COAL BED METHANE
HAZARDS
IN NEW SOUTH WALES

BY

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Prepared for:

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"*The disposal of co-produced water has proved to be the* ***biggest environmental problem associated with exploitation of coal seam methane fields in the USA****, although the quantity and quality of the water can vary enormously between coal basins. Stricter environmental regulations are making direct disposal options increasingly difficult. Sometimes extensive water treatment is necessary before discharge is permitted.*"
(Clarke, 1996)

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1. CONCLUSIONS AND RECOMMENDATIONS

The following points refer specifically to the Wyong area of NSW, but find application elsewhere in NSW.

WYONG

- Four drill holes, including two production test wells, have been completed in the Jillaby/Dooralong Valley area west of Wyong on the central coast of NSW. The operating company, Sydney Gas Ltd, has indicated that a commercial coal bed methane field could involve some 200 production wells.

- Studies have shown that the rock units overlying the target coal seams are cut by numerous fractures, breccia zones and other features visible as lineaments on regional imagery and in geophysical surveys.

- A large proportion of the drinking water supply for over a quarter of a million people in the region is provided by surface drainage systems and from groundwater discharge.

CONCLUSIONS

- The development of a significant gas field in the district based on Coal Bed Methane will severely impact on the security of supply of this water, by radically altering the groundwater levels, and purity.

- Disposal of saline and sodic water without substantial treatment is to be deplored, particularly in view of the increasing salinity problems in Australia, and particularly in light of recent predictions on the growing scarcity of potable water for Australian communities in the near future.

- Both local and overseas experience shows that fundamental changes in underground pressures can result in serious escapes of methane gas into the environment. Elsewhere this has taken the form of soil poisoning and vegetation destruction, methane venting into nearby wells, surface gas escapes and collection in surface hollows with the resultant danger to human life.

- Additional, poorly researched factors include the danger of organic coal chemicals leaching out during gas production. Research suggests these organic chemicals have carcinogenic and genetic effects. The possibility of significant surface subsidence over a prolonged period cannot be ruled out without further research.

- Based on these conclusions, there should be no further drilling in the area until a full and independent hydrology study has been carried out. Consideration should also be given to classifying coal bed methane sites as industrial chemical sites controlled by the relevant regulations.

2. INTRODUCTION

This report has been prepared at the request of Mr Tony Davis of the **Australian Gas Alliance**. It presents a brief review of the potential hazards 'Coal Bed Methane' (CBM) operations with particular reference to the Dooralong and Yarramalong Valleys near Wyong on the central coast of New South Wales. It is based on a visit to the area in January 2005 at the request of the '**Australian Gas Alliance'** and a review of a hydrological report on the area (Jones 2005). Data from a review of CBM hazards by the author prepared for the National Parks Association of NSW (Inc) in 2002 (Atkinson 2002) is also utilised.

Data on the Wyong area is drawn from Jones (2005), company sources and published literature. Data on the Bohena area west of Narrabri is drawn from site visits, company announcements and published sources. A brief note on the Gloucester/Stratford area is based on company announcements.

3 WYONG

The Dooralong and Yarramalong valleys lie inland from Wyong approximately 100 kilometres north of Sydney NSW. The Dooralong Valley is drained by Jilliby Creek a major tributary of the Wyong River which flows south and east through Wyong. The Wyong River discharges into Tuggerah Lake a coastal lagoon (Figures 1 and 2). The drainage area of the two valleys covers approximately 82,700 hectares. Large areas of the hills separating the two valleys is covered by a variety of dry sclerophyll forest types with some wet sclerophyll and rainforest areas in the sheltered gullies. Much of the forested area is covered by Wyong State Forest. The valley floors and lower slopes have were the scene of cedar logging in the late 18th century. Earlier citrus orchards and diary farms have been replaced by general grazing land. Sections of native vegetation still remain along the banks of Jilliby Creek and are recognised as some of the best preserved of their type in New South Wales. The average annual rainfall is around 1200mm (47 inches).

Water from the Wyong River below the junction with Jilliby Creek is pumped by Wyong Shire to the small Mardi Dam west of Wyong. The Wyong River provides about half of the drinking water for the Central Coast. In 2001, Gosford and Wyong Councils provided the water supply for some 285,000 people, amounting to 34,300ML/a.

Geology and Groundwater

The area lies within the Sydney Basin of Permian and Triassic age. The flat lying Hawkesbury Sandstone forms the higher ground and is underlain by sediments of the Narrabeen Group. These include a range of lithologies, conglomerates, and sandstones ranging down in grain size to fine clays and shales. The sequence is described in more detail by Jones (2005) and Uren (1980). The Newcastle Coal Measures underlie the Narrabeen Group and are at least 400m below the surface in this area. The coal seams within this rock unit have been mined for many years in the Newcastle district and Hunter

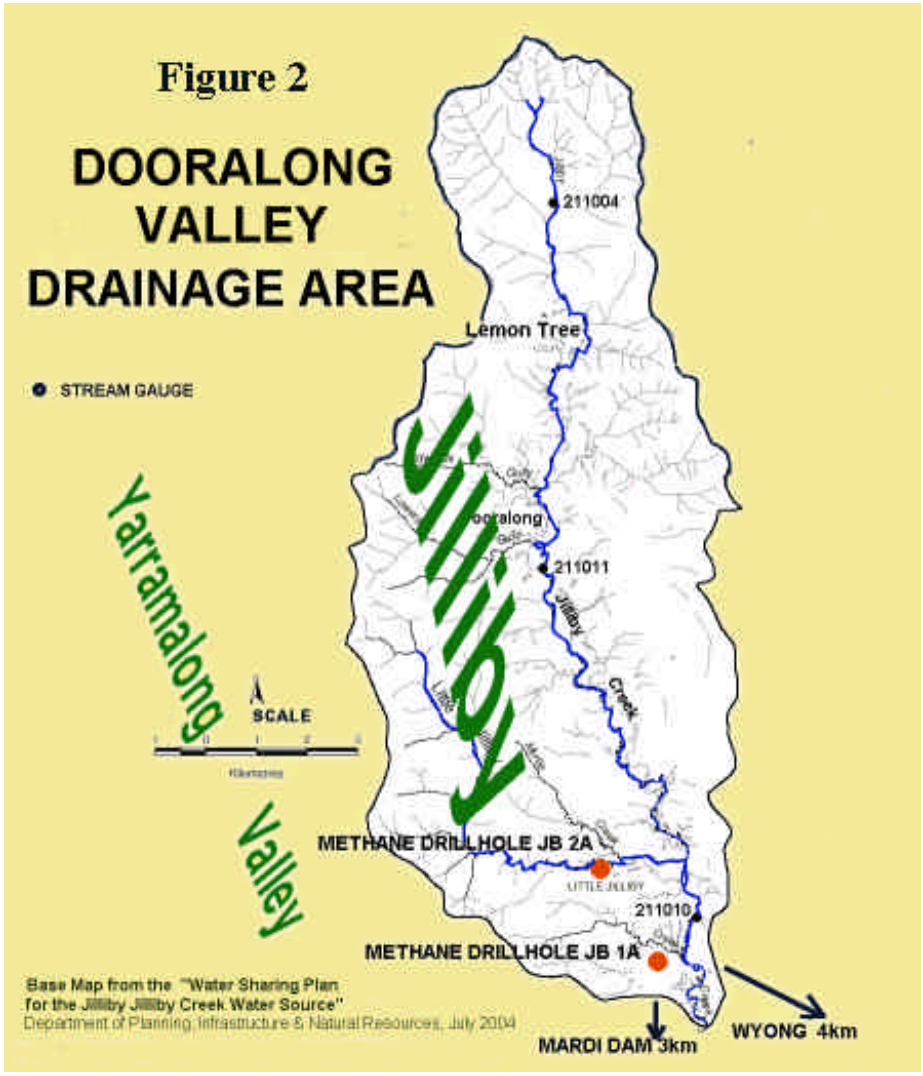
Valley to the north. They are also currently the target for a methane exploration programme by the Sydney Gas Ltd.

The water table lies from two to 20m below surface (Jones 2005). Movement of the groundwater is strongly influenced by faults, rock jointing and by bedding planes. Jones (2005) has identified several groundwater zones:-

- Shallow – 2-10m thick.
- weathered 1-30m thick,
- deeper, saturated sandstone above 400m depth, above coal measures.
- Newcastle Coal Measures

Water in the shallow aquifer flows southeastwards to topographical lows and then southeastwards discharging in Jilliby & Wyong Creeks. Deeper groundwater also flows southeast and provides recharge for the important Tuggerah Lake system. There are 52 registered water bores in the two valleys.

River flows in the Wyong River and Jilliby Creek, as monitored by a series of stream gauging stations operated by the Department of Infrastructure, Planning and Natural Resources, has been reviewed and assessed by Jones (2005). The combined annual flow is reported to average 29,256 ML between 2000 and 2005. However, the average annual flow at the Mardi Dam pumping station on the Wyong River is around 94,000 ML. A substantial portion of the difference between these two figures (approximately 64,000 ML) may be attributed discharging groundwater from the two valleys (Jones 2005). Water



samples analysed recently (Jones 200) from both water bores and surface streams was generally of good to excellent quality, and within Australian and International guidelines for potable water.

Based on field research, Jones' (2005) findings included the following comments:

> *"Groundwater modelling has shown that overhead groundwater leakage will occur in the study area during Sydney Gas Ltd dewatering operations and closure."*
>
> *"Dewatering of coal seams will allow for groundwater migration towards coal seam voids. This has a significant potential to effectively dewater sections of the study area."*
>
> *"Riparian vegetation and wetlands are at risk by a lowering of the groundwater levels and methane migration into the overlying aquifers during gas production."*

Coal Bed Methane

Four drill holes have been completed in the Dooralong Valley and a target of around 200 drillholes has been announced.

The first two drillholes, Jilliby No.1 & Jilliby No.2 were cored holes to collect deep rock samples for laboratory testing. Jilliby No.1 reached total (final) depth of 620m on 27 November 2003 and intersected a total thickness of 37m in a number of coal seams. Jilliby No.2 reached a total depth of 590m on 12 December 2003 and intersected a cumulative coal thickness of 35m. The company, Sydney Gas Ltd, reported ('*Mad about Methane'* company newsletter March 2004) that ten coal seams in the upper Newcastle Coal Measures were targeted. These were, in descending order, Vales Point, Wallarah, Great Northern, Fassifern, Pilot, Australasian, Montrose, Wave Hill, Fern Valley, and Victoria Tunnel seams. Gas recovered from these tests consisted of up to 98% methane.

Table 1. Selected Chemical Analyses of Groundwater

	Australian Drinking Water Guideline	Powder River USA	JILLIBY 1	JILLABY 2A
pH	6.5 - 8.5	7.3	9.1	8.7
Total Dissolved Solids (TDS)	500mg/l	850	**3,976**	**5,452**
Total iron	0.30mg/l	0.8	<0.30	<0.30
Sodium	180 mg/l	300	**1,646**	**2,232**
Magnesium	150 mg/l	16	2.95	4.63
Chloride	250 mg/l	13	**590**	**590**
Barium	0.70 mg/l	0.62	**1.58**	**3.3**
Aluminium	0.20 mg/l	<0.05	**0.218**	0.044
Iodide	0.10 mg/l		**0.689**	**1.27**
Boron	0.30 mg/l		0.242	**0.301**
Calcium	80 mg/l	32	4.91	8.08
Ammonia	0.50 mg/l	2.4	<0.50	<0.50
Nitrate	1.50 mg/l		<5.00	<5.00
Fluoride	1.50 mg/l	0.92	2.98	2.91
Silver	0.10 mg/l		0.002	0.003
Chromium	0.05 mg/l	<0.001	0.005	0.009
Copper	2.0 mg/l	0.0076	0.017	0.084
Lead	0.01 mg/l	<0.0001	0.0005	0.0002
Nickel	0.02 mg/l	0.005	0.001	0.003
Zinc	3.0 mg/l		0.147	0.013
Mercury	0.001 mg/l	<0.0001	0.0003	0.0001
Manganese	0.50 mg/l	0.032	<0.50	<0.50
Arsenic	0.007 mg/l		0.005	0.004
Cadmium	0.002 mg/l	<0.0001	0.0001	0.0002
Selenium	0.01 mg/l	<0.002	0.005	<0.001
Molybdenum	0.05 mg/l		0.009	0.01

Powder River data from Rice *et al.* 2000; Jilliby data from Jones 2005

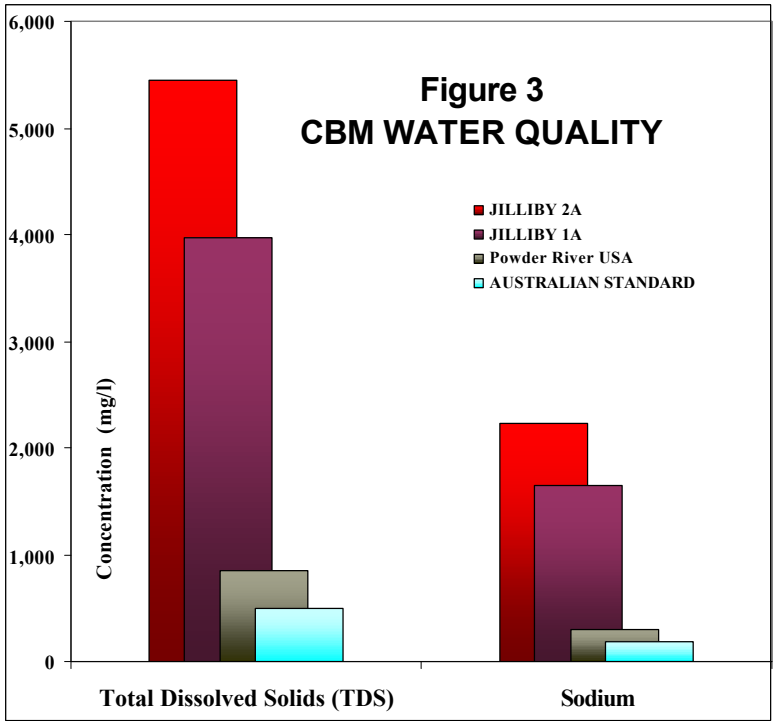
On 19 March 2004 Sydney Gas Ltd began drilling two production test wells alongside the earlier cored drillholes. Drill hole JB1A was designed to test the coal bed methane potential of the Great Northern seam at a depth of approximately 410m –417m below surface. Borehole JB2A, drilled alongside hole JB2, was drilled to test production data from 21m of coal in three coal seams: Great Northern seam at 429m-436m, the Montrose/Wave Hill (530-541m), the Borehole seam at 555m-558m. Target coal seams in

each borehole were fractured ("fracced") to improve the permeability, and then pumping tests were carried out. Removing the water from the coal seams around the borehole reduces the underground pressure and allows any gas present to be desorbed from the coal and be pumped to the surface.

In January 2005 borehole Jilliby 2A was still undergoing a prolonged pump test. Gas, largely methane was escaping to the atmosphere through a 'flare' pipe, while the ground water from the coal seams was being stored in an on-site tank and regularly taken to a site at Windsor. The volume of water produced by this single well is estimated to be approximately 100,000 litres a week, or 5.2MLa year (Jones 2005). Jones (2005) notes that if a gas field is developed this could equate to the removal of volumes groundwater in the order of over 1,000 ML a year. If all this water were to be removed by tanker this would equate to 600 tanker trips a week, a traffic density that the current road system could not cope with.

Jones (2005) also correctly points out that 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. This vegetation destruction has been well publicised in the Cataract River area south of Sydney, where methane has spread up through cracks induced by coal mining subsidence. Jilliby 1A is only 50m from Jilliby Creek, while Jilliby 2A is only about 80m from Little Jilliby Creek.

Water from the coal seams tested in the Jilliby wells is a mineral-rich highly alkaline fluid, rich in sodium, with high levels of chloride, fluoride, iodide and barium. Table 1 presents analyses of the sodic-saline groundwater from Jones (2005), while selected element concentrations are shown graphically in Figure 3 compared to Australian drinking water guidelines.



Examining the analyses in conjunction with the volumes of water from only a single well, Jilliby 2A, a value of 2,232 mg/l (or parts-per-million), equates to 2 grams per litre, or 200kg of sodium per week for a volume of 100,000 litres. Describing this in terms of dried chemicals, this could be described as a load of 730kg of washing soda being abstracted from one well in one week, assuming that a substantial amount of bicarbonate is present. Disposal of this amount of chemical over a full year, and for 10, 50 or 100 wells would be a very large chemical disposal operation. Neither the actual amount of saline water removed from the Jilliby wells nor their composition is known in detail.

It is relevant to note that at the other operation of Sydney Gas Ltd, near Camden, one of the favoured options to overcome the disposal of saline groundwater has been to dilute it with clean water from a drinking water supply until the mixture falls below the regulation concentration of chemicals.

Summary

- Four drill holes, including two production test wells, have been completed in the Jilliby/Dooralong Valley area west of Wyong on the central coast of NSW. The operating company, Sydney Gas Ltd, has indicated that a commercial coal bed methane field could involve some 200 production wells.

- Studies have shown that the rock units overlying the target coal seams are cut by numerous fractures, breccia zones and other features visible as lineaments on regional imagery and in geophysical surveys.

- A large proportion of the drinking water supply for over a quarter of a million people in the region is provided by surface drainage systems and from groundwater discharge.

- The development of a significant gas field in the district based on Coal bed Methane will severely impact on the security of supply of this water, by radically altering the groundwater levels, and purity.

- Disposal of saline and sodic water without substantial treatment is to be deplored, particularly in view of the increasing salinity problems in Australia, and particularly in light of recent predictions on the growing scarcity of potable water for Australian communities in the near future.

- Both local and overseas experience shows that fundamental changes in underground pressures can result in serious escapes of methane gas into the environment. Elsewhere this has taken the form of soil poisoning and vegetation destruction, methane venting into nearby wells, surface gas escapes and collection in surface hollows with the resultant danger to human life.

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- Based on these conclusions, there should be no further drilling in the area until a full and independent hydrology study has been carried out. Consideration should also be given to classifying coal bed methane sites as industrial chemical sites controlled by the relevant regulations.

4. STRATFORD

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.

Molopo Australia Limited has a 25% interest with the operating company AJ Lucas Coal technologies Pty. Ltd, in the Stratford gas prospect near Gloucester, approximately 100 kilometres north of Newcastle. Drill hole LMG-03 was one of two test production drill holes completed by the partners and four coal zones with an aggregate thickness of 16 metres (some announcements quote 23 metres) of coal had been fracture stimulated with sand and water. A 6-12 months testing period began in late August 2004.

However, Molopo announced on 7th September that all tests had been halted after methane had erupted from a number of old boreholes in the area. At the time a strong gas flow of 280,000 cubic feet/day had been recorded even though the water level was still about 300 metres above the coal seams. Two and a half months later Molopo Australia Limited announced that test pumping of LMG-03 had resumed. Three boreholes from an earlier coal exploration had started producing methane, and these along with eight other boreholes had now been sealed with concrete, the company explained. The project manager explained in November that this accidental methane eruption had shown how good the lateral connections were in the reservoir.

In this case there were apparently no serious injuries and the methane gas migrated into nearby boreholes rather than houses, essential water supplies or livestock areas. This example shows that even with only a partial withdrawal of the hydrostatic pressure, methane will migrate quickly and in unpredictable directions. If the drill site conditions laid down by the State Government are similar at Stratford to those elsewhere, the most visible safety precautions would have been a wire fence and a locked gate.

5. BOHENA

Hazards of coal bed methane exploration in the Bohena area of the Pilliga East State Forest near Narrabri include the bulldozing of the critical habitat of rare fauna, the collapse of the dam wall after a thunderstorm and most critically, the locally catastrophic underground seepage of caustic groundwater into the surrounding forest.

Petroleum Exploration Licence 238 covers most of the Pilliga a large area of native forest between Narrabri and the Warrambungles in central west New South Wales. Eastern Star Gas Ltd has been closely involved in all aspects of exploration and is in the process of increasing its coal bed methane interest through exploration expenditure.

The Bohena gas prospect, is near the junction of the Newell Highway and the Pilliga Forest Way, approximately 30 kilometres south west of Narrabri in the Pilliga East State Forest

The Bohena No.2 well (total depth 908 m) was completed in June 1998, and Bohena 2D, on the same one hectare site, was completed in September 1998. A barbed wire fence now encloses an area of about 80 metres by 90 metres containing the boreholes Bohena 2 and 2D, and the holding dam. This dam was built to contain the ground water pumped from underground. Portions of the settling dam wall collapsed and a very saline/sodic fluid poured in to the forest at the southern edge of the site. This collapse probably followed a heavy storm in November 2000. Figure 4 presents a sketch map of the site as seen in 2002.

The collapse of the retaining dam wall was a separate event from the extensive leakage from the dam (excavated in sandy soil) which resulted in the spread of sodic/saline liquid through the subsoil and shallow aquifers. Slight depressions in the forest floor were filled with a black treacle-like liquid. Water in the retaining dam and the black sludge were sampled by the NSW Environmental Protection Agency in April 2001. Limited analyses showed the black sludge contained high levels of tannin. The sodium level in dam water samples was 3,700 mg/litre.

The repaired dam wall remained intact but the area of dying vegetation continued to expand at this site. In addition, trees began to die at two other sites (No.4 and No.3) up to a kilometre away where the saline water from No.2 site had been diverted to through a polythene pipe. By November 2001 the pollution front at No.2 site could be traced eastwards over distance of 250m and a maximum width of 100 metres.

Several long pools of thick black oily liquid persisted for many months on the dirt track about 100m northeast of the drill site. There is no evidence that this fluid had been washed across the surface, and these pools represent liquids from the sodic subsoil saturated with soluble tannins. When these pools dry out a white soda crust develops above the black crust. Sodic soils typically become impermeable due to the effect of sodium on the clay fraction in the soil.

Clean-up work in late 2001 consisted of erecting a new barbed-wire fence around the site, surveying a grid in the affected area, spreading lump gypsum in one area of dead vegetation, and enquiries for grass seed in the local town of Narrabri.

The limited chemical analyses, the persistence of black tannin rich fluids emerging from the sub-soil and the death of normally resistant Casuarinas, all point to a chronic case of sodic soil poisoning, worse than cases described from methane gas fields in the Powder River Basin USA The full extent of the sub-surface pollution, and the final areal extent of the damage is impossible to determine without a series of shallow boreholes to monitor the

sub-surface conditions and without expert supervision. In addition, there is no evidence of soil testing, either before work commenced or after the pollution began. The Bohena area is now known to lie within an area where the rare and protected black striped wallaby occurs. No fauna or flora surveys appear to have been carried out.

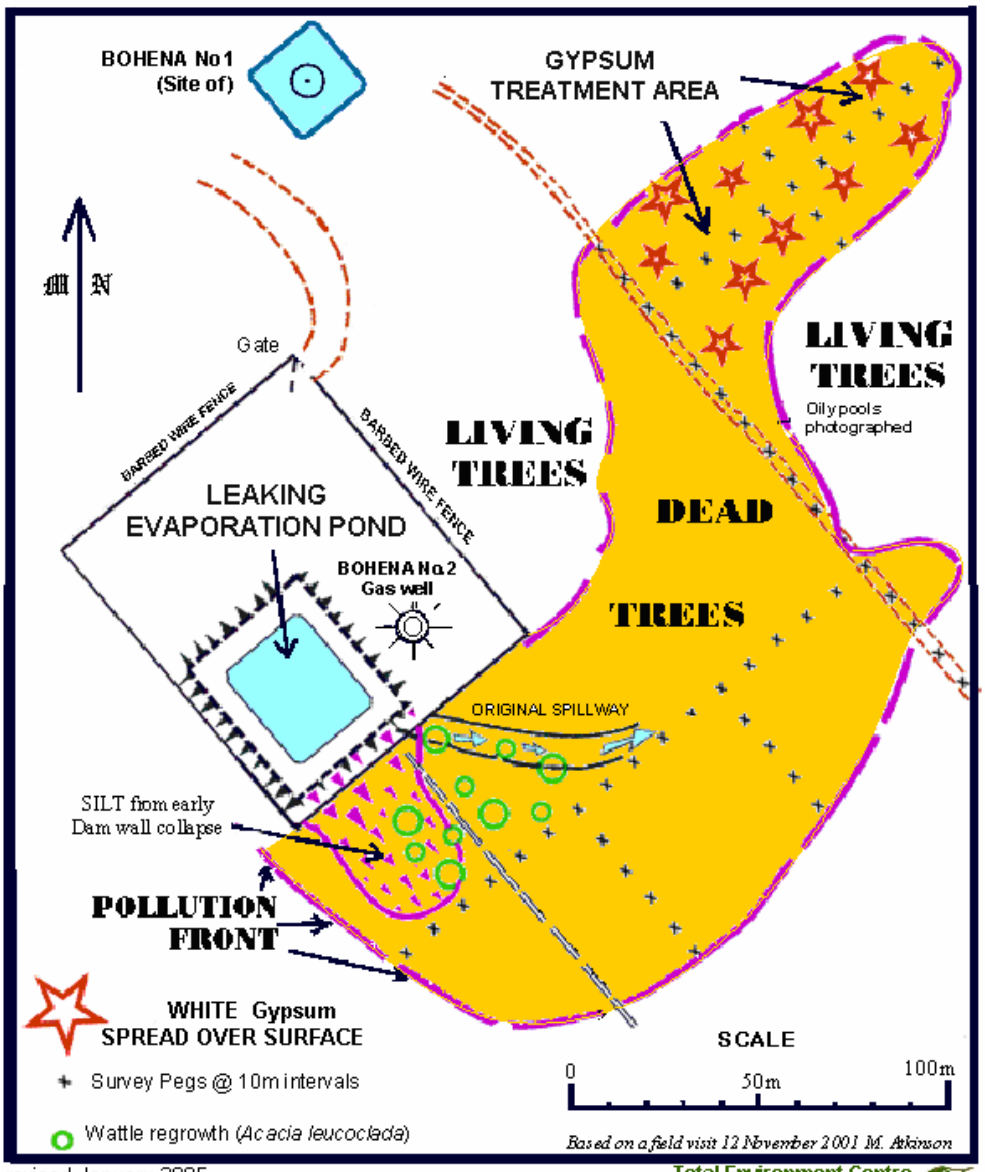


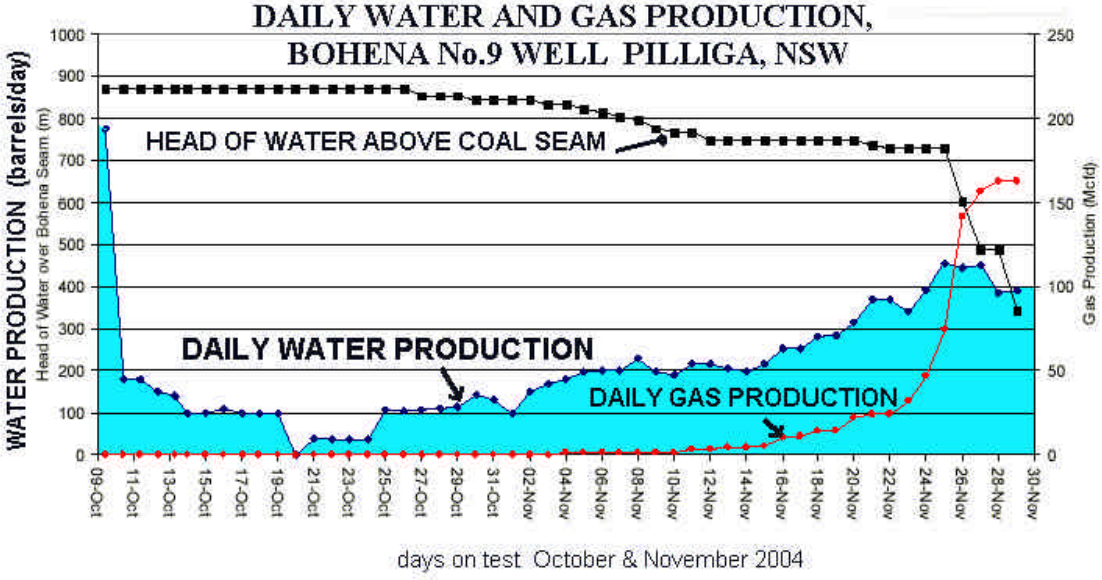
Figure 4

SUBSOIL POLLUTION at BOHENA No 2 WELL-SITE, PILLIGA, NSW

Renewed exploration in the Bohena area in 2004 included the drilling and test production of several new wells (drill holes). At least one of the storage dams was fitted with a plastic liner to combat the seepage of corrosive ground water. This was however, several years after the initial incident. Production testing of coal bed methane wells took place at at least four sites. At Bohena No. 9 ground water was being pumped at an average rate of around 200 barrels per day (1 barrel is equivalent to 0.159 cubic metres). Over this period this is

equivalent to over 30 cubic metres a day, or over 3,000 cubic metres during the 50 day period shown in Figure 5. If this water is similar in quality to the partially analysed ground water from Bohena No.2, disposal of this anywhere in the local catchment (Namoi River) should be extremely difficult.

Figure 5



from: presentation at EASTERN STAR GAS Annual General Meeting, November 2004

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