data collected on known APEX drill sites and using mostly existing fire trails, superimposed on Google Earth. It is therefore, in all probability, substantially understated.

What can be seen from this image is that **the Northern Illawarra will change from an area of outstanding beauty and protected lands to a huge roofless industrial gas production** and distribution centre. This in an area predominantly comprised of the Sydney Water Catchment Special Areas, National Parks, a designated National Park, and State Conservation Areas. **Areas that are critical for Sydney's water security, the health of two of its major rivers, public amenity and tourism, and that are extremely fire prone.**

#### 4.5.3. Destruction of large areas of forest

**It is inevitable that large scale destruction of forest will occur to accommodate the CSG drilling pads and their associated infrastructure** – such as compressors, pumping stations, storage tanks for produced water, access ways and pipelines. Wide, well constructed roads will be required to bring in the heavy CSG plant and equipment. **Existing fire trails that have been developed to minimise destruction of the bush will need to be greatly widened and a network of new roads created**. There will be **further clearing to lay the high pressure gas distribution pipe network required[53], for other production and gas distribution infrastructure, and for creating suitable fire breaks** – **methane is a highly combustible gas!**. The photo below is of a Dart Energy drilling site and gives a good idea of the minimum amount of forest that will need cleared for each exploration and production site. [54] The size of the trucks and other equipment in the photo indicate the extent to which wide access to sites and commensurate clearing of forest will be necessary.

**PHOTO:** **An aerial shot of a Dart Energy CSG exploration drilling pad[55]**

**<u>PHOTO:</u> A Gas collection pipeline laid out along an easement in forest area prior to trenching and installation – note the bush clearance width**

### 4.5.4. Impact on Biodiversity

**The Illawarra Escarpment and the adjacent areas constitute one of the most biodiverse regions in New South Wales.** They containing upland swamps, sedgeland heath, creek-centred wetlands and various forms of native forest. In the adjacent Dharawal Nature Reserve, over 500 plant species occur, and the O'Hare Creek catchment alone is home to 17 species listed as vulnerable, rare or threatened. Animal life is equally diverse, with the area supporting broad-headed snakes, koalas, long-nosed potoroos and rare frog species. The swamplands are home to swamp wallabies, eastern wallaroos, marsupial mice, New Holland honeyeaters, rare frogs and crayfish, to name a few. Both Maddens and O'Hare creeks and the surrounding wetlands are home to over a dozen different species of native frogs, which are a measure of the environmental health of the area.

**The impact of the proposed CSG mining on the natural environment will be enormous**. There will be considerable destruction of the largely pristine habitat by land clearing in both the exploration and production stages, significant ongoing heavy traffic movements with attendant risks to wildlife and the increased likelihood of the introduction of weeds. As discussed below, **CSG mining will greatly increase the risk of bush fires** and the devastation to flora and fauna that would result.

## 4.6. POTENTIAL FIRE RISKS OF CSG MINING

### 4.6.1. OVERVIEW

There are a number of fire risks associated with CSFG mining (Table 2).

**TABLE 2: FIRE RISKS ASSOCIATED WITH CSG MINING**

| Risks | Cause |
|---|---|
| Blow out of gas at a well head and subsequent fire | • During construction drilling<br>• Mechanical failure of the well head<br>• Vehicle Impact<br>• Earthquake<br>• Wildfire |
| Gas leak from pipeline infrastructure | • Faulty valve<br>• Faulty flange/seal<br>• Earthquake |
| Worker Accomodation area fire involving combustible construction, LPG or diesel | • Electrical fault<br>• Naked Flame<br>• Hot oil or surfaces in kitchen |
| Diesel fire involving mobile fuel tanker, earth moving equipment, forestry equipment and water removal trucks. Shorting from pumping, separator, compressor and other equipment | • Vehicle engine fire as an ignition source to the fuel tank<br>• Naked flame<br>• Vehicle collision, crash into trees or roll over<br>• Sparks |

There are now numerous examples of CSG operations creating a fire hazard. In February 2011, for example, Cheasapeake Energy experienced a flash fire and explosion in on-site CSG storage tanks at one of its CSG drilling sites in Pennsylvania[56]. According the US EPA, the event happened while gas condensate produced at the wells was being transferred into storage tanks[57].

**PHOTO: The fire at Chesapeake Energy's well head storage facility, February 2011**

**In June 2011, Queensland Gas Company admitted CSG leakages at five sites that represented a real fire risk**. A Queensland Government review also found a further 27 minor gas leakages that represented a lower level risk[58]. **The CSG well head blow outs at Tara in Queensland and Camden in NSW created similar CSG fire risks**.

### 4.6.2. Vulnerability of areas to Severe Bush Fires

Large tracts of the Northern Illawarra are prone to bush fires, such as the Dharawal State Conservation Area. Bush fire prone land is land that can support a bush fire or is likely to be subject to bush fire or ember attack. **All of the area affected by the proposed CSG mining under PELs 442 and 444 is highly bushfire prone**.

#### The Catchment Area

**On 25 December 2001 a series of lightning strikes initiated several wildfires** in Sydney's drinking water supply catchments managed by the Sydney Catchment Authority. These eventually burned over 225,000 hectares of forested catchment[59]. A number of impact studies have been conducted since this major fire event in order to assess the fires impacts. Amongst the findings of these studies are that:

- the severity of the fire and any following rainfall events directly determine the size of the sediment and nutrient loads that move through the drainage network and streams into the catchment . The more severe the fire and the larger the subsequent rainfall events, the greater the erosion and delivery of loads to the drainage network.[60]
- following severe wildfire events, the post-fire recovery period of soil stability is 1-4 years.[61]. During this recovery phase, above average rainfall events will lead to erosion and subsequent downstream deposition of sediments and nutrients[62].

#### The Illawarra Escarpment and Adjacent areas

**Major fires have occurred in 1939, 1968, 1980, 1994, 1976 and 2001**[63]. Wildfires occur somewhere within the area every year. **Fires west of the Illawarra Escarpment pose** a **major risk to the coastal communities in Wollongong.** This is illustrated by the 1968 fire event where numerous spot fires were ignited on the escarpment by embers blown by strong blustery winds from the adjacent plateau. These spot fires then ran north along and up the face of the escarpment, destroying large areas of residential property in the Bulli, Austinmer and Coledale areas. [64]

#### The Upland Swamps

**The upland swamps are a particularly flammable vegetation community and an important location for fire ignition.** The fire risks associated with GSC mining and identified below will substantially increase the likelihood of bushfire ignition. [65]

Several different fire regimes threaten the diversity of flora and fauna within Coastal Upland Swamp in the Sydney Basin bioregion: These include substrate fires of recurring short or long intervals. **Under extreme fire weather conditions the peaty substrate is flammable. Substrate fires are extremely difficult to extinguish and their effects may be long-lasting**, as they consume the peaty substrate, causing the mortality of soil seed banks and fauna, lignotubers, rhizomes and other underground organs that would otherwise survive surface and canopy fires. They result in extensive erosion that may be amplified when followed by intense rainfall events, resulting in the flushing of large areas of swamp sediments and vegetation from headwater valleys. Intense rainfall events are not infrequent within the distribution of Coastal Upland Swamp. **An increased frequency of extreme fire weather projected for south-eastern Australia in the 21st century is likely to promote the risk of more frequent and more extensive substrate fires**.

## 4.7. Geological damage and seismic risks

### 4.7.1. Geological damage

Discussions with local geologists have revealed their concerns for the geological integrity of the escarpment behind the Illawarra due to the extensive coal mining operations. There is already documented evidence of destruction of roads and the wholesale escape of gas through the Woronora River.

Although CSG extraction has less apparent structural impact on the rock strata than mining, there is nevertheless significant impact. The extraction of water always results in a change of ground wate volume. This will inevitably cause fracture of the local strata, creating pathways for the flow of water and gas. Control of this is out of the miner's hands.

**The is a real risk that CSG extraction operations and especially the effects of hydraulic fracturing and other coal seam stimulation techniques, will cause subsidence or other seismic events.** This could result in:

- damage to structures such as buildings, dams and roads
- drainage of rivers and dams into the subsurface water table
- increased leakage of methane gas both from natural flows and also from gas liberated from the coal seam bed but not captured for external use
- drainage of aquifers in close proximity to the mining horizon where strata caving and extensive fracturing occurs into the mine workings. Deep aquifer impacts have recently been noted in Area 2 of the Dendrobium Coal Mine[66] and subsidence caused by Long wall mining at Appin Colliery, which is close to the western edge of PEL 444. Broughtons pass weir has had significant loss of water flow coincident with reports of cracking as a result of mining operations[67].

#### 4.7.2. Seismic risks

**Fracking has been directly implicated in geological effects such as earthquakes**. The United Kingdom's only shale gas drilling project was suspended earlier this year after the British Geological Survey (BGS) recorded a 1.5 magnitude quake with the epicentre within two kilometres of a CSG exploration site near Blackpool, Lancashire. This followed a 2.3 magnitude quake that occurred close to a drilling site near Preston in the UK. According to the BGS, while it could not conclusively say that the first earthquake was linked to fracking, it states on its website that: *'Any process that injects pressurised water into rocks at depth will cause the rock to fracture and possibly produce earthquakes*.'[68]

The Arkansas Geological Survey (AGS) and the Centre of Seismographic Information and Research at the University of Memphis conducted a study of the thousands of earthquakes that occurred in Faulkner County in Arkansas, United States, over the course of over a year. On February 27, 2011, the area was hit with a 4.7 magnitude earthquake[69]. Researchers from AGS concluded that while there is no discernible link between earthquakes and gas production, there is *'strong temporal and spatial evidence for a relationship between these quakes and the injection wells'*. **Seismic activity has almost ceased since the fracking stopped**.

These incidents demonstrate that the geological impact of fracking may be significant, although it has yet to be accurately assessed. Such events can open up additional avenues for the migration of fugitive methane gases, polluted water, natural and fracking carcinogens, for some distance around the a CSG well head. This is exacerbated by the current practice of horizontal drilling, which allows CSG drilling (and fracking) to occur within a radius of several kilometres from the well head.

**This is a major potential problem for the Illawarra Escarpment,** which has large areas of geological instability. The number and size of major slippages on the escarpment could be greatly increased by the seismic impact of fracking across scores of wells, coupled with horizontal and/or radial drilling that extend drilling and fracking operations kilometres from the wellhead.

**PHOTO: RECENT SLIP ALONG THE FACE OF THE ESCARPMENT AT WOMBARA**

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