THE COLONG FOUNDATION FOR WILDERNESS LTD.

Friday 19th May, 2017

Executive Director
Resource Assessments
Department of Planning and Environment
GPO Box 39
Sydney NSW 2001

Dear Sir,

Submission as an objection on the Narrabri Coal Seam Gas Project (SSD 6456)

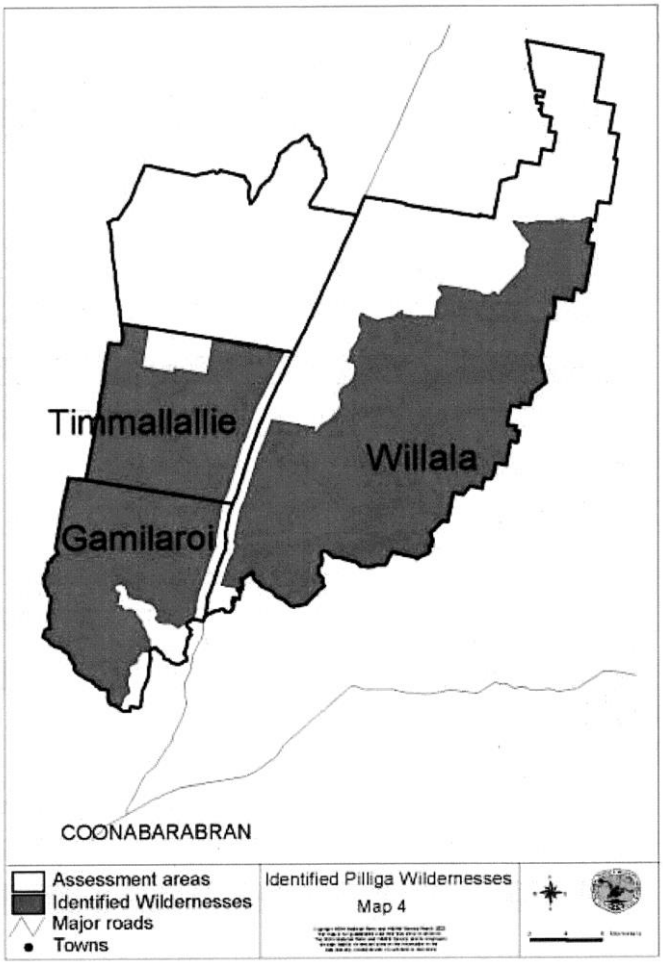
Protect the Willala Wilderness

The Colong Foundation for Wilderness objects to this very large proposed coal seam gas (CSG) project and in particular the part of it which overlaps with the Willala Wilderness of 73,734 hectares.

The affected part of the wilderness is capable of formal identification under the *Wilderness Act, 1987*. It lies in the proposed project area within Bibblewindi State Forest and totals approximately 12,000 hectares. The wilderness within the project area extends north from the Pilliga East State Conservation Area boundary from Dudleys Road to Whirly Brook Trail then to Falcon Trail, north to Warrumbungle Trail and then northwest to Beehive Road and then east to the state forest boundary (see map, page 2 of this submission).

The proponent's environmental impact statement has ignored potential impacts of the project upon wilderness values. The state forest area bounded by the roads is wilderness and this proposal will significantly degrade, if not destroy its wilderness values. The wilderness is defined in a draft Pilliga Wilderness Assessment Report that was compiled by the NPWS in 2003 but was not published by a previous administration for political reasons. As a result of a political decision, the wilderness was not formally identified by the NPWS Director-General but that does not cancel out its wilderness capabilities that are depicted on the map on page 3 of this submission.

Further, the draft Pilliga wilderness assessment found and reported that the borehole activities associated with Eastern Star Gas PEL 238 that caused the wilderness to be substantially Modified, meaning its values were degraded to beyond recovery (see page 49, draft Pilliga Assessment Report and also the extract of a report by Mike Atkinson on page 6 of this submission). The proponent company must markedly improve its management of CSG produced water to avoid such significant wilderness impacts from its proposed operations.

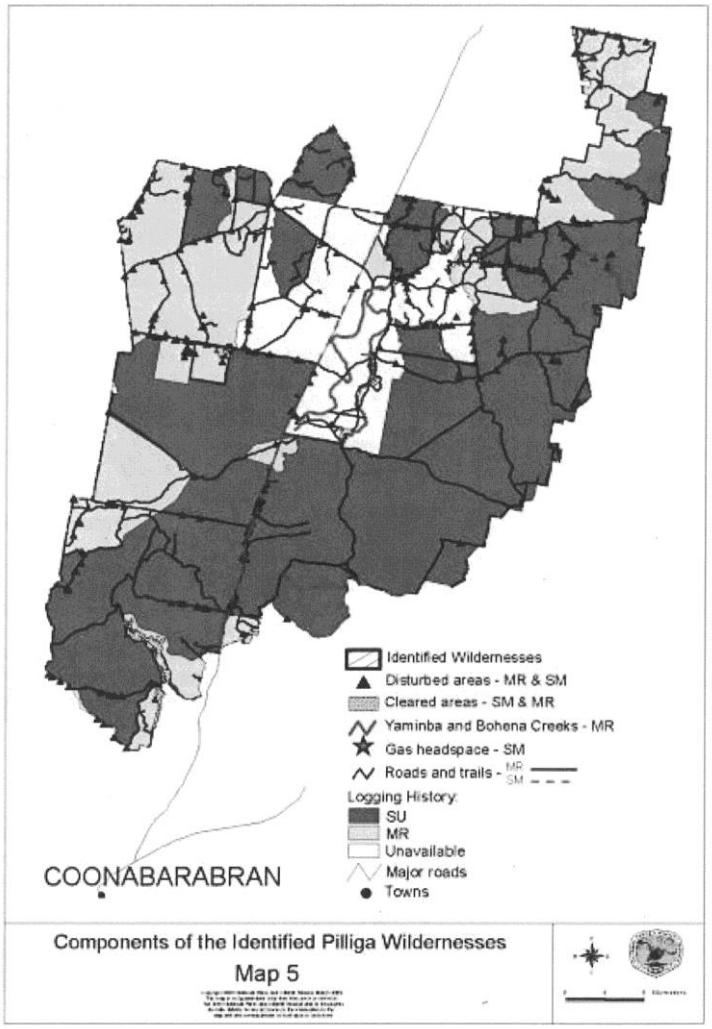


Location of Willala Wilderness in the Pilliga forests -
The Willala Wilderness lies within the Pilliga Nature Reserve,
Pilliga East State Conservation Area and the Bibblewindi State Forest
(pg 54 draft Pilliga Wilderness Assessment Report)

Be that as it may, the Willala Wilderness merits consideration regarding the potential environmental impacts arising from CSG operations, and where possible protection from these impacts by the proponent company. The proponent company has failed in its duty of care by not considering wilderness values and this significant flaw in the environmental impact assessment must be corrected when the Department of Planning and Environment (DPE) and Planning Assessment Commission (PAC) reviews of the proposal.

The proponent company should be required to undertake the necessary work to ensure its operations avoid or minimise harm to the wilderness values in the state forests of its proposed project area.

The Colong Foundation requests that the Willala Wilderness be recommended for exclusion from the project. If the DPE assessment recommends that this wilderness to be mined for CSG, then the DPE should recommend that proponent be required to design access and infrastructure so that the Willala Wilderness and other forested areas can be restored within twenty years. The proponent company should also be required to fund wilderness and other restoration works, including removal of all infrastructure and rubbish from the project area.



The Willala Wilderness in the Pilliga forests contains components:
MR = Management Recoverable as wilderness
SU = Substantially Unmodified wilderness
(pg 55 draft Pilliga Wilderness Assessment Report)

Management of works and rehabilitation in the ecological sensitive Pilliga forests

More generally, that part of the Santos CSG project area that lies within the Pilliga state forests as shown in the above map has to a large extent not been subjected to intensive alterations previous to this CSG proposal. The absence of irreversible modification is due to the forests relatively poor soils and lack of suitable surface water.

Extensive parts of the proposed CSG project contain woodlands with old-growth elements. These elements of ecologically mature woodlands have a structural diversity that includes the presence of large live trees, large standing dead trees and large logs. These woodland values need to be mapped and protected from environmental impacts by the proponent in a manner consistent with the map above.

The rehabilitation program objectives should guide the CSG proposal from the outset. After mining, the topsoil should be returned to all clearings and a process of natural rehabilitation established, in preference to any planned artificial revegetation processes.

Trails and pipeline easements will impact upon the woodlands naturalness (a quality of wilderness value) because trail and easement establishment and maintenance results in clearing of native vegetation. The proposed project trails, pipelines, produced water storage tanks and gas headworks all are incompatible with maintenance of wilderness values. The establishment of a reticular network of trails and gas infrastructure guarantees the systematic demise of the part of the Willala Wilderness in the project area.

Soil erosion and siltation hazard areas should be mapped and these areas must be avoided in the location of the proposed CSG infrastructure and roads. The installation of gas facilities, produced water storage facilities and other infrastructure must avoid these environmental hazard areas and areas of high conservation value.

To minimise damage to the natural environment, the CSG access roads should be established with local materials with no areas of cut and fill. Erosion is a serious problem in the Pilliga Forest's light sandy soils, especially near creek crossing, and trails and infrastructure will be a source of increased siltation of creek lines in the project area. To minimise siltation, roll-overs mounds should be constructed on the trails in preference to table-drains, and all earth works should be kept to a minimum and removed at the end of the project. As parts of the gas field become exhausted, trails and CSG infrastructure become unnecessary for project management operations, and this infrastructure should be removed and rehabilitated in a progressive manner.

As part of progressive rehabilitation, and in addition to the restoration of clearings and removal of developments established by the proponent company, all fence lines, tanks, dams, quarries, accommodation and clearings should also be removed from the project area.

Nature Conservation management within the project area

To enhance biodiversity during the period in which the Pilliga forest is subject to CSG extraction, the Pilliga forest must be managed by the proponent company as if it were a nature reserve.

There is only one Pilliga forest and Santos should ensure its old growth forest values are enhanced. The rehabilitation objectives for the project area should include restoring the Pilliga forest to a better wilderness and old growth woodland condition over a twenty year period after the project, than before its CSG operations commenced.

The project area has a very high diversity of native plant species. The Pilliga is regarded as one of the most significant natural faunal refuges in the state (Smith, 1982). It contains significant plant and animal species and vegetation communities found nowhere elsewhere in the Central Division of NSW.

More than 800 native vascular plant species have been recorded in the Pilliga State Forests (Beckers and Binns, 2000). Of those, 269 native plant species in the Pilliga area are not known from elsewhere in the Brigalow Belt South Bioregion. This represents the highest number of unique native species of all the data sets compiled in the vegetation mapping and survey project for the bioregion. The Pilliga East State Forests supports 12 rare or threatened plant species (NPWS, 2002c).

The Pilliga is an area of biogeographic-overlap where coastal fauna species are found at the western limit of their distribution and arid land species are found at their eastern limit. The Pilliga Mouse was only discovered in 1975 and with the Eastern Pygmy-possum utilises woodland areas with dense shrub layer. The area is also home to the Brush-tailed Rock-wallaby, Rufous Bettong and Black-striped Wallaby. A large and healthy Koala population is present in the project area, as is the threatened Squirrel Glider. There are four threatened bat species and over 200 species of bird have been recorded in the Pilliga forests, including the Swift Parrot. Almost a third of all Australian parrots and cockatoo species have been recorded in the Pilliga. A total of 22 threatened fauna are in the wilderness (NPWS, 2003 draft Wilderness Assessment Report, page 27).

Feral animals, particularly pigs, and weeds should be eradicated from the project area. A pest management plan shall be developed and funded by the proponent within the project area.

Extent of disturbance

Santos proposes up to 850 wells on 425 well pads over 95,000 hectares is more than four times the size of previously approved CSG projects in NSW. Almost 1,000 hectares of forest habitat will be cleared including habitat for critically endangered Regent honeyeater and koalas. The proposed project would also fragment the habitat of the Pilliga Mouse, which lives nowhere else. It will fragment old growth woodlands and wilderness. The proposal must be modified through independent and detailed pre-production faunal and flora surveys to prevent any clearing of endangered ecological communities, as well as any clearing of endangered animal and plant habitat.

The proposal includes a gas processing facility for compression, dehydration and treatment of gas, a water management facility for storage and treatment of produced water and brine, a possible additional power generation on site, continual flaring (for burning off of gas at two locations), an infrastructure corridor through the forest between Leewood and Bibblewindi State Forests, expansion of worker accommodation, discharge of waste produced water into Bohena Creek, irrigation with treated produced water and landfill burial of tens of thousands of tonnes of salt. These activities have the potential to cause significant environmental impacts and will require a high level of monitoring and independent compliance auditing.

Testing by the EPA in March 2001 indicated that a spill of produced water at Bohena had the following characteristics: “The analysis showed that levels of tannin (S 1.7) were 560 mg/L. That compares to tannin levels of 15 to 60 mg/L associated with run-off from timber mills. Based on that information, we believe that the "black liquid" that you reported is concentrated soluble tannin and lignin derived from decaying vegetation, most likely from the dying trees. The results of analysis for electrical conductivity (S 1.1) in the holding pond was 14000 mS/cm. Sodium and potassium levels 3700 mg/L and 50 mg/L respectively.”

The NSW Environment Protection Authority will require additional resources to ensure compliance with pollution licences for this large project given that the highly saline waters associated with the proposed project will pose a significant environmental hazard.

Light pollution from flares, compressor stations and the water treatment plant will degrade the dark sky needed by the internationally renowned Siding Springs Observatory. The Dark Sky Planning

Guideline, June 2016 established to protect the Observatory from light pollution will be compromised unless its provisions are applied to this CSG proposal. Gas flares need to be enclosed in adequate cowling to prevent light pollution. All other infrastructure lighting needs to be designed by a lighting engineer to prevent or minimise to the greatest extent possible light pollution. Unenclosed lighting standards typically used at mining operations must be prohibited in the Pilliga forest.

As previously stated, the Pilliga is the only large natural woodland area left in the Central West of NSW and must not be degraded. Spread across the Pilliga forest, clearing for infrastructure will fragment larger areas of habitat. The gasfield must not be permitted to clear Pilliga Mouse habitat, which lives nowhere else, or the breeding habitat of other wildlife.

The proposed CSG project will fragment and degrade the forest. Without specific information about where the wells and lines will be located, a proper ecological impact assessment can't be completed by either DPE or PAC processes.

The Colong Foundation believes it will not be possible to successfully regulate this CSG project to ensure the Pilliga forest is protected, and the DPE should recommend against approval of this proposal. The Pilliga is a cherished natural and cultural icon and must be protected from becoming an industrial gasfield. Under no circumstances must the Pilliga forest be left derelict following this project.

Staged and Adaptive Management of the Santos CSG project

This major petroleum project proposal should not be recommended for consent because implementation will be error prone and have a high risk of unforeseen environmental impacts. Continuous opposition to the project also should be noted by DPE in its assessment report. If any part of this CSG proposal is recommended for approval, then it should be a staged project so that it can be adjusted during the extraction process to minimise environmental damage.

As the DPE is aware, rehabilitation of thousands of hectares of natural intact woodland subjected to significant environmental impacts has not been attempted by a CSG project in NSW, and such restoration will be by its nature a trial and error process. Rehabilitation techniques will need altered where there are failures or poor outcomes and redone in those areas.

The Colong Foundation recommends an adaptive approach, where DPE sequentially controls a series of extraction plans over small areas, starting in the most environmentally disturbed and least environmentally sensitive areas, and then progressing from there. An independent monitoring panel of experts (IMP) and community feedback will be essential to ensure good environmental performance by the proponent on rehabilitation, and wildlife and GAB protection.

The DPE should consider the lack of specific details regarding the 850 wells and the lines and infrastructure that run between these wells. The proponent company must not be granted an unconstrained consent for this gasfield based on a proposed "Field Development Protocol." Essentially this Protocol sits below a "concept proposal" approach that was not fleshed out in the EIS report.

Other CSG projects that have been assessed by DPE have provided definite locations for proposed CSG infrastructure. An adaptive management and staged approach is a prudent response the proponents imprudent lack of detailed knowledge, if the DPE considers that refusal is not an option.

The community, the DPE and the PAC are unable to adequately assess this large CSG project as location details regarding well placement, pipeline reticulation, access roads and dewatering infrastructure are unclear. For example, identification of particular sites of proposed infrastructure in relation to koala habitat or soil erosion hazards is impossible.

The project must be adequately regulated and to achieve that end will require the provision of more information on the location areas of environmental sensitivity and the mine infrastructure in relation to these sensitivities. Extraction plans for small production areas will be required to adequately regulate CSG extraction.

Further the DPE should take into account that the proponent company, Santos, is partly responsible for destabilising the gas market in Brisbane, Sydney and Melbourne, placing at risk manufacturing industries that rely on a stable gas supply price. By contracting to sell more gas to overseas customers than Santos currently has approval to supply is has exposed third parties to unnecessary risk. How this was permitted should be a subject of a broader inquiry and review to improve energy policy.

Gas producers should not be allowed to manipulate the NSW gas market to drive up its gas prices for manufacturers and local power stations. The regulatory framework must ensure NSW energy security and price stability. Such factors should influence the DPE assessment regarding whether a proponent company is a good citizen of NSW that can be trusted with a protocol approach, rather than an extraction plan approach as recommended in this submission. For DPE to assess and recommend an unconstrained consent would condone the proponent's imprudent behaviour.

Poor behaviour by a proponent is grounds for the proposal to be either refused consent or be given a consent constrained by adaptive management. In addition to these concerns on past behaviour, the gas produced at Narrabri by Santos risks forcing gas prices upwards, as CSG is more expensive to produce than conventional gas. AGL believes CSG from the Pilliga would be the most expensive gas produced from anywhere for the Australian gas market. The proposed project may support 145 jobs, but it is at the cost of risking permanent damage to the Pilliga forest and the aquifers of the Great Artesian Basin (GAB), as well as maintaining upward pressure on gas prices that may cost thousands of jobs in NSW.

The DPE appreciates that coal seam aquifer needs to be dewatered to release the gas, but this aquifer lies beneath the Pilliga Sandstone of the Great Artesian Basin recharge beds. The EIS acknowledges that the proposal will result in a loss of water from the GAB recharge aquifer over time. CSG operations in Queensland have drawn down GAB aquifers.

The GAB is a ground water resource of national significance and must not be compromised by CSG operations such as dewatering. Dewatering and fracking risks compromising the long term water security for future generations of farmers in western NSW who will be dependent upon the GAB.

The Colong Foundation acknowledges that produced water from the coal seam will be treated, and 115 tonnes/day of salt will be disposed at unspecified landfill sites. These operation have many

risks, including degradation of the forest when there is a failure to contain produced water as illustrated by the follow case study.

Lessons from the mistakes made by Eastern Star Gas

The late Mike Atkinson, an experienced and respected coal geologist, provided the following report on a produced water pollution incident at Bohena:

> From the late 1990s until 2004 Eastern Star Gas Ltd had been closely involved in all aspects of exploration and is in the process of increasing its coal bed methane interest through exploration expenditure. It undertook development of the gasfield under Petroleum Exploration Licence 238 that covers most of the Pilliga forests between Narrabri and the Warrambungles in central west New South Wales.
>
> Its Bohena gas prospect was located 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 a one hectare site, was completed in September 1998. A fenced 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 produced ground water pumped.
>
> 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.
>
> 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 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 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.

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 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 produced 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) would be extremely difficult.

Bohena No. 7. Panorama of an active exploration drillsite

Based on Mr Atkinson's evidence*, including the above image, all produced water storage dams must be lined and monitored for leaks and liner failure.

The proponent and the EPA must develop a notification procedure regarding pollution incidents. Dam failure incidents and spills of saline produced water are possible. A detailed incident response protocols must be developed and approved by the EPA to address immediate repair and restoration of woodlands damaged in such produced water spill events.

It was clear from the 2001 Bohena incident that there was not an effective clean-up response and that this regulatory failure caused further environmental damage. Termination of gas production at the affected wellhead as well as environmental repair of the damage woodlands should be part of the protocol. There must be significant penalties for dam failures and produced water spills.

[*See also **Attachment A** for further details regarding Mr Atkinson's evidence.]

Scale of water treatment and land disturbance is apparent from this aerial of the Bibblewindi Water Treatment facility, Bibblewindi State Forest, 2011

Adequate Protection for the Great Artesian Basin (GAB)

The impact on CSG production on the GAB must be monitored and groundwater level change thresholds set to prevent damage to the Pilliga sandstone aquifer strata. The independent monitoring panel (IMP) of experts who are unrelated to the petroleum industry must advise DPE on any impacts to GAB, as well as including others experts in the assessment of impacts on biodiversity, old growth forests and wilderness.

If the integrity of the GAB is impacted, then the DPE must be able to stop CSG production in the project area. If approval is recommended for this proposal, then consent must be structured to protect the GAB and the integrity of the intake bed strata as a priority over continued CSG production.

Under no circumstances should fracking of the coal seam be proposed where this compromises the GAB strata. If fracking is a contingent part of the proposed project, then the Colong Foundation believes that this proposal must be refused consent as fracking will compromise the aquiclude strata that confine the GAB strata. Such damage will have potentially serious but unknown consequences.

The proponent must not be relied upon to provide accurate data on damage to the GAB and its confining rock strata. Experience with coal mine subsidence plans reveals that any such company data always is framed within misleading narratives that serve the proponent's needs and generally mislead regulatory agencies. Without good verified data being available to an IMP with no ties to the CSG industry, it is likely that monitoring will be unable to produce the sound advice necessary for adaptation and improvement of the CSG project.

Recommendations

After considering the environmental constraints of the Pilliga forest and hazards related to CSG production under the GAB, the Colong Foundation believes that DPE should recommend refusal due to an extensive and significant potential environmental impacts. The proponent has shown itself not to be a good corporate citizen by gaming the gas market and its EIS does not provide enough specific data so that the proposal can be approved with conditions of adequate precision to ensure defined environmental outcomes.

The Colong Foundation considers that there shall be too many unforeseen environmental impacts associated with this proposed project for it to be granted unconstrained development consent.

If these risks are not considered sufficient grounds for DPE to recommended refusal, then a DPE recommendation for approval must be subject to a consent that is limited in area, staged and adaptive in nature. No large approval of CSG resource security should be issued as it is not in the national interest to put at risk the water resources of the GAB or the biodiversity of a large part of the Pilliga forest. It is also completely unnecessary to issue such broad resource security to Santos.

If DPE decides to recommend approval of the project, then consent should be regulated by the following proposed conditions:

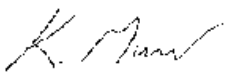
- No CSG infrastructure in the part of the Willala Wilderness within the proposed project;
- Label as **environmental constraint areas**, all areas with:
  Wilderness value (see map on page 2),
  Old growth woodlands,
  Endangered ecological communities, and
  Threatened plant and animal species habitat;

- Independent, and site detailed **pre-production faunal and flora surveys** shall ensure the habitat of threatened native species is not cleared, but avoided and protected in environmental constraint areas to the satisfaction of an IMP;
- Soil erosion and stream siltation hazards must be mapped as part of the environmental constraint area;
- Trails and CSG infrastructure must avoid all environmental constraint areas;
- To further minimise damage to the natural environment, the access roads should be established with local materials with no areas of cut and fill;
- To further minimise siltation, roll-overs should be constructed in preference to table-drains, and all earth works should be kept to a minimum and removed at the end of the project, including all access roads and trails;
- Feral animals, particularly pigs, and weeds should be continuously eradicated from the project area by pest control contractors approved by the DPE for the duration of the project;
- The proponent shall undertake effective wildlife management within the Pilliga forest to secure diversity of its flora and fauna using a wildlife management plan and a wildlife management team approved by the National Parks and Wildlife Service as part of the IMP;
- The **natural dark sky required by the Siding Springs Observatory shall be protected** from light pollution by enclosure of gas flares in cowling and proper design of all lighting by an approved lighting engineer;

- **A series of CSG extraction plans** shall be developed for the project to implement a staged program for the life of the proposed project;
- **Adaptive management approach** shall govern a sequential series DPE controlled CSG extraction plans each over small areas under a regime established at the outset of the project, starting in the most environmentally disturbed and least environmentally sensitive areas, and progressing from there towards more environmentally sensitive areas;
- **An independent monitoring panel** (IMP) experts in the GAB shall advise the DPE and community feedback on these extraction plans will inform continuous improvement of the project;
- An expert **IMP shall set and advise on thresholds** regarding impacts on the GAB, biodiversity and environmental hazards, and advise DPE on compliance of the project to these thresholds;
- In order to minimise environmental impacts, failure to meet **environmental threshold standards** specified in the consent to the satisfaction of the DPE, as advised by the IMP, shall result in the removal of areas from a current extraction plan and also entire extraction plan areas can be removed by the DPE on advice by the IMP;
- Detailed incident response protocols must be developed and approved by the EPA to address immediate repair and restoration of woodlands damaged in produced water spill events before work commences under an approved CSG extraction plan;
- The **rehabilitation program shall be continuous** and require all topsoil to be returned to all clearings and a process of natural rehabilitation established at each disturbance site as soon as possible, in preference to any planned artificial revegetation processes;
- As part of progressive rehabilitation, and in addition to the restoration of clearings and removal of developments established by the proponent company, all fence lines, tanks, dams, quarries, accommodation and clearings should also be removed from the project area.

Thank you for the opportunity to comment on and object to this proposed CSG project that threatens the integrity of the Pilliga forest in Central West NSW.

Yours sincerely,



Keith Muir
Director
The Colong Foundation for Wilderness Ltd

Attachment A follows.

References:

Atkinson, M, 2002, Environmental Hazards of Oil and Gas Exploration, prepared for NSW National Parks Association, Sydney and included as a supplementary submission by the Colong Foundation (Supplementary Submission No 132a) to the September 2011 NSW Upper House Inquiry into Coal Seam Gas, NSW Parliament House, Sydney.

Beckers, D. and Binns, D. (2000) Vegetation Survey and Mapping, Stage 1 Report – Brigalow Belt South Bioregion. Resource and Conservation Division, Department of Urban Affairs and Planning, NSW.

NPWS (2002c). Targeted flora survey and mapping. Brigalow Belt South bioregion (stage 2). A project undertaken for the Resource and Conservation Assessment Council NSW Western Region Assessments WRA/16.

NSW National Parks and Wildlife Service, 2003, Draft Pilliga Wilderness Assessment Report, unpublished report to the Director-General of NPWS, NSW NPWS (Western Directorate), Dubbo, NSW.

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Supplementary Submission No 132a

INQUIRY INTO COAL SEAM GAS

Organisation: The Colong Foundation for Wilderness Ltd

Name: Mr Keith Muir

Position: Director

Date received: 1/09/2011

Colong Foundation - supplementary submission -
BRIEFING PAPER 2002
Enviromental hazards of oil and gas exploration -
detailing the impacts arising from coal seam methane exporation
by Mike Atkinson, coal and petroleum geologist,

ENVIRONMENTAL HAZARDS OF OIL AND GAS EXPLORATION

CONTENTS

Prepared for:
National Parks Association of NSW Inc.
Sydney

C. M. ATKINSON August 2002

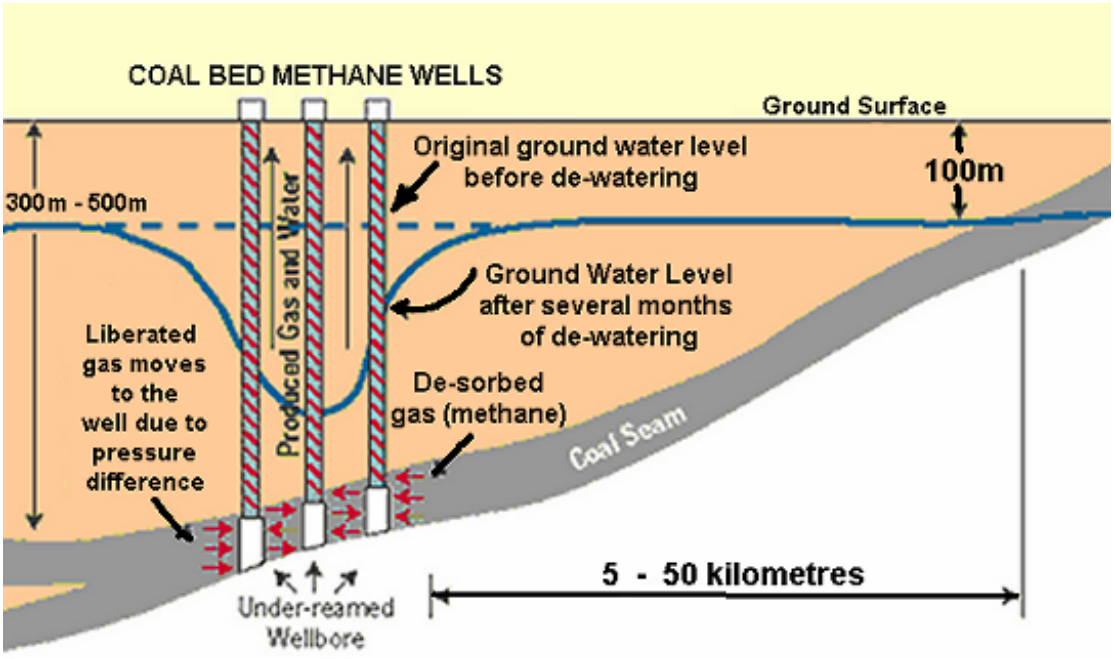
1. PETROLEUM FORMATION AND COAL SEAM METHANE

A complex mixture of oil, gases and coal are produced when of peat and/or other organic material are compacted and heated by burial over geological time. During this process, methane and more complex hydrocarbons are successively produced. The proportions and type of oil and gas depend on the original type of plant material as well as temperature. Conventional oil and gas fields form when these hydrocarbons migrate into porous rocks and are stored in the spaces between the grains of these reservoir rocks. To keep these mobile gases (and liquids) trapped in place, structural or stratigraphic traps have to be present. The commonest traps are impermeable rocks which prevent migration of the gas either upwards, or sideways.

> The term **Petroleum** includes:
> [Crude] Oil -*the liquid fraction*
> and
> Gas/ Natural Gas, (*mostly methane*), including Coal Seam Methane (CSM) / Coal Bed Methane (CBM) –*methane trapped within coal seams*

This coalification process generates methane-rich gas, large quantities of which normally remain within the coal. This 'coal seam methane' gas has been the main cause of disastrous explosions and outbursts in underground coal mines. Coal has only recently been recognized as a storage or reservoir rock for natural gas as well as a generator or 'source rock.'

Coal seam Methane (CSM) is actually soaked up by coal grain faces or micropores, and held there by the pressure of water also present in the seam. Methane is also stored in fractures and cleats. The coal seam therefore acts as the source, reservoir and seal for this type of gas deposit. Coal can potentially hold as much as six to seven times more methane per unit of volume than most conventional reservoir rocks. The methane stored can be released by removing most of the water (de-watering) causing a pressure drop which releases the methane from the coal seam. This dewatering is carried out during test pumping and during early stages of production.



Typical Coal Bed Methane De-watering Well Layout

from Queensland Gas Co Ltd (www.qgc.com.au)

2. PETROLEUM AND MINERAL EXPLORATION

There are substantial differences between the methods used to explore for petroleum and to explore for minerals. The two activities are also covered by separate government legislation.

Mineral exploration initially has a low impact on the landscape. It involves sample collection, and surveys are limited to small areas and relatively shallow drilling. If the mineral exploration continues, the scale and cost gradually increase. The main cost and environmental disturbance only comes during the development and mining phase, for which a formal environmental impact statement is obligatory.

The first on-site activity in on-shore petroleum exploration usually involves one or more seismic surveys followed by deep drilling. By the time any oil or gas field is discovered and a development/production permit is applied for, most of the environmentally damaging work has been carried out: without any formal impact statement.

Each seismic survey line is usually several kilometres in length, and in a single survey programme it is not unusual for the total length of survey lines to exceed 50 kilometres. These survey lines must be cleared to allow the passage of very large all-terrain trucks, and there are no effective rules to prohibit surveys during any wildlife breeding season. The identification and preservation of rare plants or critical plant communities are the exception, not the rule, and there are no subsequent independent and transparent flora or flora surveys to check on the damage to the environment. Drilling for oil or gas often involves the wholesale clearing and soil removal over an area of at least one hectare, with no external audit of the existing flora and fauna, and no community input. Testing of coal seam methane targets involves the removal of very large quantities of groundwater, which in most coal seams is highly mineralised.

3. COAL SEAM METHANE EXPLORATION

Since about 1980 a new type of gas resource has been developed in the USA, called ‘coal seam methane’ (CSM) or ‘coal bed methane’. As a consequence, production of natural gas and water from coal seams has risen dramatically in the U.S.A and this methane now accounts for about 6% of the total annual production. The Powder River Basin in Wyoming and Montana has been one of the most active areas since 1997. In March 1997 there were 270 gas producing wells; by March 2000 there were 2,469 (Rice *et al*. 2000).

The techniques used are similar to those used for more traditional or ‘conventional’ oil and gas exploration, but there are also a number of new features, some of which are potentially extremely harmful to the environment. Instead of the relatively few drillsites needed for tradtional oil and gas exploratiuon, CSM exploration characteristically needs numerous, separate sites. Operationg CSM fields in the USA may have several dozen drillsites each linked by roads and pipelines. Experimental testing of CSM drill holes for strong and consistent gas flows may extend over half a year, with the removal and disposal of groundwater during the early stages. This type of exploration began in Australia in the early 1990s and companies are still experimenting with different techniques to suite local conditions. Discoveries have been made in New South Wales and Queensland, and exploration is also taking place in Victoria.

4. ENVIRONMENTAL HAZARDS

Some of the environmental hazards that are associated with this evolving petroleum industry sector include the following:

Physical damage – drill site clearance; damage by survey line clearing
Groundwater loss
Groundwater contamination
Waste water, or ‘produced water’ – surface contamination by dissolved mineral salts or organic compounds;

Other hazards encountered overseas, mainly in the USA, include gas seepages near drill holes and the drying up of natural springs.

4.1 Physical damage

Seismic surveys are carried out before drilling to provide a three dimensional model of the rock structures underground. These survey lines may extend many tens of kilometres in a single year, and the total seismic coverage after a few years exploration is often over 100 kilometres. These survey lines must be cleared wide enough to allow the passage of very large all-terrain trucks. The use of numerous drill-holes and explosive charges to generate shock waves has largely been replaced by powerful 'thumper' equipment. Unlike the situation in the USA, there appears to be no effective regulations in NSW to require adequate and independent biodiversity surveys and no rules to prohibit seismic surveys during any wildlife breeding season.

A recent example of poorly executed surveys are the Pilliga East and Pilliga East Extension seismic surveys carried out for Eastern Star Gas Limited in Petroleum Exploration Licence 238 (PEL 238) in the East Pilliga State Forest south west of Narrabri. The Company announced to the Australian Stock Exchange on 3 April 2002 that the Pilliga East survey had been completed on 23rd March, and consisted of eight survey lines totalling 39.38 line-kilometres. At least part of this survey was described as "off-road". The announcement also stated that detailed cultural heritage, floral and faunal field studies had been completed. The extension survey, to the south-west, was completed by 3 May, and consisted of four new lines totalling 56.1 kilometres. A field inspection of the area (Yarraman Road west of the Newell Highway) by members of the local community on 4 July 2002 discovered an 800m section of survey line, about five metres wide, cut straight across an area of heathland vegetation locally known as 'broombush plains'. Detailed research has shown that this vegetation is the prime habitat for the rare and listed Pilliga Mouse (*Pseudomys pilligaensis*). An initial impact study should have identified this habitat and the survey line should have deviated to avoid the area. The community inspection found no indications of any attempt to minimise the impact or rehabilitate the swathe of bulldozed vegetation.

Drill sites

"The biggest disturbance associated with the development of a coal bed methane field is caused by the drilling of wells" (Clarke 1996).

Although drill sites for coal seam methane are not substantial by oil industry standards, they involve the total clearing and bulldozing of at least one hectare in size. Recent NSW examples indicate that no flora fauna or land stability surveys need to be carried out beforehand.

Several years after they have been abandoned, some of these drilling areas remain un-rehabilitated scars on the landscape – eg northern Pilliga Forests south west of Narrabri. Some six drill sites in the Bohena area and three additional sites elsewhere in the Pilliga East State Forest were cleared of all sub-soil and vegetation between June 1998 and mid-2000. Each site is at least one hectare in size and many still contain a large 'mud-pit' or dam to hold waste water and chemicals from the drilling operations. Even the earliest of these sites, which is over four years old has not been rehabilitated, the pits still contain coloured liquids, and there is no sign of any substantial vegetation regrowth. Most of these sites have been declared by the operating company to be abandoned. These sites were excavated and used by subsidiaries of Gastar Exploration Ltd of Michigan USA, either First Sourcenergy Group Inc or the associated Forcenergy Australia Pty Ltd. These companies hold the rights to any coal seam methane within PEL 238.

4.2 Groundwater Problems

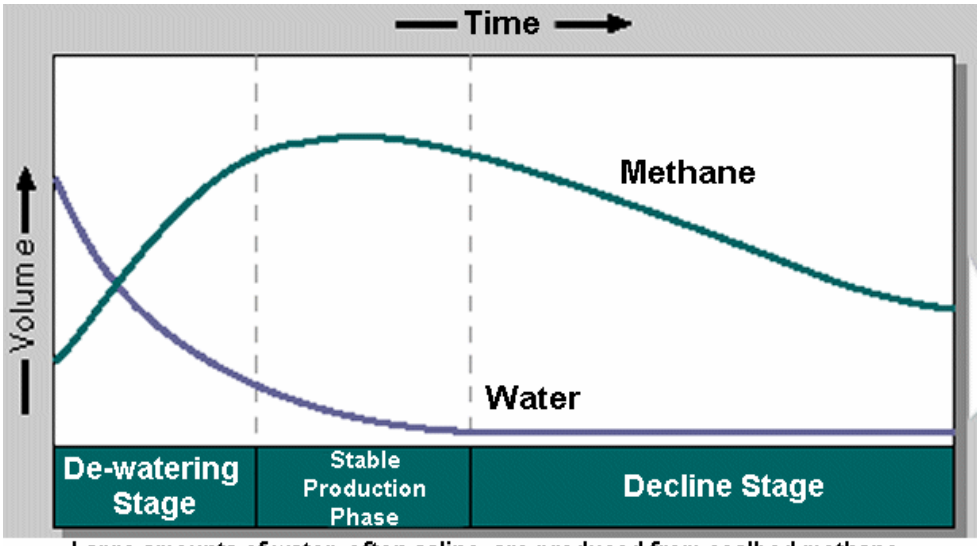
The disposal of co-produced water has proved to be the biggest environmental problem associated with exploitation of coal seam methane fields in the USA, although the quantity and quality of the water can vary enormously between coal basins. Stricter environmental regulations are making direct disposal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

In Australia, the water produced with hydrocarbon resources is often unsuitable for most domestic or agricultural purposes because of its high salinity. The presence of toxic or radioactive compounds has been largely ignored and unlike most European countries and the USA, tests for these substances do not appear to be routinely carried out in Australia. Total salinities range from about 1,000 milligrams per liter (mg/L; 1,000 milligrams equals 1 gram) to more than 400,000 mg/L. For comparison, the salinity of sea water is 35,000 mg/L and the U.S. EPA's recommended safe drinking-water limit is 500 mg/L **(**USGS Fact Sheet FS-003-97).

4.2.1 Groundwater Levels

In traditional or conventional petroleum wells, the oil or gas is produced over the life of the well, without much water. As soon as the oil or gas well starts to produce water it indicates that the main production period is over. By contrast, in coal seam methane wells the area around the well/drillhole is first drained of groundwater at the underground gas level. Only when the underground pressure is reduced, by removing the groundwater, will any significant amount of gas be produced. Once a number of gas wells have been dewatered and tested a decision may be made to produce gas on a commercial basis. At this time a production lease may be applied for and an environmental impact statement prepared. Large amounts of water are removed from the underground aquifers over the life of the gas field, mainly from the coal seams themselves. **This may lower the water table on a regional scale, and appropriate disposal methods must also be found for this groundwater**. The lowering of the water table, the possibly mixing of previously separate groundwater systems and the disposal of unwanted groundwater all begin within the exploration phase and under an exploration tenement – in New South Wales this is a Petroleum Exploration Licence or PEL.

In 2000 and 2001 the U.S. Government released a series of reports on the side effects of coal seam methane in the Powder River Basin (Rice 2000, Flores 2001). These dealt with the groundwater hazards, both the pollution by mineral-rich groundwater and the pollution of formerly clean groundwater by drilling and pumping activities. By far the most startling revelation is the prediction that within a decade or so, the groundwater level will plummet by 150 m (500 feet) below the current level.



Large amounts of water, often saline, are produced from coalbed methane wells, especially in the early stages.

In New South Wales, coal seam methane production has not been operating long enough to identify any similar changes to groundwater levels caused by dewatering coal seam methane drillholes. However, in the petroleum producing Cooper Basin in South Australia long term petroleum production has produced disturbing results. The producing horizons are very similar to the target horizons in the Pilliga region, that is, coal-bearing rocks of Permian age. In both areas this sequence is overlain by rocks of the Surat Basin, eg the Pilliga sandstones in the Pilliga region. Traditional theories have emphasised the separate nature of the older and younger rocks and also emphasised that lowering or interfering in any way with the deeper Permian aquifers would have absolutely no effect on shallower groundwater resources used widely by agriculture. The results from the Cooper Basin however show that previously unknown and unsuspected faults are acting as conduits allowing water to drain from the upper aquifers of the Artesian Basin into the previously separate lower, Permian layers.

Recent research at the Australian National University has shown that the underground water system of the Great Artesian Basin is still poorly understood. The Pilliga forests and areas to the south have long been regarded as very important recharge areas for the whole Basin. Rainwater falling in this area was thought to spread westwards underground and feed much of the Basin. Recent research (eg Lee 2001) has found that current recharge rates appear optimistic and current usage may be unsustainable. The area studied included the Bogan, Macquarie and Castlereagh Rivers catchments. The research indicated that the Great Artesian Basin was not a single connected unit, but appeared to be a series of almost separate groundwater systems.

Pollution of or lowering of the water table under this model would have a very severe effect over the surrounding district, rather than a smaller effect over the total basin.

4.2.2 Surface Pollution - Produced Water

'Produced water' includes all water produced by drilling, including ground water (or 'formation water') and water introduced by the drilling or testing operations The main type of pollution hazard associated with water produced during the extraction of coal seam methane is the high concentration of dissolved salts. Other possible pollutants include crude oil released by coal-bearing strata into the water in some coalfields. Experience in the USA has shown that it may take from two weeks to six months to completely dewater the area around one drill hole or well, and require the disposal of up to 350m^3/day of water. In contrast to traditional natural gas wells, water production tends to decline through the gas production period. However, water extraction usually does continue throughout the lifetime of the well and it is often necessary to dispose of significant quantities of co-produced water.

More water is produced in coal seam methane extraction than in traditional natural gas extraction. For example, coal seam methane contributes <2% of the total gas production in the USA but almost 13% of the water produced (10 million cubic metres per annum for coal seam methane wells). On average, for wells in the USA conventional (ie not associated with coal seam methane resources) natural gas yields about 0.13 cubic cm of water per cubic metre of gas, whereas coal seam methane produces about 1.74 cubic cm. This is about 13½ times as much water per unit volume of gas produced.

The concentration of total dissolved solids (TDS) ranges in coal seam methane produced waters from 500 mg/l to 27,000 mg/l in the eastern USA and 200-4,000 mg/l in the western USA.

Representative compositions of produced water associated with coal seam methane

Major components *mg/l*		**Trace elements & hydrocarbons** *µg/l*	
Total dissolved solids	4,000	silver (Ag)	1.1
		aluminium (Al)	40
chloride (Cl^-)	2,000	barium (Ba)	2,780
sulphate (SO_4^{2-})	12.9	cadmium (Cd)	5
bicarbonate (HCO_3^-)	597	chromium (Cr)	3
carbonate (CO_3^{2-})	0.008	copper (Cu)	5.6
fluoride (F^-)	2.6	mercury (Hg)	0.13
nitrate (NO_3^-)	3.0	lithium (Li)	92
iron (Fe)	10	manganese (Mn)	250
calcium (Ca)	89	nickel (Ni)	29
sodium (Na)	1,906	lead (Pb)	55
potassium (K)	7.5	antimony (Sb)	30
		selenium (Se)	25
pH	7.8	strontium (Sr)	4,000
		vanadium (V)	5
		zinc (Zn)	109
		total hydrocarbons	210

SALINITY AND SODIC SOILS

Salinity is a measure of the total concentration of all water-soluble salts in water and soil. Two important properties of salt affected soils are: (1) the quantity of soluble salts in the soil, and (2) the exchangeable-sodium percentage. On the basis of these values, the soil can be classed as:-

saline, which denotes excess soluble salts;
s**odic**, a term indicating that excess exchangeable sodium is found in the soil, and,
saline-sodic, which recognizes the presence of both conditions.

In Australia, sodic soils cover about 30% of agricultural land, or five times greater than the area of saline soil.

Sodium carbonate is a very common salt in groundwater in the eastern part of the Great Artesian Basin, and in rocks below the basin. Sodium carbonate has been used traditionally as washing soda, because it has the effect of loosening 'dirt' (by dispersing the clay particles) and removing or partially dissolving organic stains. When sodium carbonate builds up in soil, the same reactions take place. The clay particles dis-aggregate

forming either a slurry, when wet, or a hard impervious layer, when dry. Organic material is dissolved out of the soil helping to destroy the texture, making it a barren material for soil organisms. This dissolved vegetable remains in a soluble state and will re-dissolve whenever ther is enough moisture. The brief description below presents some aspects of the chemistry involved.

If carbonate is an important fraction of the accumulating salts, calcium and magnesium will be in low concentration because of their tendency to precipitate as very slightly soluble carbonates. Calcium carbonate solubility decreases with rising temperature, so precipitate build-up during summer may accelerate due to increased temperatures as well as increased evaporation. Similar to sodium increase, carbonate build-up in the soil can reduce hydraulic conductivity and decrease the downward movement of water.

Excess exchangeable sodium is harmful to plants principally because it produces undesirable physical and chemical conditions in soils. One result is the dispersion of clay, which lowers the permeability of the soil to air and water. Dispersion also results in the formation of dense, impenetrable surface crusts that greatly hinder the emergence of seedlings. Sodic soils low in neutral salts often have a pH as high as 10. **The high pH of sodic soils causes soil organic matter to dissolve. If the dissolved organic matter is carried upward by the capillary rise of water, it may be deposited as a dark incrustation on the surface of the soil.** When present, a dark-coloured surface film is usually indicative of a sodic-soil condition.

Salts such as calcium carbonate and calcium sulphate flocculate colloidal matter in soils. Saline-sodic soils therefore tend to appear deceptively in a better physical state than do non-saline-sodic soils. Under some circumstances, the pH of saline-sodic soils is no higher than 8.5 However, although neutral salts improve the physical state and lower the pH of sodic soils, they do not improve overall conditions for plant growth. If the salts are removed, as by leaching or precipitation, the characteristics associated with dispersed clay and a high pH quickly reappear.

BOHENA

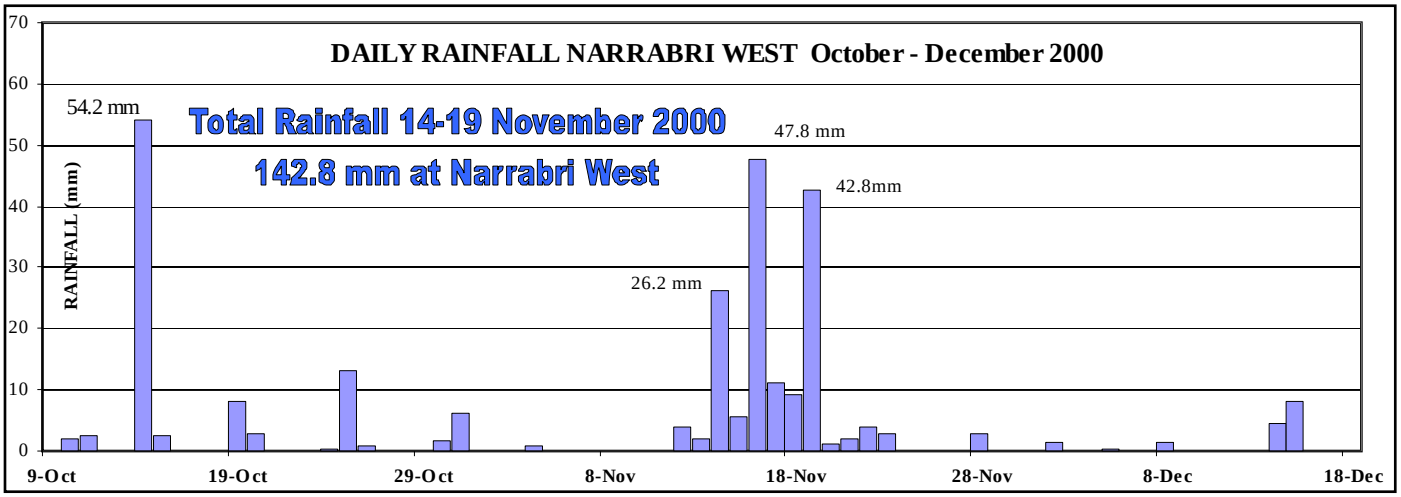
The Bohena No.2 drillsite in the northern Pilliga forest is an extreme case of sodic soil pollution as the direct result of careless exploration practices. Similar effects can also be seen at two other sites in the Bohena area. The Bohena gas prospect, sometimes known as the “Narrabri Gas Field”, is 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, mainly from coal seams. It originally had a spillway in the northeastern corner to drain off excess soda-rich water in to the surrounding forest which is in the catchment of Bohena Creek, a tributary of the Namoi River. Testing of gas-bearing sandstones and coals intersected by these wells continued into 2000. 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.. The debris from the dam wall break of late 2000 can be clearly seen south of the fence line. Pale coloured silt covers an area about 30m wide and 40m fanning out southwards from the repaired and enlarged dam wall.

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. At least as early as February 2001, trees adjacent to the site began to show signs of dieback, with dead and discoloured leaves. 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, or one third to one quarter that of sea water.

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.2site could be traced eastwards over distance of 250m and a maximum width of 100 metres. South east of the drill site most trees appeared lifeless, although a small amount of re-sprouting was visible for a short time on some of the larger trees. A lobe of dead vegetation extends northeastwards across a track for 100 metres.

Except for an area immediately below the break in the original dam wall, the surface litter in the present dead zone shows no sign of disturbance by a flood from the dam. It is probable that the current poisoning is being caused by percolating soda-rich fluids in the subsoil or shallow aquifers accessible to the tree and shrub roots. 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.

By July 2002, the trees again were leafless, and water levels in the dam had fallen, leaving a thick white crust.

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 (see website URL: http://www.powderriverbasin.org/). 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.

ORGANIC CHEMICALS

The methane targeted by coal seam methane projects has been formed during the maturation or 'coalification' of plant material over very long periods of time. This methane is thus produced as part of the same process that produces liquid hydrocarbons, and traces of hydrocarbon chemicals are usually present in the associated groundwater. Indeed, these traces are sometimes used in the hunt for oil fields.

Earlier this year (2002) it was announced (eg Sydney Morning Herald 23 March 2002) that the British Government was drawing up legislation to totally ban the surface disposal of water produced during oil and gas production, so-called 'production water'. Other European Governments were also considering similar measures, and Norway will ban the discharge of produced water by 2005. **The reason for this was the discovery that some aromatic hydrocarbons present in produced water from oil and gas wells had a devastating effect on the reproductive capacity of animals, in this case North Sea Cod.** This group of chemicals – *alkylphenols* (Meier et al. 2001) were previously not suspected of causing serious effects at very low concentrations, although at high concentrations they were known to have oestrogenic (feminising) effects on mammals, including humans, as well as several fish species. Tests have shown that even at the lowest level of detection – 0.02 parts per million, the effects could still be detected. Various other similar chemicals,

known collectively as polycyclic aromatic hydrocarbons, or PAH, have been shown to be carcenogenic and affect the immune response.

Unfortunately all the 'produced water' that has been disposed of from coal seam methane operations in New South Wales to date has been regarded merely as moderately salty water. No thorough analyses appear to have been carried out on this water. In the Pilliga it has been allowed to soak into the sub-soil, with severe effects on vegetation, while near Camden it has either been used to spray the local dirt roads, or diluted and sprayed on grazing land. All of this has taken place under exploration licences, not production licences.

5. OIL COMPANY DETAILS

EASTERN STAR GAS LIMITED

Directors

Dr. Wynford Davies	*Non-Executive Chairman*	*Mr. Dennis Morton*	*Managing Director*
Dr. David King	*Executive Director*	*Mr. Patrick Elliott*	*Non-Executive Director*
Mr. Douglas Battersby	*Non-Executive Director*		

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For further information contact:
Mr Dennis Morton *Managing Director*
Dr David King *Executive Director*

The Wilga Park-1, exploration well drilled in 1986 near Narrabri by Hartogen subsidiary Consolidated Petroleum, alerted the three foundation Eastern Star directors (Dennis Morton, David King and Doug Battersby — all then members of the Hartogen team) to the region's potential. These three formed a private syndicate to continue work in the PEL 238 permit, drilling Coonarah-1 in 1993. Eastern Star Gas was formed and subsequently listed on the Australian Stock Exchange in February 2001, with a portfolio that included a farm in arrangement to PEL 238. Since then Eastern Star Gas has earned a 20% interest in the permit by drilling three successful appraisal wells at Coonarah and recompleting a fourth. Eastern Star Gas is planning to acquire a 100% interest in PEL 238 subject to shareholder approval.
(from -*A star begins to rise in the east* By Rick Wilkinson, Oil & Gas Today an online publication of Media Dynamics Pty Ltd)

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AUSTRALIA:- First Sourcenergy Group Inc. Culgoora Road Narrabri NSW 2390

President, Thom Robinson; Directors - John Anthony Iannozzi, John William Parrott, Richard Kadasinski Geostar Corporation a private company of which John Parrott holds a 22% interest, is the controlling shareholder of Gastar, and the wholly owned subsidiary **First Sourcenergy Group Inc.**. Gastar Exploration Ltd is listed in Canada.

> "Gastar's dedication to a healthy, symbiotic relationship with the environment and the landowners influences our every decision. We welcome your comments and will be happy to address any additional concerns that you may have. Please email us at info@gastar.com for more information regarding this important topic."

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E-mail: resources@powderriverbasin.org Web Site URL: http://www.powderriverbasin.org/

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