

Advice to decision maker on coal seam gas development

Proposed action: Bowen Gas Project, Arrow Energy Pty Ltd – New Development

Requesting agency	The Queensland Department of Environment and Heritage Protection
Date of request	12 April 2013
Date request accepted	12 April 2013
Advice stage	Environment Impact Assessment (draft)
Summary of request from the regulator	<p>The Queensland Department of Environment and Heritage Protection (the Department) is currently assessing the proposed project in accordance with the <i>Environmental Protection Act 1994</i> (EP Act) and Bilateral Agreement with the Commonwealth.</p> <p>The Department notifies the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (the Committee) of an opportunity to comment on the draft Environmental Impact Statement (EIS). Specifically, the Department seeks the advice of the Committee on:</p> <p>Groundwater</p> <ol style="list-style-type: none"> 1) Does the EIS sufficiently address the potential for hydraulic stimulation to enhance interconnection of groundwater aquifers and adequately address the implications of such interconnection on groundwater quality and level? 2) Does the EIS sufficiently address the potential for interconnection of aquifers and/or coal seam gas contamination in target and non-target aquifers particularly at fault lines, with or without fracking? 3) Does the EIS provide sufficient details on groundwater impacts due to the project taking account of cumulative impacts incorporating coal and gas projects already operating in the location? <p>Surface water</p> <ol style="list-style-type: none"> 4) Are management of impacts on waterways and water quality sufficiently addressed in the EIS? 5) Does the EIS sufficiently address the management of saline groundwater extracted from the gas wells?

Advice

The Committee was requested to provide advice to the State Regulator on the Bowen Gas project – Arrow Energy Pty Ltd in Queensland at the draft Environmental Impact Statement stage. This advice draws upon aspects of information in the draft Environmental Impact Statement, together with the expert deliberations of the Committee. The relevant chapters of the draft Environmental Impact Statement are listed in the source documentation at the end of this advice.

The Bowen Gas project is a new coal seam gas field development covering an approximate area of 8000km² in Central Queensland. The proposed project tenements extend from Glenden in the north to Blackwater in the South. Arrow Energy Pty Ltd has planned for approximately 6625 production wells throughout the project area. The estimated co-produced water is approximately 264.3 billion litres. This is estimated to generate approximately 1.2 million tonnes of salt over the 40 year life of the project.

The Committee in line with its Information Guidelines¹ has considered whether the proposed project assessment has used the following:

Relevant data and information: key conclusions

Whilst the Committee appreciates that the project's assessment documentation is at a conceptual stage, there is insufficient information to provide confidence in the assessment of the potential the considerable risks associated with this project. It is imperative that additional substantiated information be provided and considered as part of the approval process, to enable scientific conclusions to be drawn.

The location of wells and infrastructure are not provided and detailed impacts at specific locations have not been assessed. The potential impacts associated with the project activities are assessed by the proponent against a reference case, rather than using project specific information.

There is a lack of information about hydrogeological characteristics and the presence of faulting within the project area, particularly at a local scale. The Committee has significant concerns regarding the lack of relevant data, field investigations and risk assessment around the role of faults within the groundwater impact assessment. No field studies were undertaken to collect site-specific groundwater data.

The surface water and ecological surveys conducted do not adequately address seasonal and temporal variability, and no field studies were undertaken to collect site-specific groundwater data. Further assessment must expand the field surveys to allow for thorough assessment of impacts to downstream ecosystems and ecological receptors, including Matters of National Environmental Significance (MNES).

Appropriate methodologies which have been applied correctly: key conclusions

Use of a Class 1 numerical groundwater model, at this stage of the proposal, does not allow for a sufficient level of confidence for predicting impacts.

An adequately substantiated Class 2 model would be more appropriate. The total predicted drawdown should be provided for each layer of the groundwater model and not limited to impacts which are greater than 5 m for consolidated aquifers, 2 m for unconsolidated aquifers, and 0.2 m for springs and spring-associated watercourses.

The proponent assumes that the Triassic Rewan Formation is a confining aquitard across the project area which will limit the potential for vertical aquifer interconnectivity between the Permian target coal measures and the shallower Tertiary and Quaternary aquifers. This conclusion is not congruent with the proponent's conceptual model, which shows coal measures in direct contact with alluvium in the western limb of the Bowen Basin.

Reasonable values and parameters in calculations

Parameters within the numerical groundwater model are based largely on literature values and engineering data. More detailed field validation of these parameters is needed, including a thorough sensitivity analysis of

the role of faults based on field data.

Question 1: Groundwater - Does the EIS sufficiently address the potential for hydraulic stimulation to enhance interconnection of groundwater aquifers and adequately address the implications of such interconnection on groundwater quality and level?

There is insufficient information on faulting and the location of proposed wells to be hydraulically stimulated to determine potential interconnectivity and its implications. The presence of many faults in the project area makes it difficult to determine the exact contribution of hydraulic stimulation to aquifer interconnection. To increase confidence in the assessment, the matters outlined below will need to be considered.

1. *EIS at the concept stage:* Whilst the Committee appreciates that the project's assessment documentation is at a conceptual stage, there is insufficient information, particularly in regard to faulting, to provide confidence in the assessment of the considerable potential risks associated with this project. It is imperative that additional substantiated information be understood and considered as part of the approval process, to enable robust scientific advice to be provided and conclusions to be drawn.
2. *Hydraulic stimulation near faults:* The potential for hydraulic stimulation to result in aquifer interconnection along faults cannot be adequately assessed when the proximity of potentially stimulated wells near faults is unknown and has associated high risks. The next version of the project's assessment documentation would be expected to contain an Execution Plan for hydraulic stimulation near known faults, detailing: well numbers, type and location; number of multi-seamed wells to be constructed; grid spacing; potential for multiple stimulation events; and details of chemical mixing and storage facilities. This information is required to assess whether the risks of this activity are adequately addressed and should also include a proposed Monitoring Plan.
3. *Groundwater conceptualisation and field studies:* The project's assessment documentation focuses predominantly on identifying broader regional-scale environmental sensitivities and development constraints and as such does not sufficiently address the potential groundwater impacts including localised aquifer interconnection, resulting from local-scale hydrogeological variations. The following recommendations are made to address these limitations:
 - a. Further conceptualisation of the groundwater processes is required to account for hydrogeological variation across the northern Bowen Basin. A single conceptual groundwater model cannot adequately account for variation across an 8000km² project area;
 - b. Groundwater field studies are required to collect site-specific data to substantiate the groundwater conceptualisation and inform the numerical model parameterisation. The current assessment relies only on existing data and literature to quantify the potential impacts to groundwater, including aquifer interconnection. The Committee advises that these field studies are necessary to characterise local scale impacts, verify the conceptualisation and establish a robust baseline and should not be deferred until post-approval monitoring and management.
4. *Interconnectivity risks:* Detailed consideration should be given to the risks for aquifer interconnectivity in the areas where the Rewan Formation is not present, particularly where the Blackwater Group subcrops and outcrops. The absence of the Rewan Formation may increase the risk of interconnectivity, drawdown and the mixing of groundwater especially where the target coal formations are in direct contact with alluvial aquifers.

Question 2: Groundwater - Does the EIS sufficiently address the potential for interconnection of aquifers and/or coal seam gas contamination in target and non-target aquifers particularly at fault lines, with or without fracturing?

The potential for aquifer interconnection is partly addressed in the response for Question 1 (above). The project's assessment documentation does not adequately address the role of faults on the interconnection of aquifers and on the potential for coal seam gas contamination. There is a potential for faults to play a role in aquifer interconnection. The Committee is concerned about the lack of relevant data, risk assessment, field

investigation on faulting, and the restricted treatment of faults within the numerical modelling. The Committee considers that the matters outlined below need to be addressed.

5. *Simplification of fault characteristics:* The project's assessment documentation has applied oversimplified assumptions when considering the potential for faults to impact and their contribution to aquifer interconnection and coal seam gas migration. The project area has a complex array of thrust faults but only major regional faults have been considered. A general assumption has been made that the faults are compressive and likely to result in compartmentalisation of groundwater. More detailed consideration is needed of the following issues:
- a. Sub-vertical faults and folds may provide preferential pathways for flow and allow groundwater aquifer interconnection;
 - b. Hydraulic stimulation, if not conducted correctly, that may allow fractures to propagate across, or along, faults and may provide conduits for water and gas to move vertically or laterally across faults and possibly into/from other geological formations;
 - c. Evidence to support the assumptions the faults will act as barriers to groundwater flow;
 - d. Faults that are seismically active should be avoided in all scenarios, rather than 'where possible' as suggested within the project's assessment documentation.
6. *Field Investigation of faults:* A thorough site-specific field investigation of fault zones, particularly those that are seismically active or have a high pressure differential, needs to be undertaken. The role of faulting and igneous intrusions (e.g. Tertiary basaltic dykes also have the potential to provide preferential pathways) and their influence on vertical conductivities and connectivity require more detail to understand the risks involved. There is a significant concern that such aquifer interconnection could result in the movement of water from the shallower quaternary alluvial and tertiary sedimentary aquifers towards depressurised coal seams. The Great Artesian Basin Water Resource Assessment provides examples that would assist with understanding the level of complexity involved in the consideration of connectivity within faulted systems.
7. *Subsidence and induced seismicity:* Quantification of groundwater movement as a result of subsidence and induced seismicity is required, as there is potential to open up preferential pathways for gas migration and interconnection of aquifers through increased geological fracturing and damage to infrastructure (e.g. production wells and monitoring wells). Potential for subsidence exists due to the depressurisation associated with the estimated removal of approximately 264 billion litres of associated water from the target coal seam. The EIS provides a limited overview of the issues and therefore does not adequately assess the potential impacts.

Question 3: Groundwater - Does the EIS provide sufficient details on groundwater impacts due to the project taking account of cumulative impacts incorporating coal and gas projects already operating in the location?

The cumulative groundwater impacts of coal and gas projects operating within the northern Bowen Basin are not sufficiently addressed within the EIS. The Committee has concerns regarding the limited inclusion of cumulative data within the numerical groundwater model and the resultant uncertainty of the model in predicting the drawdown from the development. These concerns are discussed in the points below.

8. The cumulative case scenario within the groundwater numerical model is limited to the data from the Arrow Moranbah Gas project and the Water Entitlements Registration Database and does not include consideration of the existence of more than 40 mines within the region. The long-term sustainability of groundwater resources in the region requires careful consideration given the operation of significant large coal mines and the relatively scarce groundwater resource.
9. Further refinement of the groundwater numerical model is required to better delineate potential impacts to regional groundwater. This includes, but is not limited to:
 - a. Use of a Class 1 numerical model does not allow for a sufficient level of confidence for predicting

impacts this stage of the proposal. An adequately substantiated Class 2 model would be more appropriate;

- b. The total predicted drawdown should be provided for each layer of the model and not limited to impacts which are greater than 5 m for consolidated aquifers, 2 m for unconsolidated aquifers, and 0.2 m for springs and spring-associated watercourses. Predictions of total drawdown are required to adequately assess potential impacts to water resources, particularly given the large number of developments within the region;
- c. There is potential for single phase flow modelled hydrographs to significantly underestimate actual drawdown at a well. Whilst a two phase flow numerical model (i.e. water and gas) is desirable, the project's assessment documentation should at a minimum verify the results of single phase flow modelled hydrographs;
- d. There is a need to accurately assess the potential for the contribution of future developments to ongoing consumption of groundwater resources in the region;
- e. Field validation of the model parameters is needed to verify assumptions and literature based values. It is noted, given the limited data available, that values of specific storage were generalised across the project area.

10. As indicated in the Arrow – Surat Gas project advice (2010/5344), the Committee advises that the cumulative impact assessment needs to be based on an adequate information set, including site and regional water balances. The Arrow Bowen Gas Project would reasonably be expected to contribute to cumulative impacts. There is limited information provided to determine the project's contribution to cumulative impacts, including impacts to MNES from changes to hydrology and water quality.

11. Given the large number of developments across the region, a cumulative impact assessment of well integrity is needed to enable adequate assessment of potential impacts at a regional scale and to determine appropriate mitigation measures. The Committee considers that well failure during construction, operation and decommissioning phases of the project has the potential to cause aquifer interconnectivity. With up to 6,625 wells being proposed, even a 1% failure rate has the potential to significantly impact on aquifer integrity in the region. The Committee considers that a risk assessment of well integrity is required to enable potential impacts at a regional scale to be adequately determined. This should consider mitigation measures, maintenance, and decommissioning, consistent with the Code of Practice for Constructing and Abandoning Coal Seam Gas Wells in Queensland. The Regulator may need to ensure that there are appropriate measures to deal with issues associated with legacy bores, a matter most relevant for CSG proposals given the quantum of wells being proposed by industry. This is compounded by the potential for a large number of coal exploration bores not being correctly plugged and abandoned, which could provide a conduit for gas migration.

Question 4: Surface Water - Are management of impacts on waterways and water quality sufficiently addressed in the EIS?

Whilst a methodical process was used to review the potential impacts to terrestrial and aquatic ecosystems, the assessment of impacts to waterways is not sufficient to enable a thorough consideration of project-induced impacts to the receiving waters primarily due to limitations with the surface water and aquatic ecosystem surveys and the lack of water balance modelling. Further information is needed to address the potential impacts to waterways as discussed in the points below.

12. Both a site-specific and a regional water balance model are needed to enable an assessment of changes to water resources. The project's assessment documentation commits to developing a water balance model in future phases, but the Committee recommends that this is needed in the current phase as part of the project's assessment.

13. Sampling locations were determined in the absence of the known location of infrastructure, as the project

is currently in the conceptual phase (as discussed in Question 1). The project's assessment documentation should be revised when the location of infrastructure is known to determine whether the locations of sampling points used for base-line characterisation adequately identify baseline environmental values. In addition, to ensure that adequate mitigation and management measures are developed, it would be appropriate to consider: location and sizing of water management infrastructure; discharge point locations; and discharge water quality, discharge scenarios, timings and volumes.

14. To provide confidence that potential impacts will be managed effectively, the initial field survey program of surface water, aquatic ecology and future monitoring programs needs to be supplemented with further information, including:
- a. Additional sampling of surface water and aquatic ecosystems to increase understanding of the spatial, seasonal and temporal variability of the baseline data. The current survey included only 22 surface water and 15 aquatic ecology field-sampling sites to represent a project area of 8000 km² with at least four large sub-catchments. Although a number of sampling events occurred from October 2011 to May 2012, not all sites were sampled on each occasion and this represents a relatively short period to assess seasonal and temporal variations;
 - b. Additional sampling should ensure that waterways that are potentially affected by groundwater drawdown, subsidence and fugitive gas emissions are represented within baseline surveys and that these waterways have water level and/or volume monitored. Additional sampling to characterise the geology and fluvial geomorphology of waterways that are groundwater fed is also required;
 - c. Baseline sampling of groundwater and surface water, prior to the hydraulic stimulation process, should include an analysis of the hydraulic stimulation chemicals. This will enable an appropriate assessment of the contribution of chemical spill events to groundwater and surface water contamination.
 - d. Baseline sampling points should be located away from highly disturbed areas such as large bridge structures, and the lengths of surveyed stretches of river need to be sufficient to gain an understanding of the downstream extent of changes that may take place if the project was to become operational. Where future monitoring site locations differ from existing baseline sampling locations, monitoring should commence prior to the construction phase to enable characterisation of baseline conditions in these waterways. At a minimum, the parameters tested in the baseline characterisation programs for aquatic ecology, terrestrial ecology (wetlands) and surface water should be included in the monitoring programs, along with testing for chemicals used in the hydraulic stimulation process;
 - e. The definition of waterway type adopted (e.g. ephemeral) needs to be consistent with published literature (e.g. *Kennard et al. 2010*) and baseline gauge data should be reviewed in this context. The project's assessment documentation uses inconsistent definitions to classify waterways when allocating a sensitivity status, with some waterways being classified as "small permanent / semi permanent waterbodies" in one section and then "ephemeral" in another section;
 - f. The monitoring program should be developed with reference to AusRivAS, the Australian Guidelines for Water Quality Monitoring and Reporting and should provide details of other accepted methods/standard practices to be utilised. It should continue throughout the project's operational phase and should not be limited to periods of discharge. The placement of monitoring locations should inform both the point of discharge impact and the extent of the impact/mixing zones for discharged substances;
 - g. Targets and trigger values for intervention should be identified and incorporated into the Environmental Management Plan. The Committee recommends that the setting of trigger values should be provided within the EIS as a preventative measure, rather than relying on reactive measures based on breaches of water quality or other environmental performance objectives.
15. The project's assessment documentation should provide additional assurance that impacts on surface waters arising from uncontrolled release of contaminants will be avoided, through:

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- a. All coal seam gas water, and treatment facilities, and fuel and chemical storage and handling facilities being sited above the 1:1000 year average recurrence interval water level;
 - b. All drilling sumps being lined and managed to prevent overflow;
 - c. Stormwater runoff from disturbed areas, chemical storage, and vehicle wash down, refuelling, and maintenance areas not being allowed to discharge to receiving waterways without treatment to remove sediment, hydrocarbons and/or other contaminants.

Question 5: Surface Water - Does the EIS sufficiently address the management of saline groundwater extracted from the gas wells?

The management of saline groundwater (co-produced water) is not sufficiently addressed within the project's assessment documentation, largely as the management plan is based on a conceptual layout and hypothetical treatment strategies. A broad concept is presented which proposes a system of pipelines, aggregation dams, water treatment, permeate storage and disposal, and brine management. The specific location of these facilities is unknown, with only a tentative indication of the area where each grouping of facilities will be sited. Recommendations to address the lack of detail are provided in the points below.

16. The proposed project will produce an estimated 264 billion litres of co-produced water with a predicted 4.5 tonnes of salt per million litres of water. This equates to approximately 1.2 million tonnes of salt over the project life. Given these significant volumes, the Committee is concerned that the management of this water and the residual brine/salt products, are addressed only at the conceptual level. Further detail is required to ensure that risks are adequately characterised and mitigated and are not deferred until later phases, including:
- a. A detailed plan for the management of co-produced water which incorporates the proposed location of water treatment infrastructure. The project's assessment documentation provides a range of options for the management of the treated water and residual brine/salt products that range from beneficial reuse, aquifer injection trials to potential discharge to waterways. Each of these options requires additional work to determine feasibility or identify commercial arrangements;
 - b. Design details for the water storage and brine dams are not provided and are required to assess capacity, the risk of leakage, breakage and overtopping, and the consequences to downstream aquatic ecosystems and receptors. In addition, a more accurate estimate of co-produced water production rates at each of the aggregation points is required to inform the development of design criteria for dam sizing. These criteria should include consideration of rainfall and flood events, contingency storage requirements and potential discharge scenarios;
 - c. Reverse Osmosis (RO) is outlined as the preferred treatment technology but further information is required on the anticipated efficiency rate, RO plant breakdown contingency plans, any pre-RO treatment required, and the quality of co-produced water and any treatment required prior to discharge to receiving waters. The impacts discharging water that is better quality than the receiving water also needs to be considered;
 - d. The specific in-built safety or monitoring systems within gathering lines to prevent and detect leaks and spills need to be outlined. Consideration should be given to gathering lines being remotely monitored for leaks and spills so that affected pipelines can be remotely shut off to minimise the amount of co-produced water lost in each event. The project's assessment documentation outlines that an emergency response plan will be prepared and the Committee suggests that this plan be developed and endorsed prior to a determination on the project;
 - e. A program of water quality sampling of co-produced water is undertaken in locations representative of those that will feed into each Integrated Processing Facility to ensure that the quality of CSG water does not differ significantly from estimated values. This information should then influence the design of each water treatment facility to ensure appropriate storage capacity is available for treated co-produced

water products.

17. The management options for co-produced water include discharge to the environment and the EIS states that an environmental impact assessment for this activity will be undertaken at a later phase of project development. The Committee recommends that:

- a. This assessment is not delayed and is necessary information for project assessment and provision at a later stage may lead to sub-optimal siting of discharge points and may reduce or preclude options for minimising or mitigating impacts on receiving waters;
- b. As no beneficial use for treated water or residual brine has been confirmed, the Committee considers that a precautionary approach to discharge should be adopted and that a range of discharge scenarios should be incorporated into the next version of the project's assessment documentation;
- c. Suitable mitigation and management measures should also be developed and incorporated into the next version of the project's assessment documentation according to the location, timing and volume of discharge.

Date of advice 24 May 2013

Source documentation available to the Committee in the formulation of this advice Arrow Energy Pty Ltd, 2013, The Bowen Gas project Environmental Impact Statement.

References cited within the Committee's advice ¹Information Guidelines for Proposals Relating to the Development of Coal Seam Gas and Large Coal Mines where there is a Significant Impact on Water Resources available at: <http://www.environment.gov.au.au/coal-seam-gas-mining/project-advice/pubs/iesc-information-guidelines.pdf>

Kennard, M.J. *et. al*, 2010, Classification of Natural Flow Regimes in Australia to Support Environmental Flow Management

CSIRO, 2013. Great Artesian Basin Water Resource Assessment available at: <http://www.csiro.au/Organisation-Structure/Flagships/Water-for-a-Healthy-Country-Flagship/Sustainable-Yields-Projects/Great-Artesian-Basin-Assessment.aspx>
