ADVICE IN RELATION TO THE POTENTIAL IMPACTS OF COAL SEAM GAS EXTRACTION IN THE SURAT AND BOWEN BASINS, QUEENSLAND

Phase One Final Report

for

AUSTRALIAN GOVERNMENT

DEPARTMENT OF THE ENVIRONMENT,

WATER, HERITAGE AND THE ARTS

provided by

Geoscience Australia and Dr M.A. Habermehl

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Executive Summary

Geoscience Australia (GA) and Dr M.A. Habermehl have been contracted by the Australian Government Department of Environment, Water, Heritage and the Arts (DEWHA) to provide expert advice in relation to the likely groundwater impacts of proposed and potential future Coal Seam Gas (CSG) extraction activities in the Surat and Bowen Basins, Queensland by Australia Pacific (APLNG), Queensland Gas Company/British Gas (Queensland Curtis LNG - QCLNG) and Santos Limited (Gladstone LNG - GLNG).

We have reviewed the content of the Environmental Impact Statements and supporting documentation put forward by the three proponents, along with subsequent additional data and information, supplemented by discussions with the proponents. Based on this information, we consider that, while the Environmental Impact Statements relating to proposed and potential future CSG extraction activities in the Surat and Bowen Basins, Queensland identify and assess a number of potential local scale (project area) groundwater related impacts, there are some matters that require further consideration under the *Environment, Protection and Biodiversity Conservation (EPBC) Act 1999*.

We recognise that a number of the shortfalls we have identified can be addressed through the provision of information and modelling developed by the proponents subsequent to the submission of the EIS, and through the collection of additional information and data in the context of an adaptive management approach. However, we consider that the overriding issue in CSG development is the uncertainty surrounding the potential cumulative, regional scale impacts of multiple developments. The information provided in the assessed EIS documents is not suitable for understanding the likely impacts of widespread CSG development across the Surat and Bowen Basins. This necessitates the development of a regional-scale, multilayer groundwater flow model that incorporates data from both private and public sector sources. We emphasise, however, that any modelled outcomes will be accompanied by high inherent uncertainties until sufficient CSG production data is available to calibrate the groundwater model.

The following summarises our assessment of the proposed projects according to the issues requested for specific evaluation. We emphasise that this assessment relates to the potential impacts of individual operations on the identified issues and does not consider the likely impacts of multiple CSG operations.

The adequacy of the proponents' hydrogeological models for estimating hydrogeological impacts on and within the Great Artesian Basin (GAB) and other affected surface and groundwater systems (this would include an initial assessment of the potential of one or more aquifers to depressurise and dewater and the likely impacts).

- Within the limitations of available data, the 'project-scale' models produced by all the proponents are suitable as a preliminary basis for estimating hydrogeological impacts on and within the GAB and other potentially affected surface and groundwater systems within the influence of the proposed operations. We have, however, noted a number of shortfalls in the modelling approaches taken by each proponent.

- The modelling results reported require further work to fully establish the uncertainties and sensitivity of the models to the large predicted drawdowns that will occur in the coal

measures, and hence does not provide a level of confidence in the model outputs and the conclusions drawn from them.

- APLNG's 'cumulative' model represents a useful preliminary assessment of potential regional hydrogeological impacts resulting from a range of groundwater extraction activities, and provides a good starting point for development of a regional model to underpin groundwater impact prediction and management.

- The project and regional scale models presented provide useful preliminary assessments of potential hydrogeological impacts resulting from a range of groundwater extraction activities. We understand that the proponents are in the process of developing new models or refining the existing models.

Potential impacts of groundwater extraction on aquifer interaction (e.g. water flow, cross contamination), vertical recharge, structural integrity and artesian pressure as a result of the CSG activities. This applies to both quantity and quality of groundwater.

Potential impacts of groundwater extraction on aquifer interaction have, in general, been adequately addressed with, while there is scope for further elaboration regarding some aspects. Based upon consideration of the hydrogeological, geological and project development information provided in individual proposals, we conclude that:

- The modelled vertical recharge and artesian pressure changes resulting from coal seam depressurisation are realistic and likely to result in groundwater flow into the coal measures from adjacent aquifers. We consider that these changes will be reversible over medium to long term timeframes (decades to centuries), depending on the specific aquifer and the management strategies applied.

- Cross-contamination is likely to be of little consequence as the majority of inter-aquifer transfer will involve the migration of higher quality water from adjacent underlying and overlying sandstone aquifers into coal measures.

- The structural integrity of aquifers in relation to groundwater transmission is unlikely to be significantly impacted by the proposed groundwater extraction. We note that groundwater extraction may cause some aquifer compaction that is likely to result in subsidence (as identified by the proponents and discussed below).

Potential impacts of groundwater extraction on the EPBC Act listed endangered ecological community 'The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin.'

Based upon consideration of the hydrogeological, environmental and management information provided, we agree with APLNG and QGC that the risk of impact from groundwater extraction in individual operations to the EPBC Act listed endangered ecological community '*The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin*' is low, based on the following:

- With one exception, documented and/or surveyed natural discharge sites (springs) are located outside the CSG fields and the modelled zones of groundwater drawdown.

- Proposed monitoring programs are likely to enable detection of potentially deleterious changes to groundwater level or quality.

- Proposed controls on the location and construction of infrastructure would avoid physical impacts on environments suitable for hosting EPBC Act listed communities.

- A small number of additional natural discharge sites proximal to the CSG fields may need to be investigated and assessed to determine their EPBC Act significance.

Based upon consideration of the hydrogeological, environmental and management information provided, we suggest that Santos consider further investigations to fully assess the risk of impact from groundwater extraction to the EPBC Act listed endangered ecological community '*The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin*'. Our assessment is based on the following:

- A number of surveyed and unsurveyed natural groundwater discharge sites (springs) proximal to the Santos CSG fields require assessment to determine their EPBC Act significance.

- Proposed monitoring programs do not state how trigger levels will be acted upon with regards to mitigating changes to groundwater flow or quality in springs.

Potential for recharge into the GAB to be impacted in these areas due to CSG activities and the likely long-term impact(s).

- A reduction in pressure due to water extraction down-gradient of the GAB aquifer intake beds will not affect the rate of recharge.

- We consider that proposed infrastructure located within the intake beds of the GAB in unlikely to significantly reduce the amount of groundwater recharge.

- There is currently insufficient information to understand the relative significance of the proposed CSG activities in proportion to recharge to individual GAB aquifers. We consider that the total proposed annual extraction volumes may represent a moderate proportion of annual recharge to the GAB in the project areas, but that this represents a relatively small proportion of total recharge to the GAB. Detailed water balance modelling is required to quantify these relative volumes.

- We note that however, that while individual operations may not represent a significant potential impact to overall GAB recharge, if similar extraction volumes were to occur from a number of CSG developments, GAB recharge could be significantly impacted. In such a scenario, we consider that a reduction in recharge volumes basinward of the CSG

developments could result in reduced artesian pressures and potential impacts on EPBC Act significant spring communities further afield from the developments.

- We are unaware of any existing data or modelling results that would be suitable for assessing the likelihood or potential timeframes for such impacts, although groundwater movement rates in deeper GAB aquifers suggest that any impact (and recovery) would be extremely long term (i.e. occurring over many thousands of years or more).

Potential impacts of fraccing on the structural integrity of aquifers and aquitards, and on existing groundwater flow processes.

Based upon the geological and technical information provided by the proponents with regards to the potential impacts of hydraulic fracturing ('fraccing'), we consider that the potential risks posed by fraccing are low. We conclude that:

- While the potential for fraccing activities to impact on the structural integrity of aquifers and aquitards, and on existing groundwater flow processes, can never be completely eliminated, the competent application of industry standard technologies, techniques, and monitoring/mitigation measures proposed by each proponent are considered appropriate for minimising the risk.

- All proponents have adequately assessed any potential risks associated with fraccing activities and have proposed appropriate monitoring and mitigation measures.

Initial advice on the likelihood and materiality of subsidence as the result of the proposals.

Based upon our assessment of the geological and geotechnical information provided, and relevant information from other sources, we agree with the proponents that there is a likelihood of subsidence, and that this could result in several centimetres of surface subsidence.

However, based on the estimated magnitude of the subsidence (in the order or centimetres to tens of centimetres), and with reference to subsidence assessments for CSG activities in similar geological environments elsewhere, we consider that the risk of impacts to surface water and shallow groundwater systems are very low.

We suggest that the monitoring measures currently proposed by the APLNG and Santos could be strengthened by assessing deformation at the land surface as well as in the aquifers and coal seams.

We suggest that the monitoring measures currently proposed by QGC, which assess both surface and sub-surface deformation are appropriate and could be value-added by linking into a regional program of monitoring lead by the relevant State Government agency.

Initial advice on the likelihood and materiality of any impact on MDB groundwater or connected surface water resources.

On the basis of the available information, we consider that there is a limited likelihood of impact on

MDB groundwater or connected surface water resources as a result of any of the proposed individual operations.

This assessment is based primarily on information suggesting that the only a small number of proposed CSG tenements are proximal to the Condamine River Valley and are located in an area where there is no known hydraulic connection between the Walloon Coal Measures (which will undergo depressurisation) and alluvial aquifers.

Initial advice on potential cumulative impacts on the issues above

While all proponents identify the issue of cumulative impacts of groundwater extraction activities in the region, only APLNG and Santos have attempted to quantify this.

We consider that these cumulative impact assessments are unavoidably inadequate due to the inability of individual proponents to access commercial-in-confidence data from a number of sources. We do not consider, however, that individual proponents are in a position to develop regional scale models that incorporate confidential drilling and production data from other sources.

We consider that the successful long-term monitoring and management of groundwater resources and groundwater-dependent EPBC communities dependent on natural discharge of groundwater from the GAB should be based on a comprehensive regional groundwater simulation model developed using all available data.

Recommendations

Although we consider that a number of the issues requested by DEWHA have not been fully addressed by the material within the EISs, we note that in many cases the necessary information relating to the impacts of individual operations has either been developed since the submission of the EISs, or can be acquired in the course of subsequent development under an explicit adaptive management strategy. We have noted that the current groundwater modelling is inadequate in terms of scale and detail to address the impacts of multiple CSG developments on groundwater interactions in the GAB and hence on EPBC listed discharge springs communities in the GAB. However, if the following recommendations are implemented, it should be possible to manage the potential groundwater impacts of proposed and potential future CSG extraction activities in the Surat and Bowen Basin, and minimise the risk of unintentional outcomes for the Great Artesian Basin.

We thus make the following key recommendations for a staged process of adaptive management of CSG development.

1. Management of uncertainty

Given the resulting levels of uncertainty in relation to cumulative impacts at the regional scale of a number of CSG developments, a precautionary approach should be taken in relation to approving proposed and potential CSG developments, recognising the fundamental principle that excessive rates of groundwater extraction will have impacts on groundwater and connected surface water systems, and groundwater dependent values such as EPBC listed discharge springs communities in

the GAB groundwater dependent ecosystems.

In the absence of sufficient evidence to characterise and quantify these potential impacts or to define excessive rates of extraction, we recommend that proposed and potential CSG development should be undertaken with an explicit requirement to minimise and mitigate any impacts during production.

2. Refinement of existing models as an initial basis for development

We have noted a number of shortfalls in the models presented in the EISs, but consider that overall these models provide useful preliminary assessments of potential hydrogeological impacts resulting from a range of groundwater extraction activities.

We recommend that the predictions of these models could serve as a preliminary basis for informing initial decisions about the approval of the CSG developments, pending a positive assessment of the validity and implications of the new models we understand have been developed by the proponents since the submission of the EISs.

3. Modelling regional scale impacts of cumulative CSG developments

We consider that the proponents have, for the most part, proposed appropriate mitigation measures to address the short term, local scale impacts of groundwater extraction on groundwater users. However, it is not clear that the measures proposed in the individual proponents' proposals will be adequate to fully address regional scale impacts on EPBC values or aquifer interactions.

We recommend that a regional-scale, multi-state and multi-layer model of the cumulative effects of multiple developments, and a regional-scale monitoring and mitigation approach will be developed to assess and manage these impacts. Such a model could be used to set the parameters for an adaptive management framework in which monitoring and mitigation strategies can be developed that will be applicable at both the project and regional scale. We consider that concerted Commonwealth and State action will be necessary to develop such a model as a high priority.

4. Management of long-term water balance impacts

We emphasise that any groundwater model, no matter how well-parameterised, calibrated and validated, is an interpretation of a groundwater system, and therefore subject to uncertainty. Given that there are shortfalls in the parameterisation and calibration of the models presented in the EISs, we consider that there are high levels of uncertainty in the accuracy of the predicted impacts of CSG development on groundwater behaviour and on EPBC listed ecological communities dependent on discharge from the GAB.

For this reason, **we recommend that measures to mitigate the potential impacts of proposed operations on water balances, such as the re-injection of treated associated water back into appropriate permeable formation(s) to re-establish pre-development pressure levels, be explored as an option and considered as a condition for approval of any development activities.** This needs to be undertaken in conjunction with appropriate measures to forecast and proactively manage any short term impacts, and should enable the reversal of any medium to long term changes in artesian groundwater pressures before they could impact on EPBC listed discharge communities. The design

of and volumes involved in these activities should be informed by a regional-scale groundwater model.

1. Background Information

1.1 Request for Services

Geoscience Australia (GA) and Dr M.A. Habermehl have been contracted by the Australian Government Department of Environment, Water, Heritage and the Arts (DEWHA) to provide expert advice in relation to the likely groundwater impacts of proposed and potential future Coal Seam Gas (CSG) extraction activities in the Surat and Bowen Basins, Queensland.

The scope of services detailed in the Project contract is specified as follows:

GA and Dr M.A. Habermehl will provide advice in relation to the likely impacts of proposed and potential future CSG extraction activities. Specific advice will be provided on the potential impacts of the proposed gas field activity on the Great Artesian Basin (GAB) as it relates to matters protected under the *Environment, Protection and Biodiversity Conservation Act 1999* (EPBC Act) and *Water Act 2007*. This includes:

- Potential impacts of groundwater extraction on the EPBC Act listed endangered ecological community 'The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin';

- Potential impacts of groundwater extraction on aquifer interaction (e.g. water flow, cross contamination), vertical recharge, structural integrity and artesian pressure as a result of the CSG activities. This applies to both quantity and quality of groundwater;

- Potential impacts of fraccing on the structural integrity of aquifers and aquitards, and on existing groundwater flow processes; and

- Potential for recharge into the GAB to be impacted in these areas due to CSG activities and the likely long-term impact(s).

GA and Dr M.A. Habermehl will also review specific information provided by project proponents regarding the likely impacts of their proposed activities on groundwater values including those detailed above.

The Services to be provided by GA and Dr M.A. Habermehl are described below:

1. Review the groundwater information and modelling of Australian Pacific LNG, Queensland Gas Company (British Gas) and Santos.

2. Provide a written assessment regarding:

- the extent to which risks of significant impacts to the GAB and other affected surface and groundwater systems are identified and assessed in the available documentation. Where any risks are not adequately identified and assessed, please provide initial advice on what further data or analysis is required and what steps would be needed to obtain the necessary data or analysis (including timeframes).

- the extent to which the measures and conditions proposed by the proponent and Queensland in relation to the GAB and other affected surface and groundwater systems can be regarded as adequately mitigating those risks. If your initial analysis suggests that risks will not be mitigated adequately, what other measures or requirements are potentially available to mitigate these risks and what further data or analysis is needed to reach a fully informed view?

- the adequacy of the proponents' hydro-geological models for estimating hydro-geological impacts on and within the GAB and other affected surface and groundwater systems (this would include an initial assessment of the potential of one or more aquifers to depressurise and dewater and the likely impacts);

- any further questions that should be put to the proponents or QDERM concerning hydrological or water quality impacts on groundwater and surface water systems as would affect matters of NES;

- initial advice on the likelihood and materiality of any impact on MDB groundwater or connected surface water resources;

- initial advice on the likelihood and materiality of subsidence as the result of the proposals;

- any questions that should be put to the proponents or QDERM concerning MDB system impacts.

- a work plan and budget for undertaking additional work to fill the critical information gaps, taking into account synergies with the Great Artesian Water Resources Assessment being conducted jointly by GA and CSIRO.

1.2 This Report

This report represents the final deliverable under Phase One of the Project "Provision of advice in relation to the potential impacts of coal seam gas extraction activities in the Surat and Bowen Basin, Queensland" in relation to potential impacts on *Environment, Protection and Biodiversity Conservation Act 1999* (EPBC Act) and *Water Act 2007* matters, and provides a detailed assessment and advice regarding the overall likely impacts of proposed CSG activities based on the review of material provided to GA and Dr M.A. Habermehl. This report also scopes further work required.

The advice contained herein has focused on reviewing the hydrogeological and groundwater-related management information in the Environmental Impact Statements (EIS) and related Appendices and Supplements put forward by the project proponents – Australia Pacific (APLNG), Queensland Gas Company (British Gas) - (Queensland Curtis LNG - QCLNG) and Santos (Santos Limited – Gladstone GLNG) relating to proposed CSG developments in the Surat and Bowen Basins, Queensland (Fig. 1.2-1).

The full range of documents referred to in the assessment is detailed in Appendix 2. The quantity and range of documents reviewed in order to provide the requested assessment is significantly greater than that initially specified in the Project Scope provided by DEWHA as additional EIS documentation needed to be examined and the three proponents provided significant further written material and responses to written questions and discussions at meetings during the review period.

In addition, GA and Dr M.A. Habermehl have completed this assessment in the knowledge that:

- The content of the documents reviewed may be up to 18 months old, and in many cases may have been superseded.
- Queensland Government (Qld DERM) and several of the proponents have proposed or initiated additional investigations and modelling; the timeframes for completion and delivery of these products are not compatible with the Phase One assessment process.

Additional and updated material has been almost continuously delivered to GA and Dr M.A. Habermehl by the proponents and DEWHA during the review process. In order to provide an assessment within the timeframes (17 September 2010) specified by DEWHA a cut-off date of 3 September 2010 has been imposed, although an additional meeting with the proponents and GA and Dr M.A. Habermehl was held on 10 September 2010, following an earlier meeting on 23 August 2010. This means that only documentation or data specifically requested after 3 September 2010 has been taken into account in the assessment presented here.

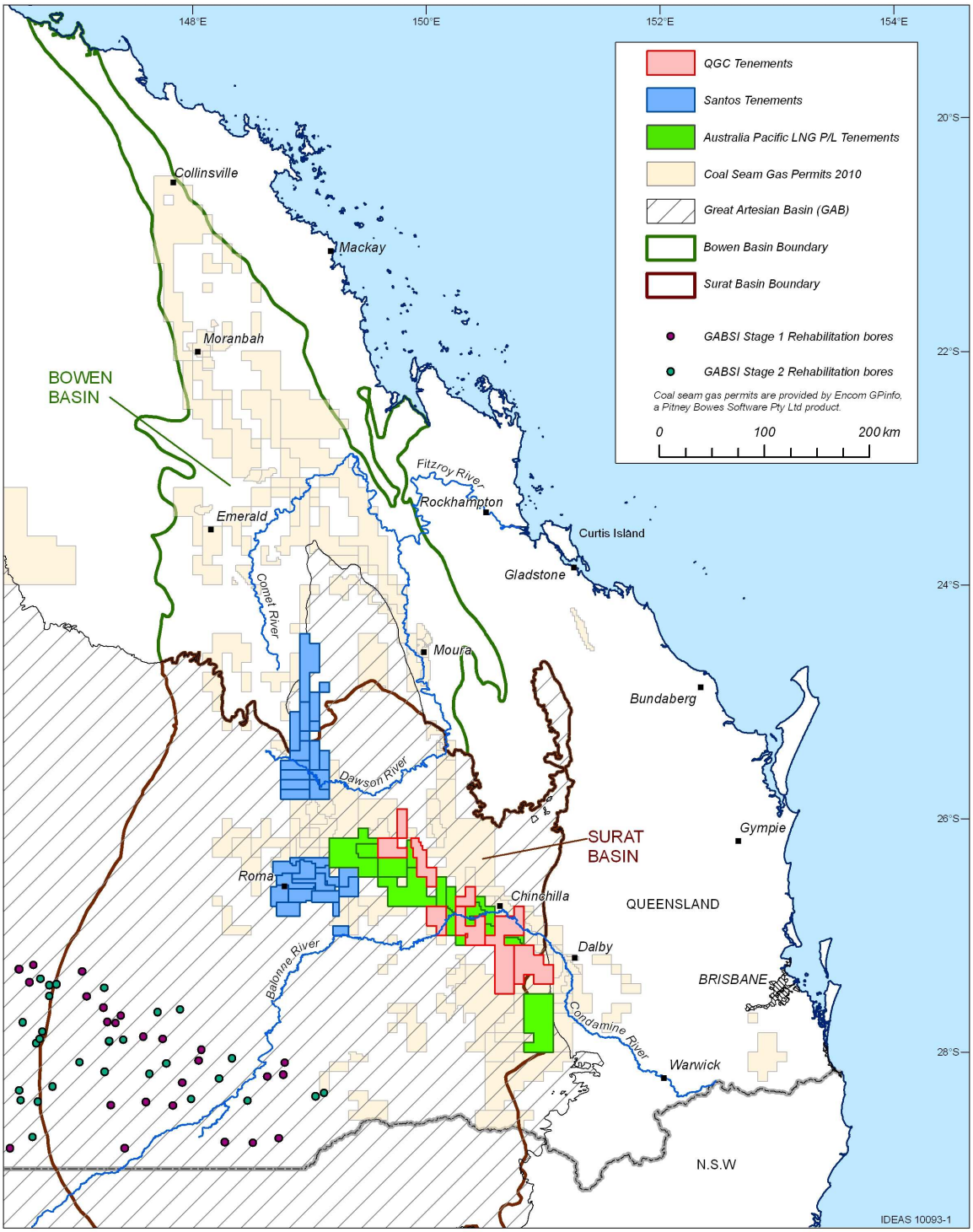


Figure 1.2-1. Map showing the location of existing and proposed coal seam gas permits in Queensland, with tenements considered in the current assessment coloured by proponent. Boundaries of the Surat, Bowen and Great Artesian Basins are indicated, as are major surface drainage systems and GABSI rehabilitated bores.

2. Assessment and Advice

2.1 AUSTRALIA PACIFIC LNG (APLNG)

2.1.1 Project Summary

Australia Pacific LNG proposes to extract coal seam gas (CSG) from the Jurassic-aged coal measures in the eastern part of the Surat Basin in Queensland. The Walloon Coal Measures gas fields are located in Queensland's Surat Basin on the Eastern Downs. The APLNG tenements in the region cover an area of approximately 5700 km^2 and are shown in Figure 2.1-1.

The development will involve drilling up to 10,000 wells over 30 years with a maximum of 600 wells drilled per year. Well spacing for field development is envisaged to be between 500 m and 1500 m. However, an average well spacing of 750 m has been used for development planning and impact assessment purposes. Approximately 5,000 wells will be drilled in the period from 2011 to 2021 to meet the demand of a two train or 9 Mtpa LNG facility to be constructed at Gladstone. An additional 5,000 wells will be drilled over the remaining years of the Project to supply the LNG facility when it is upgraded to four LNG production trains. Coal seam gas fields will produce gas at rates ranging from 75-450 TJ/day.

Associated groundwater production is expected to peak at around 170 ML/day, and this is predicted to occur within the first 20 years. However there remains a high level of uncertainty regarding both the magnitude and timing of this estimate.

The APLNG tenements fall predominantly within the Surat and Surat East Groundwater Management Areas, and partly within the Surat North Management Area, as defined in the Great Artesian Basin Water Resource Plan (DNRM 2005).

The Surat Management Area overlies the full Jurassic to Lower Cretaceous sequence in the Surat Basin and the Upper Triassic sediments of the Bowen Basin in the west.

The Surat East Management Area overlies sediments of Kumbarilla Beds, Walloon Coal Measures, Hutton and Precipice Sandstones of the Surat Basin and the Clematis Sandstone of the Bowen Basin.

The Surat North Management Area covers the sediments of the Westbourne Formation, Injune Creek Group, Hutton and Precipice Sandstones within the Surat Basin and the Clematis Sandstone within the Bowen Basin.

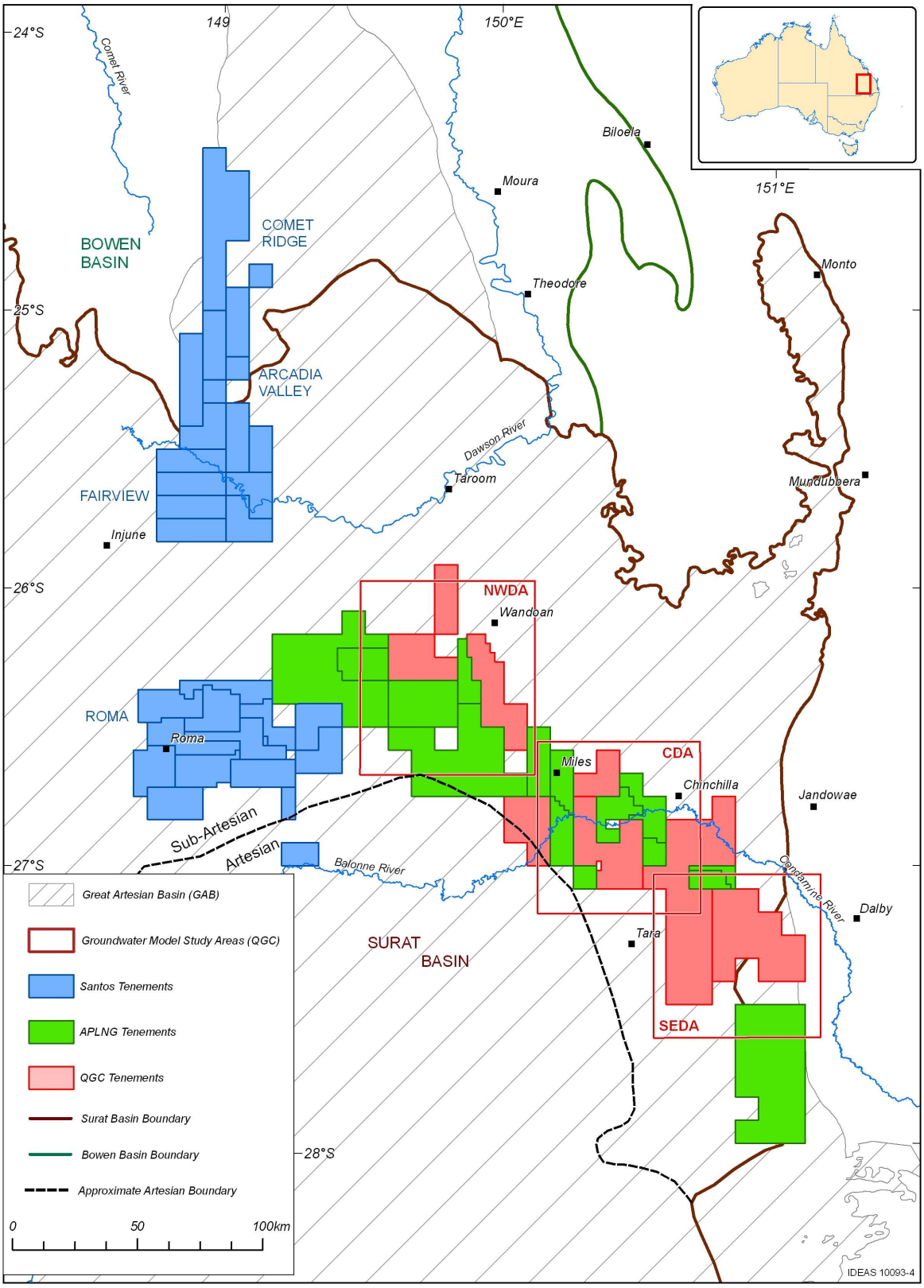


Figure 2.1-1. Location of coal seam gas tenements considered in the current assessment. The location of the artesian/sub-artesian divide, surface drainage and basin boundaries are also shown.

2.1.2 Summary of Assessment

The following summarises our assessment of the QGC proposed CSG development activities.

The adequacy of the proponents' hydrogeological models for estimating hydrogeological impacts on and within the Great Artesian Basin (GAB) and other affected surface and groundwater systems (this would include an initial assessment of the potential of one or more aquifers to depressurise and dewater and the likely impacts).

APLNG present two numerical hydrogeological simulation models – one 'project-scale' model which predicts impacts for their proposed operations, and the other a 'cumulative' model which attempts to account for impacts resulting from multiple CSG operations in the region. Based on the information provided by APLNG in their EIS documents, and discussions with APLNG, our assessment concludes that:

- Within the limitations of available data, the 'project-scale' simulation model produced is suitable for estimating hydrogeological impacts on and within the GAB and other potentially affected surface and groundwater systems within the influence of the APLNG operations. We have, however, noted some shortfalls in the modelling approach.

- The modelling results reported by APLNG require further work to fully establish the uncertainties and sensitivity of the models to the large predicted drawdowns that will occur in the coal measures, and hence does not provide a level of confidence in the model outputs and the conclusions drawn from them.

- The modelled occurrence, magnitude and extent of depressurisation in the Springbok, Hutton and Precipice Sandstone aquifers is consistent with the proposed groundwater extraction operations, and represents effective maximum drawdown values when compared with impacts from existing CSG operations in the region.

- The 'cumulative' numerical groundwater simulation model represents a useful preliminary assessment of potential hydrogeological impacts resulting from a range of groundwater extraction activities, and provides a good starting point for development of a regional model to underpin groundwater impact prediction and management.

Potential impacts of groundwater extraction on aquifer interaction (e.g. water flow, cross contamination), vertical recharge, structural integrity and artesian pressure as a result of the CSG activities. This applies to both quantity and quality of groundwater.

Potential impacts of groundwater extraction on aquifer interaction have, in general, been adequately addressed with, while there is scope for further elaboration regarding some aspects. Based upon consideration of the hydrogeological, geological and project development information provided, we conclude that:

- The modelled vertical recharge and artesian pressure changes resulting from coal seam depressurisation are realistic and likely to result in groundwater flow into the coal measures from adjacent aquifers. We consider that these changes are reversible over timeframes of decades to centuries, depending on the specific aquifer and the management strategies applied.

- Cross-contamination is likely to be of little consequence as the majority of inter-aquifer transfer will involve the migration of higher quality water from adjacent underlying and overlying sandstone aquifers into the Walloon Coal Measures.

- The structural integrity of aquifers in relation to groundwater transmission is unlikely to be significantly impacted by the proposed groundwater extraction. We note that groundwater extraction may cause some aquifer compaction that is likely to result in subsidence (as identified by the proponent and discussed below).

Potential impacts of groundwater extraction on the EPBC Act listed endangered ecological community 'The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin.'

Based upon consideration of the hydrogeological, environmental and management information provided, we agree with APLNG that the risk of impact from groundwater extraction to the EPBC Act listed endangered ecological community '*The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin*' is low, based on the following:

- With one exception, documented and/or surveyed natural discharge sites (springs) are located outside the CSG fields and the modelled zones of groundwater drawdown.

- Proposed monitoring programs are likely to enable detection of potentially deleterious changes to groundwater level or quality.

- Proposed controls on the location and construction of infrastructure would avoid physical impacts on environments suitable for hosting EPBC Act listed communities.

- A small number of additional natural discharge sites proximal to the CSG fields may need to be investigated and assessed to determine their EPBC Act significance.

Uncertainties in the extent of modelled groundwater drawdown, however, lead to the conclusion that a small number of additional natural discharge of groundwater sites (springs) proximal to the CSG fields may need to be investigated and assessed to determine their EPBC Act significance. We suggest that the outcomes of such investigations could provide input to the adaptive management process proposed by APLNG and ensure that the baseline datasets upon which monitoring and mitigation measures are based are both robust and complete.

Potential for recharge into the GAB to be impacted in these areas due to CSG activities and the likely long-term impact(s).

- Insufficient data was provided in the EIS or upon request to enable an assessment of the impact of associated water production upon recharge in terms of the GAB water balance.
- We note that the total magnitude of annual average proposed extraction by APLNG represents 15% of total annual recharge to the potentially affected GAB aquifers including the Walloon Coal Measures.
- The majority of existing groundwater users and environmental values in the Hutton and Precipice Sandstone aquifers are located up-gradient of the proposed extraction activities.
- Long-term impacts of the proposed CSG activities on recharge are possible, and would most likely manifest as a reduction in recharge volumes downgradient and basinward of the CSG developments, which could result in reduced artesian pressures and potential impacts on EPBC Act significant spring communities much further afield.
- We are unaware of any existing data or modelling results that would be suitable for assessing the likelihood or potential timeframes for such impacts, although groundwater movement rates in deeper GAB aquifers suggest that any impact (and recovery) would be extremely long term (i.e. occurring over many thousands of years or more).

Potential impacts of fraccing on the structural integrity of aquifers and aquitards, and on existing groundwater flow processes.

Based upon the geological and technical information provided by APLNG with regards to the potential impacts of hydraulic fracturing ('fraccing'), we consider that the potential risks posed by fraccing are low. We conclude that:

- The assessment completed by APLNG identifies and assesses relevant factors and risks involved in the process.
- While the potential for fraccing activities to impact on the structural integrity of aquifers and aquitards, and on existing groundwater flow processes, can never be completely eliminated, the competent application of industry standard technologies, techniques, and monitoring/mitigation measures proposed by APLNG are considered appropriate for minimising the risk.

Initial advice on the likelihood and materiality of subsidence as the result of the proposals.

Based upon our assessment of the geological and geotechnical information provided, and relevant information from other sources, we agree with APLNG that there is a likelihood of subsidence, and that this could result in several centimetres of surface subsidence.

However, based on the estimated magnitude of the subsidence (in the order or centimetres to tens of centimetres), and with reference to subsidence assessments for CSG activities in similar geological environments elsewhere, we consider that the risk of impacts to surface water and shallow groundwater systems are very low.

We suggest that the monitoring measures currently proposed by APLNG could be strengthened by assessing deformation at the land surface as well as in the aquifers and coal seams.

Initial advice on the likelihood and materiality of any impact on MDB groundwater or connected surface water resources.

On the basis of the available information, we consider that there is a limited likelihood of impact on MDB groundwater or connected surface water resources as a result of the proposed APLNG operations.

This assessment is based primarily on information suggesting that the small number of APLNG tenements proximal to the Condamine River Valley are located in an area where there is no known hydraulic connection between the Walloon Coal Measures (which will undergo depressurisation) and alluvial aquifers.

2.1.3 Assessment of Proposed Development

a. The adequacy of the proponents' hydrogeological models for estimating hydrogeological impacts on and within the GAB and other affected surface and groundwater systems (this would include an initial assessment of the potential of one or more aquifers to depressurise and dewater and the likely impacts).

Model Description

APLNG have developed a finite element groundwater simulation model (FEFLOW) to predict changes in hydraulic head in the Walloon Coal Measures and overlying and underlying aquifers in response to CSG depressurisation activities within their tenements. The model domain extends over almost all of the Surat Basin in Queensland and occupies an area of 172,740 km^2. The model is partitioned into 22 layers to represent the 11 hydrostratigraphic units in the Surat Basin (11 of the model layers are located in the Walloon Coal Measures and the Hutton Sandstone is divided into 2 layers based on permeability). The regional mesh consists of 3 km-sized triangular finite elements around the APLNG tenements, 6 km-sized triangular elements within a 70 km buffer of the tenements and 12 km-sized elements in distal areas.

Model Parameters

Hydraulic parameters estimated for each model layer include horizontal and vertical hydraulic conductivity, storativity and specific yield. Preliminary estimates of *Kh* for all model layers except the Walloon Coal Measures were essentially text-book values derived from the literature and theoretical relationships between permeability and (API) gamma ray counts from drill-holes. These were modified during model calibration. Vertical hydraulic conductivity values were estimated by applying an anisotropy multiplication factor to the calibrated *Kh* values. The anisotropy factor was 300 for aquitards and formations with pronounced layering and 30 for aquifers. *Kh* values for the Walloon Coal Measures were measured from drill stem tests (DST).

A uniform storativity value of 4×10^{-6} was assigned across the entire model domain. This value was derived from a pump test in the Precipice Sandstone at the Kogan Creek power station, and it looks to be artificially low for a permeable sandstone. A uniform specific yield value of 0.03 was assigned to the uppermost model layers. Again, this may be artificially low for a permeable sandstone.

Recharge in layer 1 was assigned according to chloride mass balance estimates for the GAB intake beds from Kellett et al. (2003). Recharge for the Upper Condamine alluvium was assigned according to Lane (1979) and Huxley (1982). Minimal groundwater recharge of 0.025 mm/year was applied over areas where Cainozoic alluvium overlies Evergreen Formation or Moolayember Formation rocks and a low recharge rate of 0.5 mm/year was applied over the large model area southwest of the tenements where Cainozoic alluvium overlies the Rolling Downs Group.

Aquifer-stream bed interaction in the model is accomplished using a channel bed conductance term. This conductance is constrained by inferred stream losses in the Condamine River and its tributaries (Huxley, 1982).

Model Boundary Conditions

No-flow boundaries are set in all layers along the perimeter of the model, except in layers 1 and 2 in the southwest of the model domain. This was to allow shallow groundwater to flow out of the model domain at the downstream ends of the Condamine and Moonie River systems and was handled by assigning a constant head boundary in these elements. The base of the Precipice Sandstone was defined as hydraulic basement (i.e. specified as a no-flow boundary condition). This implies there is no hydraulic connection between the Bowen and Surat Basins.

Model Predictions

Predicted drawdown of the potentiometric surface of the Walloon Coal Measures is not documented in the EIS or supporting documentation, however there is a plot indicating drawdown of greater than 5 m in the Taroom Coal Seams for the year 2049 (APLNG Vol. 2, Ch. 10). This shows the cone of depression >5 m extending up to 10 km beyond the tenement boundaries, but is no more specific than that. Subsequently, APLNG have supplied predicted drawdowns for the key aquifers in ten year time steps from 2019 to 2199. For the Springbok Sandstone the maximum drawdown is predicted to occur in a small area south of Miles (the Undulla Nose) and be of the order of 300 m from 2019 to 2039, declining to about 200 m after 2029 until about 2069. Lesser drawdowns of the order of 150–200 m in the Springbok Sandstone are predicted to be generated within the tenements until at least 2059.

Drawdowns of 5-10 m are predicted to occur in the Hutton Sandstone in a small area west of Miles from 2059 to 2149. Zero drawdown is predicted to occur in the Precipice Sandstone over the life of the project. Drawdowns of 5-10 m are predicted to be generated in the Gubberamunda Sandstone south-west of Miles from 2029 to 2199. The predicted drawdowns in the Springbok, Hutton and Precipice Sandstones are for the APLNG operations only, whereas cumulative operations are taken into account for the Gubberamunda Sandstone predictions.

In summary, the model predicts depressurisation of the Walloon Coal Measures and the Gubberamunda, Springbok and Hutton Sandstones, but there is no predicted dewatering.

Adherence to MDBC Groundwater Modelling Guidelines

The APLNG groundwater model has been evaluated for compliance with key criteria under the MDBC best practice modelling guidelines (Middlemis et al. 2001) which document state-of-the-art standards for undertaking and reporting groundwater modelling. Specifically, we have assessed the simulation model against the guidelines for conceptualisation, calibration, prediction and sensitivity / uncertainty analysis.

Conceptualisation

In our opinion, the APLNG model represents a realistic and defensible translation of a complex hydrogeological physical system into a simulation model. Each of the 11 hydrostratigraphic units are represented as separate layers in the model with the main layer of interest (the Walloon Coal Measures) partitioned into 11 discrete layers to reflect the abundance of information on physical parameters in that unit. The choice of the finite element code (FEFLOW) over the conventional finite difference code (MODFLOW) by APLNG for model simulation appears to be a good one because the triangular-prismatic elements allow better definition of the complex geology, particularly within the tenements. The finer discretisation of the model mesh around the tenements gives greater confidence in the predictions there.

It could be argued that a dual phase (water and gas) model would have been more appropriate for the CSG simulations, but we note that APLNG have accounted for this by gradually reducing hydraulic conductivity in the coal seams during the gas production phase.

The designation of boundary conditions by APLNG appears to be reasonable, apart from perhaps the setting of no-flow boundaries in layers 3 and beyond along the southern model boundary (the western boundary is not impacted because it is almost parallel to the regional groundwater flow lines). In reality, the southern boundary is more or less orthogonal to flow lines in the deeper aquifers and should be specified as groundwater flux (Neuman) boundary conditions. However, we acknowledge that these elements are so far removed from the main area of interest (the tenements) that this criticism is academic.

Like most models, the APLNG finite element model suffers from the assignation of bulk hydraulic parameters for all layers except the coal seams. In reality, there is significant variation in these parameters in all layers across the model domain, particularly in the Evergreen Formation. Of particular concern is the lack of knowledge of storativity values of aquifers and aquitards, with a uniform storativity derived from a single pump test being applied across the model domain. This is not a concern for steady state calibration (as in this case) but would result in large and unquantifiable uncertainties if the model was extended to transient conditions.

The model handles depressurisation of the Walloon Coal Measures by specifying constant head cells 35 m above the top of the WCM. In our opinion, it would have been preferable to configure these as active elements with specified pumping rates. However, we acknowledge the large uncertainties associated with specifying future CSG pumping rates.

Calibration

The model was calibrated against observed pressure measurements over all layers. Head measurements away from the tenements were taken from the DERM groundwater database, across various times and containing lithological interpretation uncertainties. A fundamental flaw in this methodology is the underlying assumption that all the aquifers and aquitards in the Queensland Surat Basin are in steady state equilibrium.

The overall residual mean error for the model was 2% which appears to represent an acceptable model calibration, but some of the residual standard deviations are high (25% in the Precipice Sandstone, 23% in the Westbourne Formation, 19% in the Walloon Coal Measures and 15-16% in the Springbok and Gubberamunda Sandstones).

Prediction

Predicted drawdowns in the major aquifers above and below the Walloon Coal Measures appear to be intuitively as expected and reasonable. However, a possible exception is the near-zero drawdown predicted for the Precipice Sandstone. It seems that the model developers assumed a tight seal for the Evergreen Formation aquitard (between the Hutton and Precipice Sandstones). We have no way of assessing this because Kh and Kv values for the aquitards were not documented in the EIS or in any subsequent APLNG reports. In this regard, it is pertinent to note that drill stem tests in the nearby petroleum well SDA Paddy Creek South #1 (Hodgkinson et al. 2010) show hydraulic continuity between the Hutton and Precipice Sandstones (i.e. the Evergreen Formation is leaky at this location).

The presentation of predicted drawdowns could be improved in the APLNG reports. The colour coding used has too wide a range – it would have been better to use labelled contours. In the particular case of the Gubberamunda Sandstone, it would have been more informative to show the lateral extent of the 2 m drawdown contour, rather than the >5 m contour. This is important because the Gubberamunda Sandstone aquifer has been targeted extensively and at great public and private investment for pressure restoration works under the GABSI Phase 1 and 2 programs. Bore capping has been done in many bores intersecting this aquifer 100 km down gradient and it would be useful to know whether the 2 m drawdown cone of depression propagates this far.

The magnitude of drawdown in the cumulative and stand-alone models is remarkably similar. This result is somewhat counter-intuitive considering a three fold difference in extraction rates between the two models and implies the model may be insensitive to pumping rate.

Sensitivity/Uncertainty Analysis

There is an inherent uncertainty in this and all other CGS proponent models related to the capacity of the model to predict the system response to large drawdowns of the order of several hundreds of metres that will be generated in the Walloon Coal Measures. Groundwater models have been developed primarily to predict the system response to perturbations, but the fundamental question we must ask is: are such large drawdowns beyond the solution space of the model to predict impacts satisfactorily? Is such a large perturbation beyond the scope of the model? It is therefore essential that a post-audit of the model be made after, say, the first 5 years and thereafter at 5 yearly intervals to check what actually happened. It may well be that the greatest uncertainties lie in the water production volumes, not in the estimation of aquifer parameters. Note that the post-audit review is a recommended final step in the MDBC Best Practice Guidelines for medium and high complexity models.

Whilst it is not clear whether a formal sensitivity analysis was carried out on the APLNG model (i.e. Assessing model sensitivity to doubling and halving *Kh*, etc), we note the developers produced a

'best estimate' (calibrated) model, a 'potential minimum impact' model and a 'potential maximum impact' model. These best and worst case scenarios are a surrogate for a formal sensitivity analysis.

Adequacy of Model for Estimating Impacts

Notwithstanding the shortcomings identified above, we are of the opinion that the APLNG groundwater model is adequate to estimate potential hydrogeological impacts from CSG production. As far as practicable, the model developers have followed MDBC best practice guidelines. However, it needs to be acknowledged that the model has only been calibrated against steady state (and variable quality) data, and that better constraints for aquifer storage values would be needed before the model could be extended to transient conditions. The model could also be improved by varying hydraulic parameters across the domain as these data become available. The fundamental question regarding the capacity of the model to handle very large drawdowns in the Walloon Coal Measures will only be answered when production ramps up.

b. Potential impacts of groundwater extraction on aquifer interaction (e.g. water flow, cross contamination), vertical recharge, structural integrity and artesian pressure as a result of the CSG activities. This applies to both quantity and quality of groundwater.

APLNG CSG developments are located between Millmerran and Roma – Wandoan, in an area where most waterbores tap the aquifers of the Bungil Formation, Gubberamunda Sandstone, Walloon Coal Measures, Hutton Sandstone and Precipice Sandstone (APLNG Volume 2, Chapter 10, Figures 10.9 and 10.10). Predictions of the drawdown in these aquifers resulting from CSG groundwater extraction have been made using numerical groundwater simulation models and the results are shown in APLNG Volume 2, Chapter 10, Figures 10.11 to 10.16.

Groundwater extraction from bores causes drawdown of the potentiometric surface of the aquifer from which the groundwater is pumped. A cone of depression will develop, which will expand laterally and vertically over time. Cones of depression of adjoining bores will overlap and the result is interference and accumulation of the cones of depression. Significant lowering of the potentiometric surfaces of the most commonly exploited aquifers in the Great Artesian Basin has taken place since the start of development of the GAB in 1878.

The modelling results indicate that this historical drawdown is likely to be exacerbated by extraction of the volumes of groundwater extracted through coal seam gas developments in the Surat Basin. The considerable volumes of groundwater will be extracted over a period of several decades from the Walloon Coal Measures will depressurise this geological unit to allow coal seam gas to desorb and be produced. As a result, vertical leakage is likely to take place from the overlying and underlying aquifers of the Springbok Sandstone, Hutton Sandstone and Precipice Sandstone, and to a lesser extent from the Gubberamunda Sandstone, into the Walloon Coal Measures and cause drawdown of the potentiometric surface of these aquifers.

We assess that drawdown beyond the CSG tenements is relatively small compared to the

drawdowns from a relatively large concentration of bores to the southwest of the tenements. Bores in the latter area are currently showing a slight increase in aquifer potentiometric surfaces as a result of continuing GABSI rehabilitation. Any drawdown effect from the CSG activities will be compensated by the increase due to the GABSI program, therefore it will be difficult to differentiate the opposing changes. A small number of bores in the southwestern part of the northern APLNG tenement and the southern part of the SANTOS Roma tenements are still artesian, with all other bores within and beyond the tenements being now sub-artesian (Figure 2.1-1). Most of the present sub-artesian bores were artesian during the early part of last century, but as a result of large scale drawdown by all bores in the region, they have become sub-artesian. Any reduction in artesian pressure caused by the CSG activities will only have a limited effect on bores in the immediate surroundings of the CSG tenements.

The degree to which artesian pressures will be affected will not be known until either further vertical hydraulic conductivity data is collected, allowing more accurate drawdown predictions, or a monitoring of multiple aquifers within existing fields verifies the magnitude of hydraulic connection between aquifers adjacent to the coal measures. As a surrogate regional pressure data provided by APLNG for the Springbok, Precipice, Hutton Sandstones and the WCM was assessed to obtain an indication of the degree of connection with the groundwater system.

Pressure values for the Springbok, Precipice, Hutton Sandstones and the WCM generally lie on a similar pressure gradient. A plot of hydraulically connected aquifer pressures would show a similar trend, but this does not necessarily prove connectivity between individual aquifers. Further data such as aquifer chemistry, long-term pumping tests or pressure data from adjacent aquifers during production of water from WCM would be required in order to fully assess connectivity of the system. However, pressure data from within the WCM provided by APLNG and QGC, from the Talinga and Berwyndale South fields respectively, indicates that there is poor vertical interconnection within some areas of the WCM. This agrees with the proposition from the proponents that vertical flow is likely to be low due to the low permeability of the interburden within the WCM and may reduce the amount of induced leakage likely to occur from adjacent aquifers to that which numerical simulation modelling predicts. APLNG are currently installing nested piezometers to monitor pressure variations within over and underlying aquifers in their producing CSG field. (pers. comm. A. Moser 1/9/10).

Cross-contamination is considered a minor issue, as the physical characteristics and groundwater chemistry of the groundwater in the aquifers is similar and within acceptable ranges for water supply purposes. The exception is the groundwater from the Walloon Coal Measures, which is more saline and has a different chemistry compared to the other Jurassic aquifers. However, the groundwater from the Walloon Coal Measures is pumped to the ground surface as associated water during coal seam gas production and disposed of or re-injected following desalination processes. Vertical leakage of better quality groundwater from the other Jurassic aquifers is likely to take place into the Walloon Coal Measures.

We consider that structural integrity of the coal seams and aquifers of the Walloon Coal Measures has the potential to be affected by groundwater extraction. Coal seam gas extraction involves reducing the hydrostatic pressure in the coal seams to allow gas production by desorption of

methane from the coal. This depressurisation results in a large drawdown cone (up to 600 m) in the potentiometric surface of the Walloon Coal Measures, which spreads out from the coal seam gas field production area. The drawdown of the groundwater levels propagates vertically through the over- and underlying aquitards or confining beds into the over- and underlying aquifers. As a result, vertical leakage from these aquifers takes place towards the Walloon Coal Measures and drawdown cones develop in the potentiometric surfaces of the Gubberamunda, Springbok, Hutton and Precipice sandstone aquifers, although at a smaller scale than in the Walloon Coal Measures. We consider that the depressurisation of these other aquifers will generally be too limited to affect the integrity of the aquifer rock structure, as drawdowns in those aquifers are only of the order of several metres.

c. Potential impacts of groundwater extraction on the EPBC Act listed endangered ecological community 'The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin'.

Risk Identification and Assessment

DEWHA (2001) stipulates that an assessment of each individual natural discharge of groundwater (spring) is required to determine its origin (i.e. whether it is a "discharge" or "recharge" spring) and in turn, whether it is associated with the EPBC listed ecological community (APLNG Vol. 5, Attach. 21, p. 58). It is our understanding that the main sources for spring data in Queensland - the Queensland Herbarium database and the Spring Register in the Queensland Water Resources (Great Artesian Basin) Plan 2006 - are not complete and that not all springs have been investigated, assessed and classified. This could lead to "recharge" springs as well as "discharge" springs being excluded from the EPBC listing, as well as springs being excluded simply because they are located in the recharge areas of the Great Artesian Basin ("recharge" springs are excluded as shown in DEWHA, 2001). This could also mean that the impacts of drawdown of groundwater levels caused by groundwater extraction may not be considered for communities assessed as being "recharge" springs purely on the basis of floristic composition.

The location and EPBC classification (i.e. "discharge" versus "recharge") of known springs in proximity to the APLNG development area is illustrated in Figure 2.1-2.

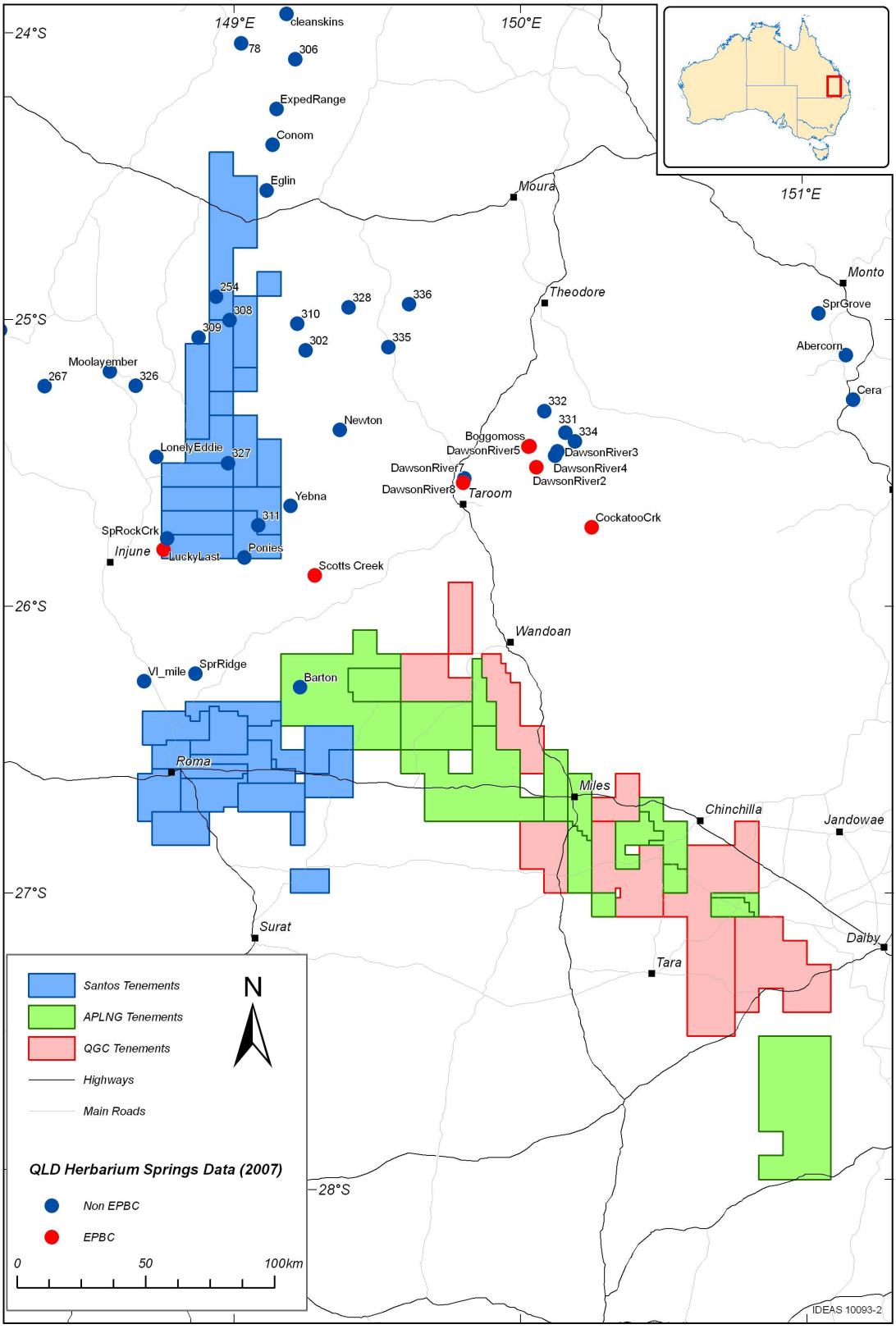


Figure 2.1-2. Location of natural groundwater discharge sites (springs) with respect to coal seam gas tenements considered in the current assessment.

Only one registered “recharge” spring was identified within APLNG leases, in the western corner of the Pine Hills development area (Fig. 2.1-2). The spring is included on the Qld GAB WRP Springs Register and the Qld Herbarium database, but does not appear in the DEWHA mapping of Threatened Ecological Community - The Community of Native Species Dependent on Natural Discharge of Groundwater from the Great Artesian Basins. The spring is listed as ‘RJF Site No NV333’ and classified as active but not visited. APLNG hydrogeologists visited the site in July 2010 and reported no surface hydrological expression or vegetation indicative of a spring or GDE. The feature was reported as a possible seepage relating to an incised erosional feature at base of deep soil profile after significant rainfall (APLNG response to Geoscience Australia questions – 23 August 2010, p. 29).

APLNG identify numerous high value “recharge” and “discharge” spring complexes associated with the Hutton Sandstone and Precipice Sandstone units. These are located proximal to the Taroom and Injune townships, at least 50 km north and north-west of the northernmost APLNG development areas (DNR 2005). The “discharge” spring complexes located near Taroom are supplied by artesian flow from the Precipice Sandstone, rising to the surface through joints and fractures in that unit. These complexes are known locally as 'boggomosses', and provide a wetland habitat in an area that experiences prolonged below average rainfall conditions (DEWHA 2001) (APLNG Vol. 2, Ch. 10, p. 17).

Recharge springs with high conservation values occur approximately 25 km north and northeast of Roma (Fig. 2.1-1), within outcropping areas of the Gubberamunda Sandstone (DNRM 2005). APLNG report having consulted with Dr. Rod Fensham (DERM) on 18 February 2010 regarding the condition and source of the spring complexes located 25 km to the north of Roma. Dr. Fensham apparently confirmed that these springs are “recharge” springs, which emanate from the Gubberamunda Sandstone and that they have all been substantially damaged by damming and excavation. Water chemistry data provided by Dr. Fensham indicate that the water associated with these springs is of good quality, with near neutral pH, low mineralisation (as mg/L TDS) and an ionic composition similar to shallow groundwater and surface waters in the region. This supports the interpretation that the springs are derived from shallow, short flow systems (related to the outcropping Gubberamunda Sandstone), rather than being “discharge” springs associated with the deeper Great Artesian Basin aquifers (APLNG Vol. 5, Attach. 17, Table 5-1, p. 112).

It is noted that there is some ambiguity in the definition of “discharge” springs. Some definitions of natural discharge of groundwater sites are based on floristic composition rather than hydrogeological characteristics.

The proposed gas transmission pipeline corridor crossing Cockatoo Creek (east of Taroom) is known to be associated with GAB spring communities. No EPBC listed communities were recorded during the dry season survey conducted on behalf of APLNG, although the consultant reports that communities could be present where suitable habitats (i.e. actively flowing springs) exist. The EPBC listed *Myriophyllum artesium* (Artesian milfoil) and *Eriocaulon carsonii* (Salt pipewort) are known to

occur in Cockatoo Creek (APLNG Vol. 5, Attach. 18, p. 99). The main activities that could impact artesian spring communities on Cockatoo Creek are identified as direct excavation and/or sediment delivery from road and pipeline construction, rather than effects from groundwater extraction (APLNG Vol. 5, Attach. 18, p. 94). Based on the current location of the pipeline corridor, the likelihood of impacts occurring would be minimal according to APLNG (Vol. 5, Attach. 17, Table 5-1, p. 108).

The groundwater model predicted drawdown cone of depression associated with the CSG extraction of groundwater has the potential to impact on the aquifer pressure of and groundwater flows from artesian springs that are within the cone of depression from CSG activities. For a period of time post-CSG production, during the recovery phase, the groundwater level drawdown cones in the affected GAB aquifers, whilst reducing in magnitude, are projected to broaden beyond the boundaries of the CSG development areas. APLNG's groundwater modelling (APLNG Vol. 2, Ch. 10) suggests that there is a very low risk that groundwater levels will be affected post-operation (APLNG Vol. 2, Ch. 9, p. 25), but it is unclear whether this relates strictly to bore water levels, or whether spring levels are included in this assessment. According to their initial 'project case' and 'cumulative case' numerical groundwater simulation model projections, APLNG determine that associated water production may have the following implications for spring complexes (and their dependent ecosystems) post-CSG operations (APLNG Vol. 5, Attach. 21, p. 81):

- High-value spring complexes and their associated ecosystems that occur east of the town of Injune - low risk that groundwater levels (and potentially the rate of vertical groundwater flows) will be affected by the APLNG operations.

- High-value spring complexes and their associated ecosystems *("discharge"* spring complexes) located near Taroom - not considered by APLNG to be at risk of reduced groundwater levels or vertical flows as a consequence of APLNG operations.

- Spring complexes that occur 25 km north and northeast of Roma in outcropping areas of Gubberamunda Sandstone - not expected to be affected by any reduced groundwater levels that may occur in this area.

- Various spring complexes that may exist approximately 100 km west of Roma. These spring complexes are *"recharge"* springs (pers. comm. R. Fensham, 18 February 2010) and as such APLNG does not expect them to be affected by any reduced groundwater levels that may occur in this area.

GA and Dr M.A. Habermehl consider that the risk methodology applied by APLNG (Vol. 1, Ch. 4) is appropriate for assessing potential risk to EPBC listed communities. Against the criteria specified in their risk assessment documentation, we agree with APLNG's determination that there is a high risk of impact to EPBC communities as a result of pipeline and road construction in proximity to the Cockatoo Creek springs (APLNG Vol. 5, Attach. 17, Table 5-3, p. 119) and a low risk of potential impact associated with aquifer drawdown during the operation and decommissioning phases (APLNG Vol. 5, Attach. 17, Table 5-4, p. 121-122). These conclusions are based primarily on the relative proximity of CSG activities and modelled groundwater drawdown effects to known spring communities. However, it should be noted that any variation in the groundwater simulation model predicted lateral and vertical extent of groundwater drawdown could alter the potential impact and

hence risk rankings.

On the basis of the available documentation, GA and Dr M.A. Habermehl consider that the majority of risks of significant impacts to the GAB and other affected surface and groundwater systems have been adequately identified and assessed. However, there are several identified spring communities for which the risk could be more thoroughly assessed. Acquisition of the data identified below would provide a mechanism for APLNG to reduce or eliminate these uncertainties.

Further Analysis

APLNG have already adopted the recommendation put forward by their consultant (Hydrobiology – APLNG Vol. 5, Attach. 17, p. 126) that they undertake field investigations to confirm the classification and condition (as well as location, type, source aquifer) of springs north of Roma (Six Mile, Spring Ridge). In addition, we recommend that APLNG undertake investigations of the springs east of Taroom (Cockatoo Creek) in order to inform a revised route for the pipeline. Despite being outside the APLNG tenements and modelled range of drawdown, it would also be pertinent to assess the spring (Scott's Creek) north of the Pine Hill's development. This site is known to host EPBC significant communities and to account for any variation in the modelling results which may alter the extent of drawdown influence it is recommended that this site be fully characterised for baseline purposes.

It is also suggested that for a minimum of 12 months prior to CSG development all spring sites within the APLNG tenements, plus those referred to above, be investigated and monitored at least quarterly (i.e. every 3 months) in order to identify any temporal or seasonal variation in the presence/absence of the EPBC Act communities of native species dependent on natural discharge of groundwater from the GAB. This recommendation is consistent with observations of large seasonal variability in the watercourses of the region, as reported by the consultant (Hydrobiology – APLNG Vol. 5, Attach. 17, p. III).

The completion of these investigations and monitoring results would provide a robust baseline data set against which to monitor any potential impacts of the CSG gas field and pipeline developments.

Adequacy of Mitigation Measures and Conditions

The monitoring and mitigation strategies proposed by APLNG are based on the principles of adaptive management. Adaptive management is a structured, iterative process of optimal decision-making in the face of uncertainty, with a focus on reducing uncertainty over time via system monitoring and knowledge enhancement. The main advantage of this approach is seen by APLNG to be the ability to utilise new groundwater quality and quantity knowledge generated in the region to update the conceptual hydrogeological model and associated numerical groundwater flow simulation model and adapt CSG operations and associated water management decisions accordingly (APLNG Vol. 5, Attach. 21, p. 29).

APLNG provide details of the location of their proposed monitoring bores and the aquifer targeted by each (APLNG Vol. 2, Ch. 10, Fig. 10.18). The presence of multiple monitoring bores in the Gubberamunda Sandstone to the west of the APLNG tenements is considered by GA and Dr M.A.

Habermehl to be a particularly appropriate decision with regards to monitoring any potential impact on springs to the north of Roma. Some additional monitoring bores in the Springbok Sandstone could be considered, particularly midway between Miles and Surat, where a major area of drawdown of the Springbok Sandstone aquifer will be located. Monitoring bores should have a frequency of groundwater level readings of at least quarterly from the start-up of CSG development, increasing to monthly or even weekly when groundwater levels start to show changes. Monitoring frequency of springs should be similar.

The potential implementation of monitoring bores concentrically outward from the CSG gas fields, in conjunction with indicative regional monitoring locations, to be developed in collaboration with other CSG proponents and government in accordance with the Queensland Government's Blueprint for the LNG Industry (APLNG Vol. 2, Ch. 10, p. 44), are also considered by GA and Dr M.A. Habermehl to be positive and appropriate decisions.

The monitoring measures proposed by APLNG (Vol. 5, Attach. 17, p. 126) are considered by GA and Dr M.A. Habermehl to require further explanation. While APLNG propose water quantity and quality indicators and trigger thresholds for changes in water level and water quality (APLNG Vol. 2, Ch. 10, Section 10.5.1), it is not clear how trigger levels will be acted upon with regards to mitigating changes to groundwater flow or quality in springs. Accordingly, GA and Dr M.A. Habermehl consider that the current mitigation measures require further elaboration to provide confidence that critical impacts on springs can be mitigated.

Proposed Measures or Requirements

- It is recommended that the proposed monitoring bore network be expanded to include bores monitoring the Precipice Sandstone between the APLNG tenements and both Taroom and Cockatoo Creek, in order to quantify any potential impact of drawdown on EPBC significant springs in that region.

- Although one monitoring bore in the Hutton Sandstone aquifer is already proposed immediately west of the westernmost (Pine Hills) APLNG CSG field, it is recommended that additional monitoring of the Hutton Sandstone to the north of Pine Hills be established to facilitate impact monitoring on the EPBC significant springs east of Injune (Scott's Creek).

- Additional monitoring bores in the Springbok Sandstone could be considered, particularly midway between Miles and Surat, where a major area of drawdown of the Springbok Sandstone aquifer is predicted.

- Monitoring measures proposed for adaptive management of spring communities in the region could be expanded to include those additional sites referred to previously. Springs in the areas west, northwest, north and northeast of Roma are not expected to be affected by the APLNG CSG activities, but some monitoring might be required, particular if the modelling predictions divert significantly from the actual drawdown conditions.

- The aquifer source of natural groundwater discharge sites (springs) needs to be established in all cases. In order to estimate the potential for impacts caused by CSG groundwater level drawdown, the elevation of the spring (vent) and the potentiometric surface elevation of the

source aquifer in the spring region should be determined (where not already known) prior to the onset of CSG groundwater extraction and be monitored throughout the production and recovery stages of the project.

Summary

On the basis of the available information, and subject to the adoption of recommendations proposed in earlier sections, GA and Dr M.A. Habermehl consider that APLNG have, in general, adequately identified and assessed the risk of significant impacts of groundwater extraction on the EPBC Act listed endangered ecological community *'The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin'*. Exceptions have been noted and recommendations for further analysis to generate more robust baseline data sets are proposed. We agree with APLNG's assessment that the risks to EPBC communities resulting from both physical disturbance and groundwater drawdown are low, based primarily on the absence of any *"discharge"* springs from the CSG fields and the modelled zones of drawdown. However, we consider that the monitoring and mitigation measures proposed by APLNG could be strengthened, and we make a number of the proposed recommendations, including the expansion of the monitoring bore network.

d. Potential for recharge into the GAB to be impacted in these areas due to CSG activities and the likely long-term impact(s).

The potential for recharge into the GAB aquifers to be impacted due to CSG activities can be considered as three separate issues:

- Potential for infrastructure associated with CSG activities located on the GAB intake beds to reduce the amount of recharge due to soil compaction and a reduction in intake bed surface area due to infrastructure footprint.
- Potential for infiltrating recharge water to be contaminated prior to recharging the GAB aquifers.
- The effect on the GAB water balance caused by induced leakage from the GAB aquifers through extraction of associated water from the CSG formations.

It should be noted that a reduction in pressure due to water extraction down-gradient of the GAB aquifer intake beds will not affect the rate at which infiltrating water moves through the unsaturated zone into these aquifers. Hence the rate of recharge will not change. Recharge is a function of rainfall and rock permeability, which regulates the rate at which water can enter the rock matrix of the aquifer.

The risk that infrastructure located within the intake beds of the GAB will significantly reduce the amount of groundwater recharge is negligible and is not assessed further. For example, estimates of surface area covered by each production well drill pod, headworks and infrastructure are in the

order of 0.005 km^2. As such, the total area impacted for the maximum 15,000 proposed CSG extraction wells will be in the order of 75 km^2. This area is insignificant considering that the GAB intake beds cover an area of several thousand square kilometres.

APLNG has identified shallow groundwater contamination as an issue; specifically contamination from associated water brine ponds and chemical and fuel storage sites associated with processing plants. APLNG state that Qld EPA guidelines will be adhered to in respect of the lining of brine ponds and on-site storage of chemicals and that these "best-practice" strategies will prevent on-site contamination.

GA and Dr M.A. Habermehl consider that the shallow groundwater monitoring strategies outlined in the APLNG EIS should be sufficient to address any potential shallow groundwater contamination issues.

Insufficient data was available in the EIS to enable an assessment of the impact of associated water production upon recharge in terms of the GAB water balance. To this end, data for the latest leakage estimates for aquifers adjoining the coal seams in each development area were requested from APLNG.

APLNG have been unable to provide the requested induced leakage data in the timeframe for delivery of this report. They have provided recharge estimates for the intake areas, used as input into numerical groundwater simulation model. These GAB aquifer recharge estimates are in general agreement with those of Kellett et al. (2003), as indicated by a comparison of the equivalent units in Table 2.1-1. However, at this stage a direct comparison of recharge against induced leakage from individual aquifers adjacent to the WCM is not possible, but a comparison of the bulk recharge of aquifers likely to be impacted, including the WCM with forecast average annual water production has been undertaken.

Table 2.1-1. Estimated recharge values for key hydrogeological units based on APLNG groundwater modelling.

Geological sub-unit	**Recharge (ML/yr) (APLNG data)**	**Surat Management Zone Recharge (ML/yr)(Kellett et al. 2003)**
Condamine Alluvium	9977	
Cainozoic Units/Rolling Downs Group	43572	
BMO/Gubberamunda Grouping	55827	60300 (Hooray Sst & Equivalents)
Springbok Sandstone	893	
Injune Creek Group	6885	
Hutton Sandstone	42439	54280
Evergreen Formation/Precipice Sandstone	119859	
Model Base	234	
Total	*279688 (279.7 GL/yr)*	

Based on water production forecasts and the recharge estimates provided by the proponents, average annual water production, over the life of the project, amounts to 15% of annual recharge for likely to be impacted aquifers adjacent to and including the WCM (Table 2.1-2).

Table 2.1-2. Estimated water production as a percentage of recharge.

Aquifer	Estimated annual recharge ML/yr	Forecast average annual water production (best case scenario) ML/yr	Forecast water production as % recharge
BMO/Gubberamunda Group + Springbok Sandstone + Injune Creek Group (WCM) + Hutton Sandstone	106045	15931	15

e. Potential impacts of fraccing on the structural integrity of aquifers and aquitards, and on existing groundwater flow processes.

A series of risks associated with hydraulic fracturing ('fraccing') have been identified by APLNG that have the potential to impact the structural integrity and flow characteristics of surrounding aquifers. These risks include compromise of the integrity of the cement behind bore casings that could allow vertical fluid movement, fault reactivation, and the growth of induced fractures out of the intended zones into the surrounding aquifers and aquitards. Each risk is addressed in brief by the proponent who considers the overall risk of impact to be low.

The integrity of casing cement is confirmed through the use of cement bond logs and pressure testing of the casing. These are industry standard procedures (see API, 2009) and are considered adequate.

The risk of reactivation of existing faults is mitigated through the geological characterisation of the areas where fracture stimulation activities are carried out. In addition, design of the fraccing to generate multiple, smaller volume treatment zones also limits the extent of fracture growth.

Numerous steps and precautions are taken to mitigate the risk of induced fracture growth into surrounding aquifers and aquitards. These include the application of appropriate fracture monitoring techniques, maximising the distance between fracture zones and known aquifers, the use of a larger number of small stages of fracture fluid volume to limit fracture extent, and control of treating pressures to avoid extreme pressure. Mitigation measures have only been addressed briefly, but we believe they are adequately covered and are in line with industry standards, as are the remedial measures proposed.

As such, we consider that fraccing represents a low risk to the structural integrity of aquifers and aquitards, and on existing groundwater flow processes, so long as the proponent applies industry standards (e.g. API, 2009) and follows operating procedures as defined by the regulator.

f. Initial advice on the likelihood of materiality of subsidence as the result of the proposals.

APLNG identify the possibility of differential subsidence and assess it empirically. They determine a low risk ranking for the potential of both subsurface and land surface subsidence (APLNG Vol. 5, Attach. 21, pp. 91-92), despite providing an estimate of up to 0.5 m of subsidence. In the absence of appropriate data for the proponent to undertake a full geotechnical assessment of potential subsidence, we interpret the current information to suggest that the likelihood of subsidence is high. However, subsidence assessments for an existing CSG field in the Powder River Basin, USA, which represents a broadly similar geological setting to the Surat Basin, suggest that compression in the coal seams has not been transmitted to the surface due to the strength of materials above the coals. It is expected that such subsidence would be uniform over the area, and would not result in

significant impact (Case et al. 2000).

APLNG propose baseline and ongoing regional groundwater level monitoring in areas at higher risk of CSG effects. They consider that early detection of potential land subsidence through groundwater monitoring would trigger mitigation measures, such as the injection of water into affected aquifers to counteract the effects. APLNG also state that groundwater level and quality monitoring may also assist in identifying any compromise to aquitard integrity through fracturing (and inter-aquifer flow); a possible consequence of geological deformation (APLNG Vol. 5, Attach. 21, p. 127).

GA and Dr M.A. Habermehl consider that the monitoring and mitigation measures proposed by APLNG are adequate to account for potential subsidence resulting from groundwater extraction and coal seam depressurisation.

Monitoring proposed by APLNG is restricted to the subsurface, and no consideration has been given to assessing change over time at the land surface. We suggest that the proponent, in conjunction with relevant State Government agencies and other proponents, establish baseline and ongoing geodetic monitoring programs to quantify deformation at the land surface. These should link from the tenement scale to the wider region across which groundwater extraction activities are occurring.

g. Initial advice on the likelihood and materiality of any impact on MDB groundwater or connected surface water resources.

APLNG have not provided information to enable assessment of the likelihood and materiality of any impact on MDB groundwater or connected surface water resources.

The GAB Water Resource Plan (DERM 2006) indicates that all identified baseflow reaches in the MDB are in the sub-artesian zone of the GAB, thus significantly limiting the possibility that base flow is derived from deep GAB aquifers. This assessment was based on a simplistic comparison of groundwater pressures and river bed elevations without consideration of the potential for connection between the aquifers and rivers. As a result, the identified potential for GAB sourced baseflow is likely to be a significant overestimation.

Although this broad assessment suggests that MDB surface water resources are not likely to be sourced from underlying GAB aquifers, there remains a minor possibility that the river sections may receive some baseflow from unconfined GAB sediments. To further assess this possibility, APLNG have commenced landowner surveys, remote sensing, field and stream gauging studies to re-assess potential GAB aquifer connected baseflow reaches. The hydrological and GDE significance of projected model drawdowns in any reaches with residual potential baseflow are planned be assessed through detailed investigation and monitoring (APLNG response to GA questions – August 2010, pp. 46-47).

On the basis of hydrograph analyses and water quality trends presented by Hillier (2010) there is an identified hydraulic connection between the Walloon Coal Measures (WCM) and Condamine River alluvium in the Cecil Plains area (southeast of Dalby). If the Walloon Coal Measures in this area are

depressurised due to CSG activities, Hillier (2010) predicts that leakage could occur from the River and the alluvium into the Walloon Coal Measures. The Hillier (2010) report recommends that this potential leakage rate be quantified before approving any CSG activities in the Cecil Plains area. A small number of APLNG tenements intersect the Condamine River and its alluvium downstream of Chinchilla, but this area is unlikely to leak into the Walloon Coal Measures because there is no hydraulic connection between the Condamine alluvium and the WCM north west of Dalby.

On the basis of the available information, we thus consider that there is a limited likelihood of impact on MDB groundwater or connected surface water resources as a result of the proposed APLNG operations, and that APLNG are taking appropriate steps to better clarify the nature of any potential impact.

The following recommendations are made with regards to assessing potential impact on MDB groundwater or connected surface water resources:

- Data acquisition through drilling and pumping tests to quantify the connectivity between aquifers overlying the Walloon Coal Measures;

- Development of a regional scale, multi-layer model of the interaction between the Walloon Coal Measures and overlying aquifers to evaluate the long-term impacts of coal seam gas development on groundwater and connected surface waters in the MDB.

2.2 QUEENSLAND GAS COMPANY (QGC)

2.2.1 Project Summary

QGC propose to develop an area extending from around Wandoan southeast to Dalby, including areas west and south of Miles and Chinchilla (Fig. 2.2-1). The development areas target the Walloon Coal Measures of the Surat Basin.

The basis for the Project design is the delivery of 1,360 million standard cubic feet per day (MMscfd) of compressed CSG to the LNG Facility to be constructed at Gladstone. QGC plan to progressively establish approximately 6,000 gas production wells over the life of the project (20-30 years) with initially 1,000 to 1,500 wells across the gas field by mid-2014. The remaining wells will be phased in over the life of the project (20 to 30 years) to replace declining wells. Wells are drilled to a depth of between 200 m and 700 m, and have a typical life of between 15 and 20 years. Gas production is expected to ramp up from the current rate of 200 TJ/day to approximately 707 TJ/day (equivalent to 680 MMscfd), and ultimately to 1,415 TJ/day (1,360 MMscfd).

Cumulative groundwater production over the life of the project is expected to be approximately 1,200,000 ML (1200 GL). The volume of water generated is projected to peak at approximately 180 ML per day in 2013/2014, with average production in the order of 160 ML per day between 2015 and 2025. The estimated water volumes may vary by ± 50%.

The QGC tenements fall predominantly within the Surat Groundwater Management Area, with small areas in the Surat East, Surat North and Eastern Downs Management Areas, as defined in the Great Artesian Basin Water Resource Plan (DNRM 2005).

The Surat Management Area overlies the Jurassic to Lower Cretaceous sequence in the Surat Basin and the Upper Triassic sediments of the Bowen Basin in the west.

The Surat East Management Area covers the sediments of Kumbarilla Beds, Walloon Coal Measures, Hutton and Precipice Sandstones the within the Surat Basin and the Clematis Sandstone within the Bowen Basin.

The Surat North Management Area covers the sediments of the Westbourne Formation, Injune Creek Group, Hutton and Precipice Sandstones within the Surat Basin and the Clematis Sandstone within the Bowen Basin. This area has a large number of high value recharge and discharge springs within the outcrop areas of the major aquifer units.

The Eastern Downs Management Area covers western part of the Clarence Moreton Basin, extending from the Kumbarilla Ridge to the Great Dividing Range. The area includes the Jurassic sedimentary rocks of the Walloon Coal Measures, Marburg Sandstone and Helidon Sandstone, which are equivalent to sediments in the Surat Basin over the Kumbarilla Ridge.

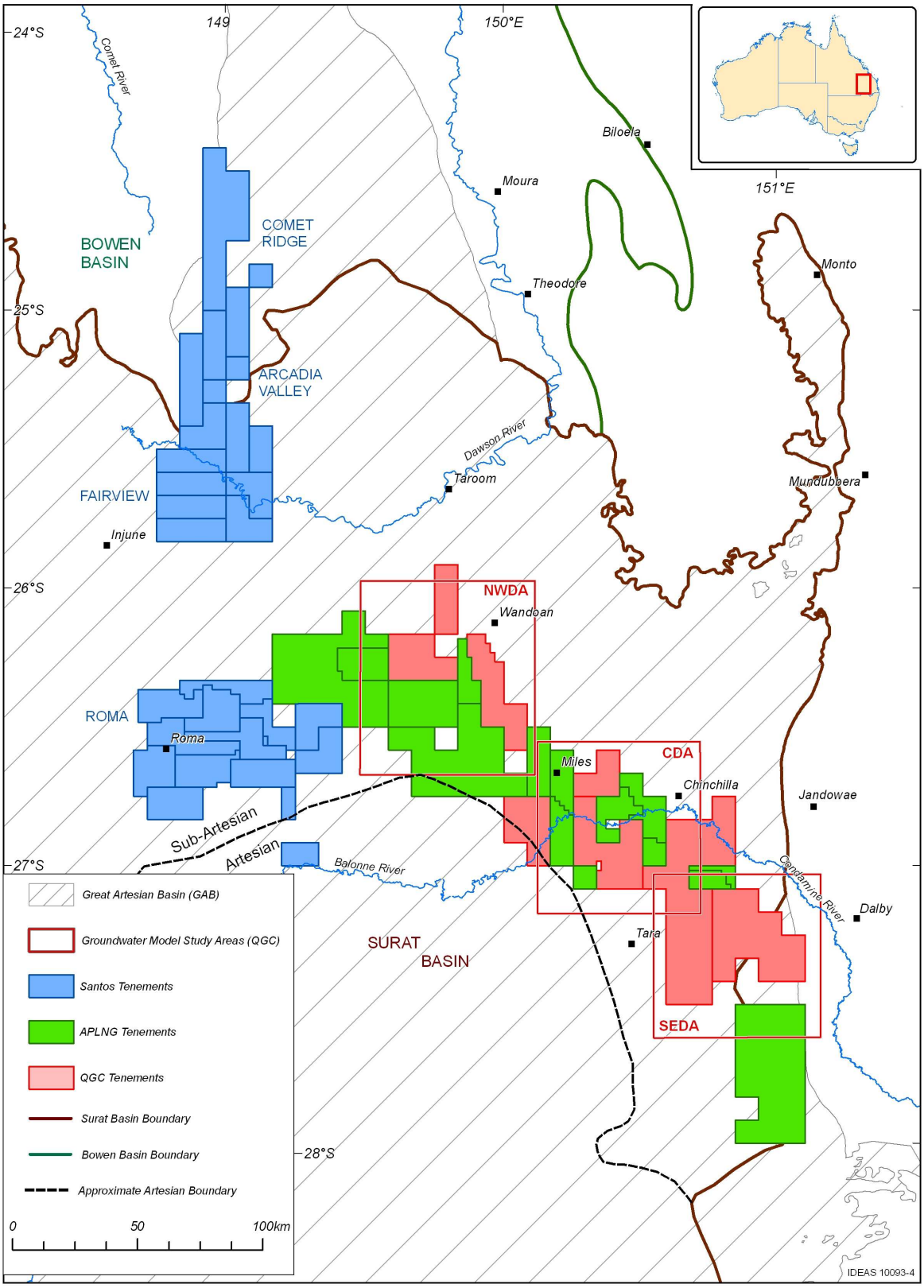


Figure 2.2-1. Location of coal seam gas tenements considered in the current assessment. The location of the artesian/sub-artesian divide, surface drainage and basin boundaries are also shown.

2.2.2 Summary of Assessment

The following summarises our assessment of the QGC proposed CSG development activities.

The adequacy of the proponents' hydrogeological models for estimating hydrogeological impacts on and within the Great Artesian Basin (GAB) and other affected surface and groundwater systems (this would include an initial assessment of the potential of one or more aquifers to depressurise and dewater and the likely impacts).

QGC present three numerical hydrogeological simulation models – using the modular finite-difference groundwater flow model (MODFLOW) computer code. The three model domains have been developed to encompass the location of the NWDA, CDA and SWDA - QGC CSG development areas. Each development area is considered geographically and geologically distinct and occupies an area of 17280 km^2. Based on the information provided by QGC in their EIS documents, and discussions with QGC, our assessment concludes that:

- Within the limitations of available data, the 'project-scale' groundwater models produced are suitable for estimating hydrogeological impacts on and within the GAB and other potentially affected surface and groundwater systems within the influence of the QGC operations. We have, however, noted a number of limitations in the modelling approaches taken.

- The modelling results reported by QGC require further work to fully establish the uncertainties and sensitivity of the models to the large predicted drawdowns that will occur in the coal measures, and hence does not provide a level of confidence in the model outputs and the conclusions drawn from them.

- The numerical groundwater simulation models were developed to produce drawdown predictions that could provide input into a risk management strategy, and the models are not designed to produce absolute and quantitative prediction of the magnitude of drawdown at specific locations

- The modelled occurrence, magnitude and extent of depressurisation in the Mooga Sandstone, Gubberamunda Sandstone and Springbok Sandstone, Hutton Sandstone and Precipice Sandstone aquifers is consistent with the proposed groundwater extraction operations, and is conservative in comparison with known impacts from existing CSG operations in the region.

Potential impacts of groundwater extraction on aquifer interaction (e.g. water flow, cross contamination), vertical recharge, structural integrity and artesian pressure as a result of the CSG activities. This applies to both quantity and quality of groundwater.

Potential impacts of groundwater extraction on aquifer interaction have, in general, been adequately addressed with, while there is scope for further elaboration regarding some aspects. Based upon consideration of the hydrogeological, geological and project development information

provided, we conclude that:

- The modelled vertical recharge and artesian pressure changes resulting from coal seam depressurisation are realistic and likely to result in groundwater flow into the coal measures from adjacent aquifers. We consider that these changes are reversible over timeframes of decades to centuries, depending on the specific aquifer and the management strategies applied.

- Cross-contamination is likely to be of little consequence as the majority of inter-aquifer transfer will involve the migration of higher quality water from adjacent underlying and overlying sandstone aquifers into the Walloon Coal Measures.

- The structural integrity of aquifers in relation to groundwater transmission is unlikely to be significantly impacted by the proposed groundwater extraction. We note that groundwater extraction may cause some aquifer compaction that is likely to result in subsidence (as identified by the proponent and discussed below).

Potential impacts of groundwater extraction on the EPBC Act listed endangered ecological community 'The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin.'

Based upon consideration of the hydrogeological, environmental and management information provided, we agree with QGC that the risk of impact from groundwater extraction to the EPBC Act listed endangered ecological community '*The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin*' is low, based on the following:

- The location of documented and/or surveyed natural discharge sites (springs) from the CSG fields and the modelled zones of groundwater drawdown.

- Proposed monitoring programs enabling detection of potentially deleterious changes to groundwater level or quality and instigating mitigation measures.

- Proposed controls on the location and construction of infrastructure to avoid physical impacts on environments suitable for hosting EPBC Act listed communities.

- A small number of additional natural discharge sites proximal to the CSG fields may need to be investigated and assessed to determine their EPBC Act significance.

Uncertainties in the extent of modelled groundwater drawdown, however, lead to the conclusion that a small number of additional natural discharge sites proximal to the CSG fields may need to be investigated and assessed to determine their EPBC Act significance. We suggest that the outcomes of such investigations could provide input to the monitoring and management process proposed by QGC and ensure that the baseline datasets upon which monitoring and mitigation measures are based are both robust and complete.

Potential for recharge into the GAB to be impacted in these areas due to CSG activities and the likely long-term impact(s).

Consideration of a range of hydrogeological, geological and groundwater production data provided by QGC lead us to agree that their proposed CSG activities represent a low risk to recharge into the GAB. This is primarily because:

- The proposed extraction volumes are small in comparison to GAB intake bed recharge volumes, and;
- The majority of existing groundwater users and environmental values are located up-gradient of the proposed extraction activities.

Long-term impacts of the proposed CSG activities are possible, however, and would most likely manifest as a reduction in recharge volumes basinward of the CSG developments, which could result in reduced artesian pressures and potential impacts on EPBC Act significant spring communities much further afield north of the QGC tenements.

We are unaware of any existing data or modelling results that would be suitable for assessing the likelihood or potential timeframes for such impacts, although groundwater movement rates in deeper GAB aquifers.

Potential impacts of fraccing on the structural integrity of aquifers and aquitards, and on existing groundwater flow processes.

Based upon the geological and technical information provided by QGC with regards to the potential impacts of hydraulic fracturing ('fraccing'), we consider that the potential risks posed by fraccing are low. We conclude that:

- The assessment completed by QGC identifies and assesses relevant factors and risks involved in the process.
- While the potential for fraccing activities to impact on the structural integrity of aquifers and aquitards, and on existing groundwater flow processes, can never be completely eliminated, the competent application of industry standard technologies, techniques, and monitoring/mitigation measures proposed by QGC are considered appropriate for minimising the risk.

Initial advice on the likelihood and materiality of subsidence as the result of the proposals.

Based upon our assessment of the geological and geotechnical information provided, and relevant information from other sources, we agree with QGC that there is a likelihood of subsidence, and that this could result in several centimetres of surface subsidence.

However, based on the estimated magnitude of the subsidence (in the order or centimetres to tens of centimetres), and with reference to subsidence assessments for CSG activities in similar geological

environments elsewhere, we consider that the risk of impacts to surface water and shallow groundwater systems are very low.

We suggest that the monitoring measures currently proposed by QGC, which assess both surface and sub-surface deformation and are considered appropriate, could be value-added by tying into a regional program of monitoring lead by the relevant State Government agency.

Initial advice on the likelihood and materiality of any impact on MDB groundwater or connected surface water resources.

On the basis of the available information, we consider that there is a limited likelihood of impact on MDB groundwater or connected surface water resources as a result of the proposed QGC operations.

This assessment is based primarily on information suggesting that the small number of QGC tenements proximal to the Condamine River and its alluvium are located in an area where there is no known hydraulic connection between the Walloon Coal Measures (which will undergo depressurisation) and alluvial aquifers of the Condamine Valley. QGC predicts that there will be no measurable reduction or loss of baseflow contribution to rivers or creeks as a result of the QGC CSG project operation.

2.2.3 Assessment of Proposed Development

a. The adequacy of the proponents' hydrogeological models for estimating hydrogeological impacts on and within the GAB and other affected surface and groundwater systems (this would include an initial assessment of the potential of one or more aquifers to depressurise and dewater and the likely impacts).

Model Description

QGC have developed three numerical groundwater simulation models using the modular finite-difference groundwater flow model (MODFLOW) computer code. The three model domains have been developed to encompass the location of the North-West, Central and South-East development areas. Each area is considered geographically and geologically distinct and occupies an area of 17,280 km^2. Each model has the same structure and consists of 18 layers corresponding to known aquifer and aquitards. The Walloon Coal Measures are represented by 2 aquifer layers within the model. The well field area is represented by 250 x 250 m cells. Model cells increase in width beyond the boundary of the well field. The respective well fields in each development area are represented as 50 x 10 km rectangular strips.

Model Parameters

A preliminary set of hydraulic parameters based mainly on published broad regional estimates has been used to provide a starting point for deriving a minimum and maximum set of parameters.

A minimum and maximum set of model hydraulic parameters have been arrived at by varying hydraulic conductivity, *Kv*/*Kh* ratios and storativity values ("within realistic ranges") in an attempt to match the model associated water volumes to upper and lower bound of a predicted associated water production forecasts that has an uncertainty of +-50%.

No recharge was used for the model to provide a level of conservatism in model outputs.

Model Boundary Conditions

To simulate the lateral extent of layers within the model beyond the model boundaries, constant head conditions were applied. The constant head boundaries used are 305 m AHD, 295 m AHD and 315 m AHD for the central, north-west and south-east development areas respectively.

Model Predictions

THE QGC EIS states that modelled drawdown in Gubberamunda Sandstone is minimal.

Drawdowns listed in Table 2.2-1 are for a point 1.8 km from the edge of the depressurised zone. No drawdown maps showing the areal extent of drawdown are provided in the EIS to allow an assessment of the distribution of groundwater drawdown within aquifers overlying and underlying the Walloon Coal Measures.

Table 2.2-1. Predicted drawdown at a point 1.8 km from the edge of modelled depressurisation zone (NWDA = North-West Development Area; CDA = Central Development Area; SEDA = South-East Development Area).

Aquifer	Drawdown (m) NWDA	Drawdown (m) CDA	Drawdown (m) SEDA
Springbok Sandstone	2 (max) 0 (min)	55 (max) ~5 (min)	23 (max) ~1 (min)
Hutton Sandstone	+0.1 (max) ~+0.8 (min)	2.5 (max) +0.25 (min)	~8 (max) ~1 (min)
Precipice Sandstone	+0.75 (max) + 0.001 (min)	1.8 (max) 0 (min)	~6 (max) 0 (min)

Adequacy of Model for Estimating Impacts

QGC state that their groundwater simulation model was developed to produce drawdown predictions that could provide input into a risk management strategy, and that the model is not designed to produce absolute and quantitative prediction of the magnitude of drawdown of the potentiometric surface at specific locations (at this stage). Further, the lack and quality of available data has influenced the level of sophistication of the model, resulting in a relatively simple model that has not been calibrated against measured groundwater levels.

However, QGC state that the conservatism built into the model provides high end estimates of aquifer leakage and drawdowns that are unlikely to be observed in reality. This assertion is based on their interpretation that extensive drilling within the Walloon Coal Measures suggests that the Walloon Coal Measures are hydraulically isolated from the adjacent aquifers. Furthermore, QGC state the high vertical hydraulic conductivity and low thickness values for the aquitard overlying the upper representative coal seam, and the lack of recharge into the model are evidence of the model's conservatism.

It is the opinion of GA and Dr M.A. Habermehl that, while the quantity and quality of available data may not permit a more sophisticated model to be constructed, the current QGC model provides only a rudimentary level assessment of hydrogeological impacts of associated water production on the GAB groundwater system.

b. Potential impacts of groundwater extraction on aquifer interaction (e.g. water flow, cross contamination), vertical recharge, structural integrity and artesian pressure as a result of the CSG activities. This applies to both quantity and quality of groundwater.

Coal seam gas developments proposed by QGC are located in a NW-SE oriented belt between Wandoan and Dalby, in an area where the majority of waterbores tap aquifers of the Bungil Formation, Mooga, Gubberamunda and Springbok Sandstones, and the Walloon Coal Measures (QGC Appendix 3.4, Report No. 9, pp. 89-92; DNRM 2005, pp. 29-31). Predictions of the drawdown in these aquifers by the CSG groundwater extraction have been made using numerical groundwater simulation models and the results are summarised in QGC Appendix 3.4, Report No. 11, pp. 105-109 and detailed in QGC Appendix 3.4, Report No. 13.

QGC model predictions indicate that CSG production will result in considerable volumes of groundwater being removed from the Walloon Coal Measures over a period of several decades. Consequently vertical leakage will take place from the overlying and underlying aquifers of the Springbok Sandstone, Hutton Sandstone and Precipice Sandstone, and to a lesser extent from the Gubberamunda Sandstone, into the Walloon Coal Measures causing drawdown of the potentiometric surface of these aquifers.

We assess that drawdown beyond the CSG tenements is relatively small compared to the drawdowns from a relatively large concentration of bores to the southwest of the tenements. Bores in the latter area are currently showing a slight increase in aquifer potentiometric surfaces as a

result of continuing GABSI rehabilitation. Any drawdown effect from the CSG activities will be compensated by the increase due to the GABSI program, therefore it will be difficult to differentiate the opposing changes. A small number of bores in the southwestern part of the northern APLNG tenement and the southern part of the SANTOS Roma tenements are still artesian, with all other bores within and beyond the tenements being now sub-artesian (Figure 2.2-1). Most of the present sub-artesian bores were artesian during the early part of last century, but as a result of large scale drawdown by all bores in the region, they have become sub-artesian. Any reduction in artesian pressure caused by the CSG activities will only have a limited effect on bores in the immediate surroundings of the CSG tenements.

The degree to which artesian pressures will be affected will not be known until either further vertical hydraulic conductivity data is collected, allowing more accurate drawdown predictions, or a monitoring of multiple aquifers within existing fields verifies the magnitude of hydraulic connection between aquifers adjacent to the coal measures. As a surrogate regional pressure data provided by APLNG for the Springbok, Precipice, Hutton Sandstones and the WCM was assessed to obtain an indication of the degree of connection with the groundwater system.

Pressure values for the Springbok, Precipice, Hutton Sandstones and the WCM generally lie on a similar pressure gradient. A plot of hydraulically connected aquifer pressures would show a similar trend, but this does not necessarily prove connectivity between individual aquifers. Further data such as aquifer chemistry, long-term pumping tests or pressure data from adjacent aquifers during production of water from WCM would be required in order to fully assess connectivity of the system. However, pressure data from within the WCM provided by APLNG and QGC, from the Talinga and Berwyndale South fields respectively, indicates that there is poor vertical interconnection within some areas of the WCM. This agrees with the proposition from the proponents that vertical flow is likely to be low due to the low permeability of the interburden within the WCM and may reduce the amount of induced leakage likely to occur from adjacent aquifers to that which numerical simulation modelling predicts.

Cross-contamination is considered a minor issue, as the physical characteristics and groundwater chemistry of the groundwater in the aquifers is similar and within acceptable ranges for water supply purposes. The exception is the groundwater from the Walloon Coal Measures, which is more saline and has a different chemistry compared to the other Jurassic aquifers. However, the groundwater from the Walloon Coal Measures is pumped to the ground surface as associated water during coal seam gas production and disposed of or re-injected following desalination processes. Vertical leakage of better quality groundwater from the other Jurassic aquifers will take place into the Walloon Coal Measures.

Structural integrity of the coal seams and aquifers of the Walloon Coal Measures has the potential to be affected by groundwater extraction. Coal seam gas extraction involves reducing the hydrostatic pressure in the coal seams to allow gas production by desorption of methane from the coal. This depressurisation results in a large drawdown cone (up to 600 m) in the potentiometric surface of the Walloon Coal Measures, which spreads out from the coal seam gas field production area. The drawdown of the groundwater levels propagates vertically through the over- and underlying aquitards or confining beds into the over- and underlying aquifers. As a result, vertical leakage from

these aquifers takes place towards the Walloon Coal Measures and drawdown cones develop in the potentiometric surfaces of the Gubberamunda, Springbok, Hutton and Precipice sandstone aquifers, although at a smaller scale than in the Walloon Coal Measures. The depressurisation of these other aquifers is considered to be generally too limited to affect the integrity of the aquifer rock structure, as drawdowns in those aquifers are only in the order of several metres.

c. Potential impacts of groundwater extraction on the EPBC Act listed endangered ecological community 'The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin'.

Risk Identification and Assessment

It is noted that there is some ambiguity in the definition of discharge springs. Some definitions of natural discharge sites are based on floristic composition rather than hydrogeological characteristics. DEWHA (2001) stipulates that an assessment of each individual natural discharge of groundwater site (spring) is required to determine its origin (i.e. whether it is a "discharge" or "recharge" spring) and in turn, whether it is associated with the listed ecological community (APLNG Vol. 5, Attach. 21, p. 58). It is our understanding that the main sources for spring data in Queensland - the Queensland Herbarium database and the Spring Register in the Queensland Water Resources (Great Artesian Basin) Plan 2006 - are not complete and that not all springs have been investigated, assessed and classified. This could lead to "recharge" springs as well as "discharge" springs being excluded from the EPBC listing, as well as springs being excluded simply because they are located in the recharge areas of the Great Artesian Basin ("recharge" springs are excluded as shown in DEWHA, 2001). This could also mean that the impacts of drawdown of groundwater levels caused by groundwater extraction may not be considered for communities assessed as being "recharge" springs purely on the basis of floristic composition.

The location and EPBC classification (i.e. "discharge" versus "recharge") of known springs in proximity to the QGC development area is illustrated in Figure 2.2-2.

QGC provide little information in their main EIS documents regarding the assessment, monitoring and mitigation of potential impacts of groundwater extraction on the EPBC Act listed endangered ecological community 'The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin'. Initial assessment of an insignificant impact is the stated reason for this information not being considered in their final reporting (QGC Response to Geoscience Australia initial Assessment – 13 August 2010, p. 10), owing largely to the absence of any listed springs within or in close proximity to their tenements. Based on a review of the Queensland Herbarium Springs of Queensland Dataset (Version 4.0), QGC identify and report that no "discharge" springs or EPBC Act threatened communities of 'native species dependent on the Great Artesian Basin' occur within the study area (QGC Vol. 3, Ch. 8, p. 5).

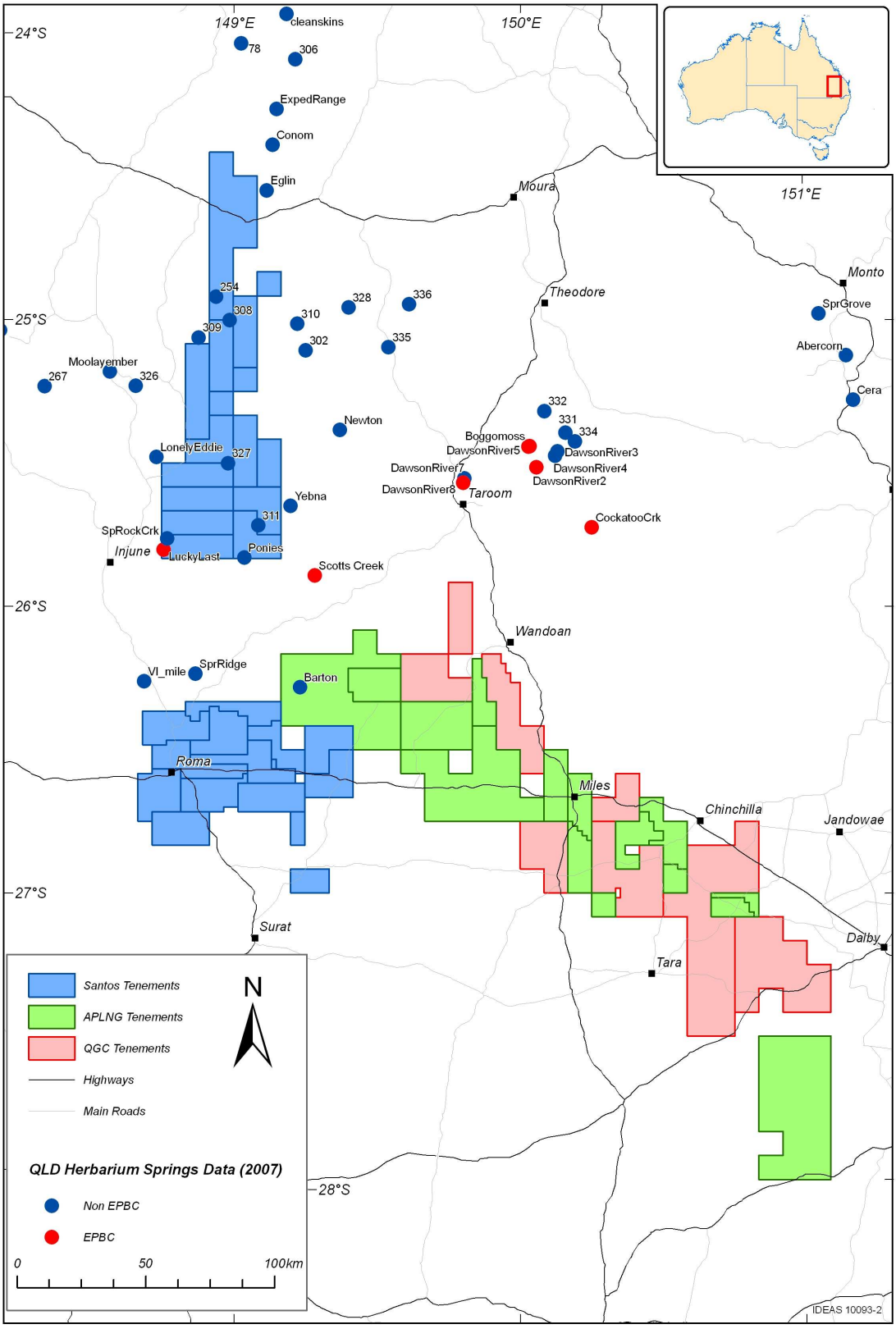


Figure 2.2-2. Location of natural groundwater discharge sites (springs) with respect to coal seam gas tenements considered in the current assessment.

GA and Dr M.A. Habermehl also identify no EPBC listed communities within the QGC tenements or within the QGC modelled zone of depressurisation. Some springs (type unspecified) are noted by QGC within 30 to 50 km of the CSG project area. At 30 to 50 km from the CSG fields QGC predict that drawdown in the Springbok Sandstone aquifer (Injune Creek Group), Hutton Sandstone and Precipice Sandstone aquifers will be negligible (QGC App. 3.4, Rep. 7, p. 72).

However, the springs within 50 km of the QGC tenements are noted by GA and Dr M.A. Habermehl to comprise of a number of EPBC Act significant springs, which include the Dawson River 8 springs immediately north of Taroom and the Scott's Creek springs to the northeast of Roma. The Cockatoo Creek springs, which are known to host the EPBC listed *Myriophyllum artesium* (Artesian milfoil) and *Eriocaulon carsonii* (Salt pipewort), are located east of Taroom and just over 50 km from the nearest QGC tenement. The QGC modelled potential drawdown extents for the Springbok Sandstone aquifer, and the cumulative impact case, show that radius of drawdown influence will be in very close proximity to springs near Taroom and Cockatoo Creek (QGC Impact Areas – Fig. 2).

While QGC have identified all major spring complexes in the region, and correctly reported that none are within their tenements or modelled drawdown zones, GA and Dr M.A. Habermehl consider that their assessment could be improved by considering potential impacts on springs of EPBC Act significance within 50 km of the QGC tenements, particularly given the uncertainty in the groundwater drawdown extents.

Further Analysis

QGC have committed to surveying and re-assessing springs within their tenements and within a 30 km radius of their proposed development areas (QGC Response to DEWHA 300810 – Attach. 1 – Springs Monitoring).

Adequacy of Mitigation Measures and Conditions

QGC's commitment to undertake further assessment and monitoring of springs within the region of their proposed development areas will improve on the initial level of assessment undertaken by QGC. However, the information available regarding the presence of EPBC significant communities in proximity to QGC modelled drawdown extents leads GA and Dr M.A. Habermehl consider that the QGC mandated 30 km survey radius will be inadequate to properly assess (and monitor) any potential impacts on these areas of EPBC significance. While the proposed 7 km radius imposed as the limit for ongoing monitoring may be helpful in assessing impacts to local surface water systems or shallow groundwater, it will not enable assessment or monitoring of any potential impacts on EPBC significant springs, which are located further afield. Accordingly it is recommended that the QGC radius of investigation of springs be extended to include at least the EPBC significant Dawson River 8 springs north of Taroom, the Cockatoo Creek springs east of Taroom, and the Scott's Creek springs northeast of Roma.

The current QGC monitoring proposal for the key aquifers in the region, namely the Springbok,

Precipice, Hutton and Gubberamunda sandstones, should be reviewed in light of the need to assess potential impact on the springs identified above.

Trigger mechanisms using water quantity and quality criteria are specified (QGC Vol. 3, Ch. 10, pp. 6-7). However, despite putting in place provision for monitoring springs, QGC do not state how trigger levels will be acted upon with regards to mitigating changes to groundwater flow or quality in springs. Accordingly, GA and Dr M.A. Habermehl consider that the current mitigation measures require further elaboration.

Proposed Measures or Requirements

- QGC should be asked to detail what remedial action will be taken should groundwater drawdown be identified as impacting water quantity or quality in any springs, as all remedial measures currently proposed address only impacts on groundwater bores.

- The QGC radius of investigation of springs should be extended to include at least the EPBC significant Dawson River 8 springs north of Taroom, the Cockatoo Creek springs east of Taroom, and the Scott's Creek springs northeast of Roma.

- The current QGC monitoring proposal for the key aquifers in the region, namely the Springbok Sandstone, Precipice Sandstone, Hutton Sandstone and Gubberamunda Sandstone, should be reviewed in light of the need to assess potential impact on the springs identified above.

- In order to estimate the potential for impacts caused by groundwater level drawdown, and the appropriate application of trigger values, the elevation of the spring (vent) and the potentiometric surface elevation of the source aquifer in the spring region should be determined prior to the onset of CSG groundwater extraction and be monitored throughout the production and recovery stages of the project lifetime.

Summary

On the basis of the available information, and subject to the adoption of recommendations proposed in earlier sections, GA and Dr M.A. Habermehl consider that QGC have, in general, adequately identified and assessed the risk of significant impacts of groundwater extraction on the EPBC Act listed endangered ecological community '*The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin'*. Exceptions have been noted and recommendations for further analysis to generate more robust baseline data sets are proposed. We agree with QGC's assessment that the risks to EPBC communities resulting from groundwater drawdown are low, based primarily on the absence of any "discharge" as well as "recharge" springs from the CSG fields and the modelled zones of drawdown. We consider that the monitoring and mitigation measures proposed by QGC are not yet adequate, and we make a number of recommendations with reference to the expansion of the monitoring bore network and the extent of the spring assessment.

d. Potential for recharge into the GAB to be impacted in these areas due to CSG activities and the likely long-term impact(s).

The potential for recharge into the GAB aquifers to be impacted due to CSG activities can be considered as three separate issues:

- Potential for infrastructure associated with CSG activities located on the GAB intake beds to reduce the amount of recharge due to soil compaction and a reduction in intake bed surface area due to infrastructure footprint.
- Potential for infiltrating recharge water to be contaminated prior to recharging the GAB aquifers.
- The effect on the GAB water balance caused by induced leakage from the GAB aquifers through extraction of associated water from the CSG formations.

It should be noted that a reduction in pressure due to water extraction down-gradient of the GAB aquifer intake beds will not affect the rate at which infiltrating water moves through the unsaturated zone into these aquifers. Hence the rate of recharge will not change. Recharge is a function of rainfall and rock permeability, which regulates the rate that water can enter the rock matrix of the aquifer.

The risk that infrastructure located within the intake beds of the GAB will significantly reduce the amount of groundwater recharge is negligible and is not assessed further. For example, estimates of surface area covered by each production well drill pod, headworks and infrastructure are in the order of 0.005 km2. As such, the total area impacted for the maximum 6000 proposed CSG extraction wells will be in the order of 30 km2. This area is insignificant considering that the GAB intake beds cover an area of several thousand square kilometres.

QGC has identified shallow groundwater contamination as an issue. Specifically contamination from associated water brine ponds and chemical and fuel storage sites associated with processing plants. QGC state that Qld EPA guidelines will be adhered to in respect of the lining of brine ponds and on-site storage of chemicals and that these “best-practice” strategies will prevent on-site contamination.

GA and Dr M.A. Habermehl consider that the shallow groundwater monitoring strategies outlined in the QGC EIS should be sufficient to address any potential shallow groundwater contamination issues.

To assess the impact of associated water production upon recharge in terms of the GAB water balance, data for the latest leakage estimates for aquifers adjoining the coal seams in each development area were requested from QGC.

Leakage estimates were provided by QGC (Table 2.2-2) for each of their three CSG development areas is based upon revised CSG gas and associated water production forecasts. Current estimates of

total associated water production from the Walloon Coal Measures across the QGC gas fields is 829 GL over 40 years. We note that these water production forecasts are 45% lower than the figures used in the EIS (File Note: Groundwater Modelling – Aquifer Water Budget Estimates Rev. 1, 8 September 2010).

Table 2.2-2 Estimates of induced leakage from the QGC gas fields (NWDA = North-West Development Area; CDA = Central Development Area; SEDA = South-East Development Area).

Formation	Field	Average leakage during field operation (ML/day)	Cumulative leakage during field operation (~40 yrs) (ML)
Springbok Sandstone	NWDA	0.22	3212
Hutton Sandstone	NWDA	0.002	29.2
Precipice Sandstone	NWDA	0.0000	0
Springbok Sandstone	CDA	3.01	43946
Hutton Sandstone	CDA	0.008	116.8
Precipice Sandstone	CDA	0.0001	1.46
Springbok Sandstone	SEDA	0.57	8322
Hutton Sandstone	SEDA	0.018	262.8
Precipice Sandstone	SEDA	0.0002	2.92

A comparison of the predicted volumes of groundwater extracted following vertical leakage from the Springbok and Hutton Sandstones with groundwater recharge in the intake beds is summarised in Table 2.2-3. This comparison puts into perspective the likely impacts of QGC associated water extraction on the GAB water balance. Where sufficient information exists, a comparison has been made of the estimated groundwater recharge in the intake beds and the modelled induced leakage rates from overlying and underlying aquifers into the formations from which CSG associated water will be extracted.

It should be noted that the comparisons give an order of magnitude estimate only. Estimates of recharge are based on either chloride mass balance calculations undertaken by Kellett et al. (2003) or inferred recharge rates based on the proximity of intake beds to locations with existing chloride mass balance calculations. For the purpose of this comparison the intake area for each aquifer is the area of outcrop equal to the lateral extent of the field area plus a ~20 km buffer either side (a buffer of ~40 km was used for the Precipice Sandstone, Figure 2.2-3). It is recognised that the method used to define the intake bed areas for each field is relatively crude but is sufficiently precise to undertake

an order of magnitude comparison. Additional further work would be required to increase the level of accuracy of the recharge rate estimates made in both the Springbok and Precipice Sandstones.

Table 2.2-3. Estimated induced leakage as a percentage of aquifer recharge for QGC CSG fields considered in the current assessment (NWDA = North-West Development Area; CDA = Central Development Area; SEDA = South-East Development Area).

CSG field	Aquifer	Water Production Scenario	Estimated annual recharge (ML/yr) (Kellet et al. 2003)	Estimated induced leakage (ML/yr) (QGC)	Leakage as % of recharge
NWDA	Springbok Sandstone	Average	1671	80	4.8
NWDA	Hutton Sandstone	Average	6662	0.73	0.01
CDA+ SEDA*	Hutton Sandstone	Average	12657	9.49	0.07

* Recharge into the Springbok Sandstone was not determined; intake bed area cannot be differentiated within the vicinity of CDA & SEDA.

QGC – North West Development Area (NWDA)

Within the NWDA (see Fig. 2.2-1 for location) the average annual induced leakage from the Springbok Sandstone is 4.8% of the annual recharge of the aquifer from the area up-gradient of the CSG field, while from the Hutton Sandstone the induced leakage is 0.001% of annual recharge.

The EIS states that water from the Springbok Sandstone is not generally used for human or livestock consumption within the vicinity of the development area due salinities ranging from 3,000-24,000 uS/cm. It is inferred from this statement that there are very few bores intersecting the Springbok Sandstone within the NWDA.

The majority of bores intersecting the Hutton Sandstone within the vicinity of the NWDA are to the east and north east and increase in number toward the outcrop area of the Hutton Sandstone. Due to the low amount of induced leakage predicted from the Hutton Sandstone, recharge into deeper parts of the basin is unlikely to be affected.

Induced leakage from the Precipice Sandstone is low and a more detailed assessment of the location of intake areas influencing the NWDA, CDA and SEDA would be required to determine actual recharge rates. For these reasons a comparison has not been made.

The CDA and SEDA are directly adjacent to each other (see Fig. 2.2-1 for location) and induced leakage rates have been combined for ease of comparison with aquifer recharge rates. Within the vicinity of the CDA and SEDA the Springbok Sandstone is undifferentiated within the Kumbarrilla beds, and thus no estimate of recharge based on outcrop area is possible.

The annual average induced leakage rate from the Hutton Sandstone is 0.07% of annual recharge of the aquifer from the area up-gradient of the CSG fields.

The QGC EIS states that induced leakage of groundwater from the overlying and underlying water supply aquifers during CSG operations directly impacts the recharge to the CSG formation (coal measures), and hence may affect the sustainability of licensed water allocations in the affected aquifers further away from the recharge zone. However, the EIS also states that the likelihood of this occurring is considered negligible and that precautionary monitoring and management of the key aquifers will be implemented as part of a Groundwater Monitoring and Management Plan.

In contrast the "Groundwater Monitoring Strategy Risk Assessment Matrix" in the EIS indicates that the probability of "Loss of available water/loss of water column in bores" (i.e. drawdown caused by the extraction of associated water) within bores tapping the "Precipice & Hutton" and the "Springbok & WCM" is high, but that the risk of "Reduction in through flow to down-gradient aquifers" is low.

It is the opinion of GA and Dr M.A. Habermehl that the risk of reduction in through-flow to down-gradient aquifers is highly likely to occur but the magnitude of the reduction will only be known after production commences and monitoring information becomes available. Modelled drawdowns should be compared with the monitoring results and the numerical model adjusted and re-run with updated information. Based on the current analysis, however, the magnitude of the impact on GAB water balances is likely to be low.

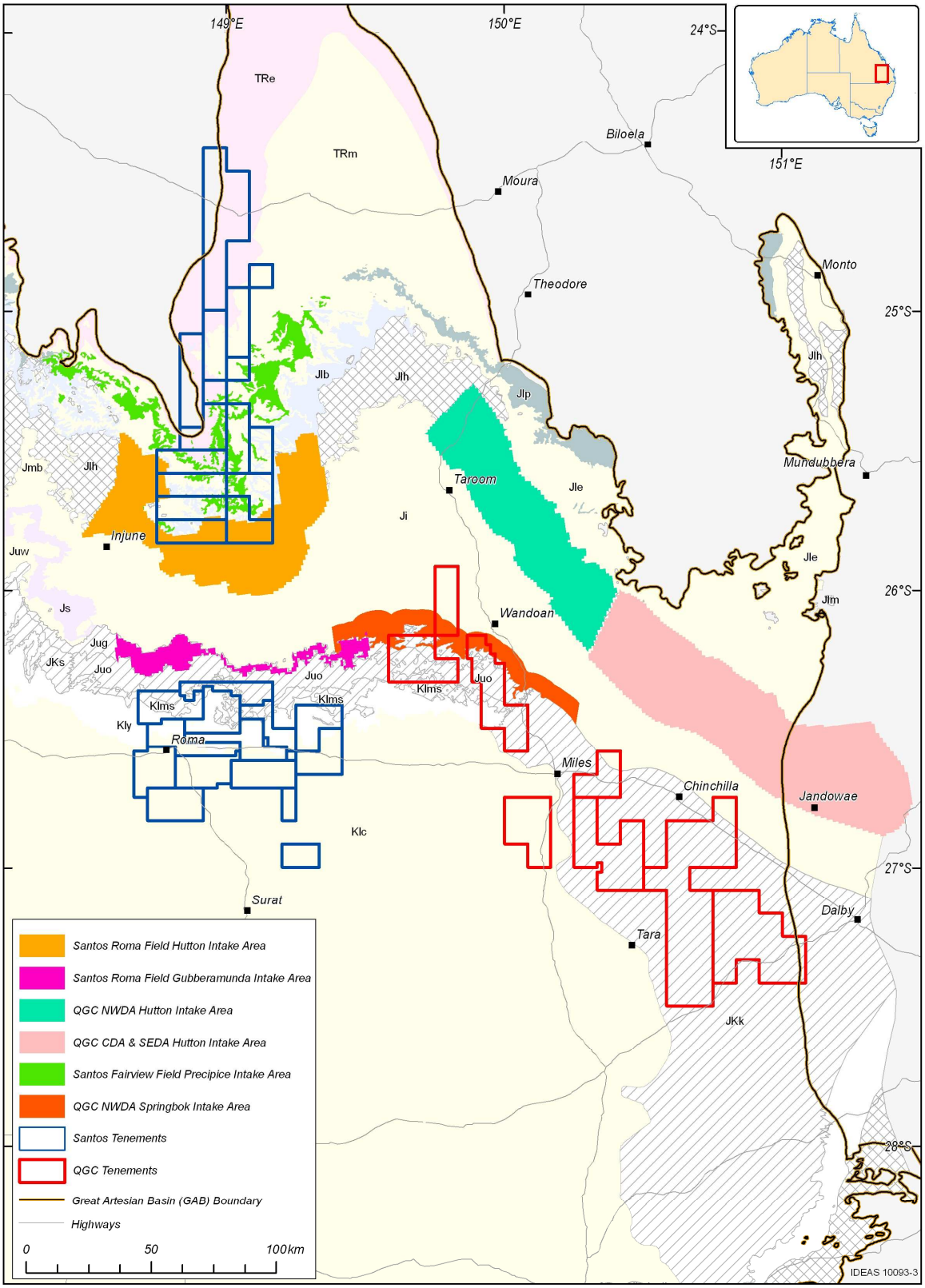


Figure 2.2-3. Location of QGC tenements shown relative to the defined areas of the GAB intake beds used for annual recharge calculations.

e. Potential impacts of fraccing on the structural integrity of aquifers and aquitards, and on existing groundwater flow processes.

QGC indicates that any fracture resulting from hydraulic fracturing ('fraccing') should remain contained within the coal seams of the Walloon Coal Measures (WCM). QGC expect no impact from hydraulic fracturing on overlying aquifers above and including the Springbok Sandstone based on the occurrence of the low permeability Upper Walloon Measure, which separates the Springbok Sandstone from the Macalister Coal Seam. However, where the Springbok Sandstone has incised into the coal measures direct connection is possible.

QGC states that if such a breach were to occur, the limited volume of saline water in coal (cleats compose ~1% of total volume) and low permeability of the interburden would provide little opportunity for saline contamination of the Springbok Sandstone. As the hydraulic gradient would be from the Springbok into the WCM, the most likely impact would be a flux of low salinity water into the uppermost coal measures (i.e. from the Springbok into the WCM). QGC have not specified any potential for gas generated from the WCM to migrate into the overlying formation.

QGC indicates that increased drilling, ongoing improvements in understanding of the reservoir, geologic modelling and use of technical diagnostics can be employed to successfully manage and prevent or limit the occurrence of vertical fracturing. Interconnection would be recognised by monitoring pressure changes and would be effectively remediated by cementing any fractures that did exceed target dimensions.

According to the EIS documentation, fracture fluid will be injected through perforated holes in a casing and accurately located over the mid-point of the coal seam allowing the fraccing to occur in a very targeted way. Additionally, downhole pressure and fraccing fluid viscosity will be monitored during the process to identify any unexpected fracture propagation.

As identified in the fraccing risk assessment, fracture fluid is injected through perforated holes in a casing and accurately located over the mid-point of the coal seam allowing the fraccing to occur in a very targetted way. Additionally, downhole pressure and fraccing fluid viscosity are monitored during the process to identify any unexpected fracture propagation.

In conjunction with an adequate number of appropriately instrumented monitoring wells drilled into the adjacent aquifers and aquitards to monitor the changes in pressure and chemistry, these industry standard measures outlined above are considered to be appropriate for the proposed fraccing activities.

As such, we consider that fraccing represents a low risk to the structural integrity of aquifers and aquitards, and on existing groundwater flow processes, so long as the proponent applies industry standards (e.g. API, 2009) and follows operating procedures as defined by the regulator. We note that QGC are currently working with APPEA and the Queensland Government (DERM) to minimise any potential impacts of hydraulic fracturing on landholder groundwater bores in the vicinity of fraccing treatment areas.

f. Initial advice on the likelihood of materiality of subsidence as the result of the proposals.

QGC identified subsidence as a potential impact of coal seam depressurisation and commissioned an assessment of the potential. The conclusion of the QGC assessment is that predicted settlements would result in up to 0.18 m of subsidence at the land surface. In the absence of appropriate data for the proponent to undertake a full geotechnical assessment of potential subsidence, we interpret the current information to suggest that the likelihood of subsidence is high. However, subsidence assessments for an existing CSG field in the Powder River Basin, USA, which represents a broadly similar geological setting to the Surat Basin, suggest that compression in the coal seams has not been transmitted to the surface due to the strength of materials above the coals. It is expected that such subsidence would be uniform over the area, and would not result in significant impact (Case et al. 2000).

In addition to subsurface monitoring of the coal measures and key aquifers, QGC have committed to developing an industry acceptable monitoring program of the likely subsidence across their tenements (QGC Response to DEWHA 300810 – Attachment 3 – Geodetic Monitoring). In line with this, we consider that the proposed monitoring and mitigation measures are adequate with regards to the specific responsibilities of the proponent. We would encourage the proponent, in concert with the State Government and other companies in the area, to consider the development of an integrated and collaborative program of monitoring across the region to complement that undertaken at the tenement scale.

g. Initial advice on the likelihood and materiality of any impact on MDB groundwater or connected surface water resources.

QGC (QGC Volume 3 QGC Groundwater Study Surat Basin, Queensland prepared by Golder Associates) show the generalised sub-crop geology and provide maps showing the water level contours (potentiometric surfaces) and electrical conductivity values and contours obtained from bores in the area between Pittsworth-Chinchilla-Miles and Wallumbilla for the:

- Condamine River Alluvium,
- Shallow unit (Griman Creek Formation, Surat Siltstone and Wallumbilla Formation),
- Intermediate unit (Bungil Formation, Mooga Sandstone, Orallo Formation and Gubberamunda Sandstone),
- Walloon unit (Westbourne Formation, Springbok Sandstone, Walloon Coal Measures and Eurombah Formation),
- Hutton unit (Hutton Sandstone, Evergreen Formation, Marburg Sandstone), and
- Precipice Sandstone unit

Groundwater levels in the Condamine River Alluvium mimic topography towards the valley of the Condamine River. Most groundwater levels in the GAB aquifers are down dip and generally are in an east to west direction. It is suggested that in some areas a potential connection exists between

the Walloon Coal Measures and the Hutton Sandstone.

Hydrographs of bores in the Condamine River Alluvium show longer term trends over approximately 28 years of declining groundwater levels (up to approximately 6 m) and also in a bore in the Walloon Coal Measures. Bores in the intermediate and Quaternary units shows small declines and other bores in the Walloon Coal Measures are static or show some declines across the area. No information has been provided in the report about possible leakage from the Condamine River Alluvium into the Walloon Coal Measures. No discussion is presented on the Murray-Darling Basin surface water aspects of the region, but it is predicted that there will be no measurable reduction or loss of baseflow contribution to rivers or creeks as a result of the QGC CSG project operation (p. 119).

A small number of QGC tenements intersect or are very close to the Condamine River and its alluvium downstream of Chinchilla, but this area is unlikely to leak into the Walloon Coal Measures because north west of Dalby there is no hydraulic connection between the Walloon Coal Measures and the river and its alluvium. Accordingly we consider that there is a limited likelihood of impact on MDB groundwater or connected surface water resources as a result of the proposed QGC operations.

2.3 SANTOS

2.3.1 Project Summary

Santos proposes to develop three CSG fields in an area extending from 50 km south of Roma northward to Rolleston. The project will deliver 5,300 petajoules (140 million m^3) to supply to the first stage of the LNG facility at Gladstone. This will involve the development of around 2,650 exploration and production wells. It is anticipated that about 1,200 wells will be established prior to 2015, with potential for 1,450 or more wells after 2015. The 'reasonably foreseeable development' (RFD) areas are comprised of tenements centred at Roma-Wallumbilla (Surat Basin) and Fairview and Arcadia Valley (Bowen Basin) north of Injune (Fig. 2.3-1). The total RFD area is 6,900 km^2 with a further 12,100 km^2 designated as 'future development areas'. The Roma field targets the Middle Jurassic Walloon Coal Measures for CSG development and the Fairview and Arcadia Valley fields target the Upper Permian Bandanna Formation. Santos anticipates drilling 1,200 production wells in the three fields up to 2014 and 1,450 wells after 2015.

Production of groundwater in the Fairview field is expected to increase from about ~8ML/day to a peak of about ~64 ML/day in 2012. Water production is expected to then steadily decline to about ~13ML/day in 2023, apart from a small increase to ~38ML/day in 2018.

Water production at Arcadia Valley is expected to commence in 2011 and rise to a maximum of ~13ML/day in 2013 and then to steadily decline to about ~8ML/day in 2023.

Production of water in the Roma field is expected to peak at ~3ML/day in 2012 and decline to about ~8ML/day by 2023.

The Santos Roma CSG field falls within the Surat Management Areas as defined in the Great Artesian Basin Water Resource Plan (DNRM 2005). This area overlies the full Jurassic to Lower Cretaceous sequence in the Surat Basin and the Upper Triassic sediments of the Bowen Basin in the west.

The Fairview CSG field fall predominantly within the Surat North Management Area. This covers the sediments of the Westbourne Formation, Injune Creek Group, Hutton and Precipice Sandstones within the Surat Basin and the Clematis Sandstone within the Bowen Basin. This area has a large number of high value recharge and discharge springs within the outcrop areas of the major aquifer units.

The northernmost Arcadia CSG field falls predominantly within the Mimosa Management Area. This covers the extent of the Triassic aged sediments of the Bowen Basin in the northern part of the Mimosa Syncline extending south to the Surat Basin in which the Clematis Sandstone is the only aquifer of significance.

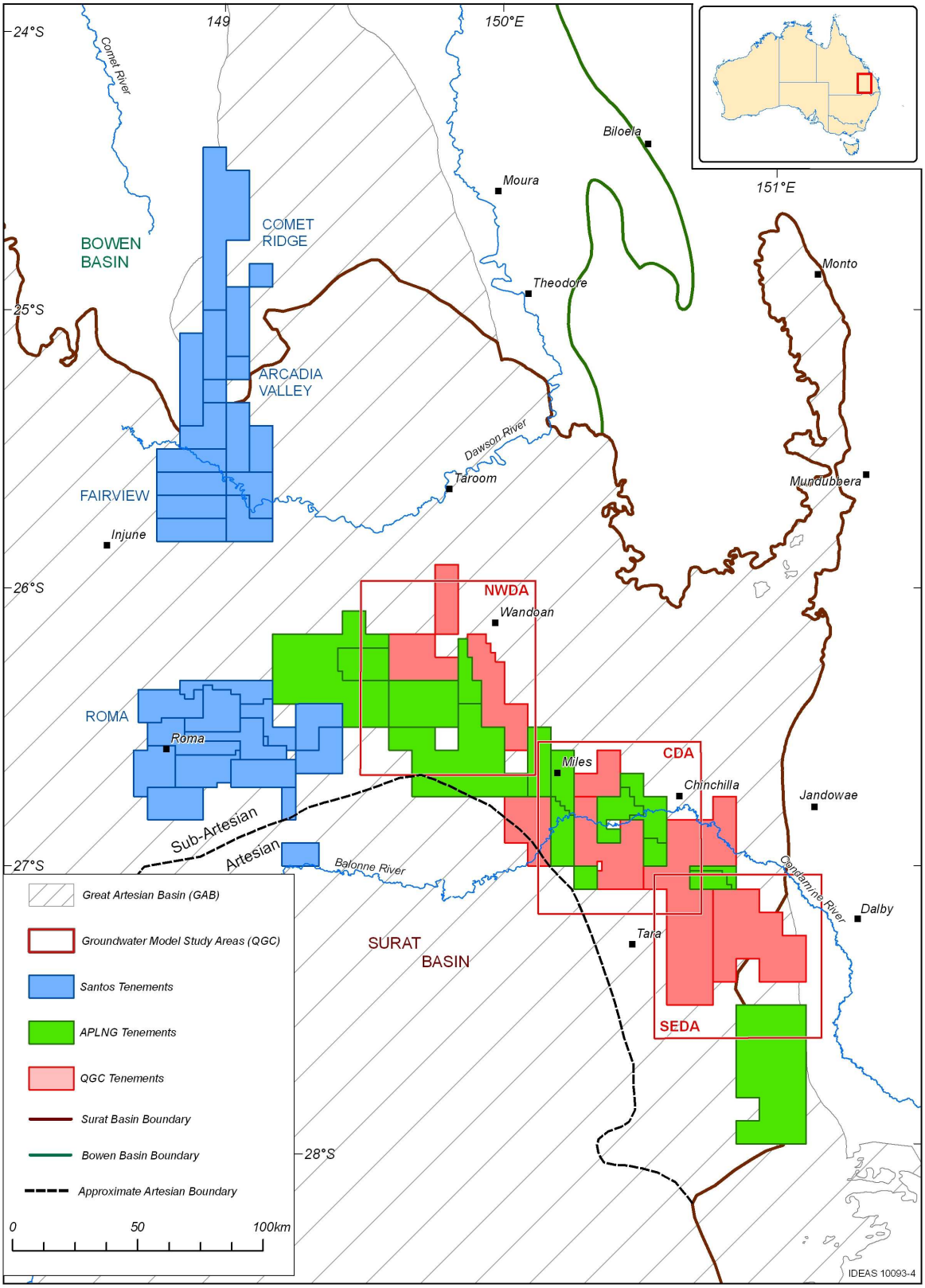


Figure 2.3-1. Location of coal seam gas tenements considered in the current assessment. The location of the artesian/sub-artesian divide, surface drainage and basin boundaries are also shown.

2.3.2 Summary of Assessment

The following summarises our assessment of the Santos proposed CSG development activities.

The adequacy of the proponents' hydrogeological models for estimating hydrogeological impacts on and within the Great Artesian Basin (GAB) and other affected surface and groundwater systems (this would include an initial assessment of the potential of one or more aquifers to depressurise and dewater and the likely impacts).

Santos present two hydrogeological simulation models – one 'project-scale' numerical groundwater simulation model based on MODFLOW, which predicts impacts for their proposed CSG operations in the Fairview and Arcadia CSG developments, and the other an analytical 'project-scale' model, which attempts to account for impacts resulting from CSG operations in the Roma region. Based on the information provided by Santos in their EIS documents, and discussions with Santos, our assessment concludes that:

- Within the limitations of available data, the 'project-scale' models produced are suitable for estimating hydrogeological impacts on and within the GAB and other potentially affected surface and groundwater systems within the influence of the Santos operations. We have, however, noted a number of shortfalls in the modelled occurrence, magnitude and extent of drawdown of the modelling approach taken, and we understand the proponent is in the process of developing a new model.

- The modelling results reported by Santos require further work to fully establish the uncertainties and sensitivity of the models to the large predicted drawdowns that will occur in the coal measures, and hence does not provide a level of confidence in the model outputs and the conclusions drawn from them.

- The modelled occurrence, magnitude and extent of drawdown potentiometric surfaces in the Gubberamunda Sandstone, Springbok Sandstone, Hutton Sandstone and Precipice Sandstone aquifers of the Roma area, Surat Basin, where the Walloon Coal Measures are depressurised and the modelled occurrence, magnitude and extent of drawdown of the potentiometric surfaces in the Hutton Sandstone, Precipice Sandstone and Clematis Sandstone aquifers of the Fairview and Arcadia area, Bowen Basin, where the Bandanna Formation is depressurised, are consistent with the proposed groundwater extraction operations, and are conservative in comparison with known impacts from existing Santos operations in the region.

- The models presented provide useful preliminary assessments of potential hydrogeological impacts resulting from a range of groundwater extraction activities. Santos is in the process of developing a new model, which will encompass the two areas and will underpin enhanced groundwater impact prediction and management.

Potential impacts of groundwater extraction on aquifer interaction (e.g. water flow, cross contamination), vertical recharge, structural integrity and artesian pressure as a result of the CSG activities. This applies to both quantity and quality of groundwater.

Potential impacts of groundwater extraction on aquifer interaction have, in general, been adequately addressed with, while there is scope for further elaboration regarding some aspects. Potential water quality impacts have been adequately identified and addressed. Based upon consideration of the hydrogeological, geological and project development information provided, we conclude that:

- The modelled vertical recharge and artesian pressure changes resulting from coal seam depressurisation are realistic and likely to result in groundwater flow into the coal measures from adjacent aquifers. We consider that these changes are reversible over timeframes of decades to centuries, depending on the specific aquifer and the management strategies applied.

- Cross-contamination is likely to be of little consequence as the majority of inter-aquifer transfer will involve the migration of higher quality water from adjacent underlying and overlying sandstone aquifers into the Walloon Coal Measures.

- The structural integrity of aquifers in relation to groundwater transmission is unlikely to be significantly impacted by the proposed groundwater extraction. We note that groundwater extraction may cause some aquifer compaction that is likely to result in subsidence (as identified by the proponent and discussed below).

Potential impacts of groundwater extraction on the EPBC Act listed endangered ecological community 'The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin.'

Based upon consideration of the hydrogeological, environmental and management information provided, we do not agree with Santos that the risk of impact from groundwater extraction to the EPBC Act listed endangered ecological community '*The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin*' is low, based on the following:

- The location of documented and/or surveyed natural discharge of groundwater sites (springs) from the CSG fields and the modelled zones of groundwater drawdown, with a significant number of surveyed and not-surveyed springs, including EPBC listed springs being located within the drawdown region of affected aquifers.

- Proposed monitoring programs do not state how trigger levels will be acted upon with regards to mitigating changes to groundwater flow or quality in springs.

Uncertainties in the extent of modelled groundwater drawdown, lead to the conclusion that monitoring and mitigation measures documented by Santos are inadequate. Monitoring of groundwater levels and quality are proposed, but there is insufficient acknowledgement of the uncertainty of modelled groundwater drawdown extents. It is suggested that Santos broaden the

spatial extent of their spring survey, assessment and monitoring programs. Additional natural discharge of groundwater sites or springs proximal to the CSG fields may need to be investigated and assessed to determine their EPBC Act significance. We suggest that the outcomes of such investigations could provide input to the monitoring and management process proposed by Santos and ensure that the baseline datasets upon which monitoring and mitigation measures are based are both robust and complete.

Potential for recharge into the GAB to be impacted in these areas due to CSG activities and the likely long-term impact(s).

Consideration of a range of hydrogeological, geological and groundwater production data provided by the proponents lead us to conclude that there is currently insufficient information to understand the relative significance of the proposed CSG activities in proportion to GAB recharge. Our analysis of the relative volumes of induced leakage from adjacent aquifers in comparison to GAB intake bed recharge volumes has had ambiguous results.

- Estimates from modelled leakage volumes provided by Santos suggest that leakage from GAB aquifers as the result of CSG operations may be a relatively high proportion of recharge to the operations area, particularly to the Gubberamunda Sandstone.
- The majority of existing groundwater users and environmental values in the Hutton and Precipice Sandstone aquifers are located up-gradient of the proposed extraction activities.

Potential impacts of fraccing on the structural integrity of aquifers and aquitards, and on existing groundwater flow processes.

Based upon the geological and technical information provided by APLNG with regards to the potential impacts of hydraulic fracturing ('fraccing'), we consider that the potential risks posed by fraccing are low. We conclude that:

- the fraccing risk assessments completed by Santos identify and assess relevant factors and risks involved in the process.
- while the potential exists for fraccing activities to impact on the structural integrity of aquifers and aquitards, and on existing groundwater flow processes, the competent application of industry standard technologies, techniques, and monitoring/mitigation processes proposed are appropriate.
- Santos have adequately assessed any potential risks associated with fraccing activities and have proposed appropriate monitoring and mitigation measures.

Initial advice on the likelihood and materiality of subsidence as the result of the proposals.

Based upon our assessment of the geological and geotechnical information provided, and relevant information from other sources, we agree with Santos that there is a likelihood of subsidence, and that this could result in several centimetres of surface subsidence.

However, based on the estimated magnitude of the subsidence (in the order or centimetres to tens of centimetres), and with reference to subsidence assessments for CSG activities in similar geological environments elsewhere, we consider that the risk of impacts to surface water and shallow groundwater systems are very low.

We suggest that the monitoring measures currently proposed by Santos could be strengthened by assessing deformation at the land surface as well as in the aquifers and coal seams.

Initial advice on the likelihood and materiality of any impact on MDB groundwater or connected surface water resources.

On the basis of the available information, we consider that there is a limited likelihood of impact on MDB groundwater or connected surface water resources as a result of the proposed Santos operations.

This assessment is based primarily on the fact that most of the Santos CSG operations are located outside of the Murray-Darling Basin catchment area (Fairview and Arcadia tenements) and the Roma CSG tenements are high in the Murray-Darling Basin catchment area, with few major streams being present. Impacts of CSG induced drawdown in overlying and underlying aquifers will have little impact on the Murray-Darling Basin groundwater and surface water resources.

2.3.3 Assessment of Proposed Development

a. The adequacy of the proponents' hydrogeological models for estimating hydrogeological impacts on and within the GAB and other affected surface and groundwater systems (this would include an initial assessment of the potential of one or more aquifers to depressurise and dewater and the likely impacts).

Model Description

For the Arcadia and Fairview CSG fields, SANTOS have developed a finite difference numerical groundwater simulation model (MODFLOW – the industry standard) to predict changes in hydraulic head in the Bandanna Formation and overlying Precipice Sandstone aquifer in response to CSG depressurisation activities within their tenements. This model is referred to as the 'Comet Ridge ' model. The model domain occupies an area of 83,500 km^2. The model is partitioned into 3 layers

representing the Precipice Sandstone, Triassic rocks (mainly the Rewan Formation) and Bandanna Formation (Bowen Basin – the source rock containing the gas). The overlying Hutton Sandstone, which outcrops over part of the Fairview tenements is not modelled. The model grid is aligned NNW, sub-parallel to the Hutton-Wallumbilla Fault, which is assumed to be an impermeable barrier to groundwater flow in the Bandanna Formation. The model cell size is variable with the minimum cell widths of 1,350 m, presumably within the tenements, but the sizes of the other cells are unknown. The model progressed in yearly stress periods, each with 5 time steps, from 2009 to 2028.

At Roma, an in-house analytical model developed by SANTOS consultants was used to predict the changes in hydraulic head in the Walloon Coal Measures due to CSG depressurisation. Details of the methodology are sketchy but by its very nature the analytical model would be simplistic and not as good as a numerical model in simulating the spatial variability of the system.

Both the Comet Ridge and Roma models have been superseded by a large scale finite element model but we have not received any documentation of the new model at the time of writing.

Model Parameters

For the Comet Ridge model, constant T values (the product of *Kh* and thickness) were applied to the layers representing the Precipice Sandstone and Triassic rocks. T values were distributed in layer 3 (Bandanna Formation) according to drill stem test results from individual wells in the tenements.

A uniform storativity value of 1×10^{-4} was assigned for layers 1 and 2 and 1.3×10^{-4} in layer 3. A specific yield value of 0.15 was adopted throughout. These values appear to reasonable estimates. Vertical leakage in layers 1 and 3 was set at $10^{-8} d^{-1}$ and 10^{-10} d^{-1} in layer 2.

Recharge in layer 1 was set at 15 mm/year in the Precipice Sandstone outcrop northwest of the Comet Ridge and recharge rates of 7 mm/year were specified in other areas of Precipice Sandstone outcrop.

Aquifer-stream bed (Dawson River) interaction was accomplished by specifying river cells with channel bed conductances in an area to the east of the CSG fields where the Dawson River and Hutton Creek incise the Precipice Sandstone.

In the Roma analytical model, all hydraulic parameters were assumed to be uniform across the entire CSG field.

Model Boundary Conditions (Comet Ridge model only)

No-flow boundaries were set in all layers where particular rock formations were absent and in the particular case of layer 3, to simulate the Hutton-Wallumbilla Fault. Head dependent outflow boundaries were set along the northern boundary of the Precipice Sandstone outcrop to simulate springs and seepages. General head boundaries were assigned to the western and southern boundaries of layer 1, and to the western boundary of layer 3.

Model Predictions

The Comet Ridge model predicts very large drawdowns to occur in the Bandanna Formation east of the Hutton-Wallumbilla Fault. Maximum drawdowns of 600 m are predicted in some places with large areas in excess of 300 m. Predicted drawdowns propagate steadily outwards from 2013 to 2028. Because of the relatively high transmissivity of the Bandanna Formation, the cone of depression is predicted to spread well beyond the boundary of the tenements.

A drawdown plume of >5 m is predicted to occur in the Precipice Sandstone. This plume is predicted to grow from a radius of influence of 50 km in 2013 to 100 km by 2028. The plume is centered about the Hutton-Wallumbilla Fault, an area where the Bandanna Formation directly underlies the Precipice Sandstone. The maximum drawdown of 65 m in the Precipice Sandstone is predicted to occur in 2028, collinear with the Hutton-Wallumbilla Fault south of Hutton Creek.

The Roma analytical model predicts large drawdowns to be generated in the Walloon Coal Measures between 2013 and 2028, up to 600 m in some places with significant acreage in excess of 500 m drawdown in the Wallumbilla area. The cone of depression is predicted not to spread much beyond the tenement boundaries because of the low transmissivity assigned to the coal measures in the model.

Drawdown in predicted to be minimal in the underlying Hutton Sandstone – about 3 m at the well-field perimeter after 20 years of operations. The radius of influence in the Hutton Sandstone is predicted to spread out to 54 km beyond the tenement boundaries after 20 years. This is an artefact of the high resistance to vertical flow imposed by the modellers at the top of the Walloon Coal Measures.

No predicted drawdowns are reported for the overlying Springbok Sandstone, which we consider to be an omission in the EIS. We also note the Roma model considers the SANTOS fields in isolation (unlike the Comet Ridge model which included the existing Spring Gully CSG operation). In reality there will be separate CSG operations in the Roma area concurrent with the proposed CSG depressurisation, so the drawdowns presented here will be the minimum case only.

Adequacy of Model for Estimating Impacts

SANTOS recognised that the Comet Ridge and Roma models were inadequate to predict drawdowns in the aquifers but they are probably applicable for predicting drawdowns in the coal measures. Accordingly they have replaced both models with a large scale finite element model comparable to that developed by APLNG. We are not in a position to comment on this model at present.

b. Potential impacts of groundwater extraction on aquifer interaction (e.g. water flow, cross contamination), vertical recharge, structural integrity and artesian pressure as a result of the CSG activities. This applies to both quantity and quality of groundwater.

Santos CSG developments in the Surat Basin are the Roma field, located within a ~50 km radius of Roma, and the Fairview field to the north-east of Injune. In the Bowen Basin the Arcadia field is located immediately north of the Fairview field (Fig. 2.3-1). In the vicinity of the Santos Surat Basin fields the majority of waterbores tap aquifers of the Bungil Formation, Mooga, Gubberamunda, Hutton and Precipice sandstones, with minimal extraction from the Walloon Coal Measures (Santos Appendix P2, p. 14). In the Bowen Basin the Hutton, Precipice and Clematis sandstones are the main aquifers utilised. Predictions of the drawdown in these aquifers for the respective CSG groundwater extraction projects have been made using numerical groundwater simulation models and the results showing impacts on the Precipice Sandstone (Bowen Basin) and Hutton Sandstone (Surat Basin) are presented in Santos Appendix P2 (summarised on page 67 of that document).

The modelling predicts that the volumes of groundwater pumped over a period of several decades from the Walloon Coal Measures will result in vertical leakage from the overlying and underlying aquifers of the Springbok Sandstone, Hutton Sandstone and Precipice Sandstone, and to a lesser extent from the Gubberamunda Sandstone, into the Walloon Coal Measures and cause drawdown of the potentiometric surface of these aquifers. A similar situation will occur in the Bowen Basin, with depressurisation of the Bandanna Formation (coal measures) resulting in drawdown in the Precipice Sandstone and transfer of groundwater into the Bandanna Formation.

Cross-contamination is considered a minor issue, as the physical characteristics and groundwater chemistry of the groundwater in the aquifers is similar and within acceptable ranges for water supply purposes. The exception is groundwater from both the Walloon Coal Measures and Bandanna Formation, which are more saline and have a different chemistry compared to the other Jurassic aquifers. However, the groundwater from the coal measures is pumped to the ground surface as associated water during coal seam gas production and disposed of or re-injected following desalination processes. Vertical leakage of better quality groundwater from the other Jurassic aquifers will take place into the Walloon Coal Measures and Bandanna Formation.

Structural integrity of the coal seams and aquifers of the Walloon Coal Measures and to a lesser extent the Bandanna Formation have the potential to be affected by groundwater extraction. Coal seam gas extraction involves the reduction of the hydrostatic pressure in the coal seams to allow gas production by desorption of methane from the coal. This depressurisation results in a large drawdown cone (up to 600 m) in the potentiometric surface of both the Walloon Coal Measures and Bandanna Formation, which spreads out from the coal seam gas field production area. The drawdown of the groundwater levels propagates vertically through the over- and underlying aquitards or confining beds into the over- and underlying aquifers. As a result, vertical leakage from these aquifers takes place towards the coal-bearing formations and drawdown cones develop in the potentiometric surfaces of the Gubberamunda, Springbok, Hutton and Precipice sandstone aquifers, though at a smaller scale than in the coal measures. The depressurisation of the other aquifers is generally too limited to affect the integrity of the aquifer rock structure, as drawdowns in those aquifers are only in the order of several metres.

c. Potential impacts of groundwater extraction on the EPBC Act listed endangered ecological community 'The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin'.

Risk Identification and Assessment

DEWHA (2001) stipulates that an assessment of each individual natural discharge of groundwater site (spring) is required to determine its origin (i.e. whether it is a "discharge" or "recharge" spring) and in turn, whether it is associated with the listed ecological community. It is our understanding that the main sources for spring data in Queensland - the Queensland Herbarium database and the Spring Register in the Queensland Water Resources (Great Artesian Basin) Plan 2006 - are not complete and that not all springs have been investigated, assessed and classified. This could lead to "recharge" springs as well as "discharge" springs being excluded from the EPBC listing, as well as springs being excluded simply because they are located in the recharge areas of the Great Artesian Basin ("recharge" springs are excluded as shown in DEWHA, 2001). This could also mean that the impacts of drawdown of groundwater levels caused by groundwater extraction may not be considered for communities assessed as being "recharge" springs purely on the basis of floristic composition.

The location and EPBC classification (i.e. "discharge" versus "recharge") of known springs in proximity to the Santos development areas is illustrated in Figure 2.3-2.

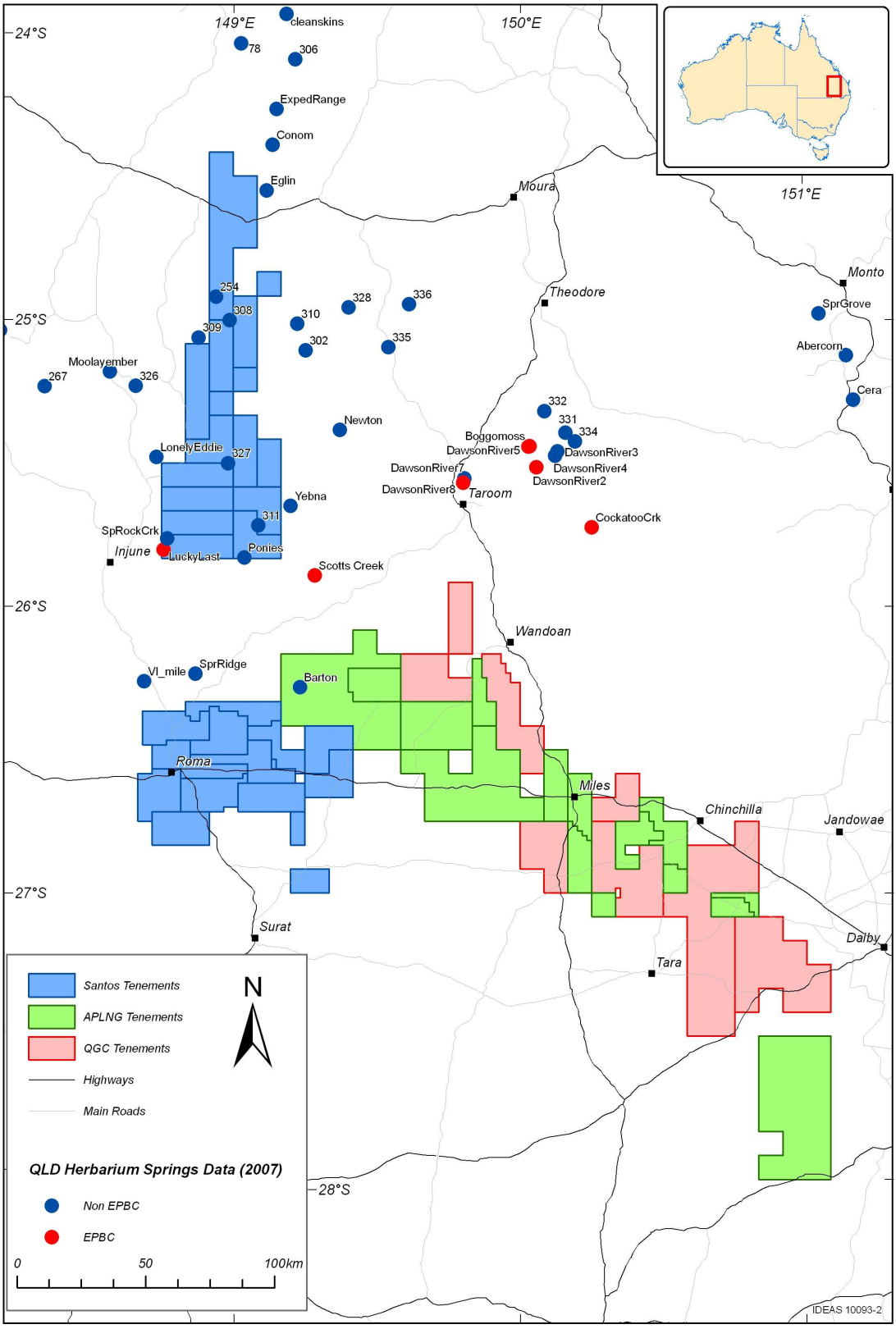


Figure 2.3-2. Location of natural groundwater discharge sites (springs) with respect to coal seam gas tenements considered in the current assessment.

Dry season field investigations (Santos Appendix N4) identify no rare or threatened aquatic species at active artesian spring sites in catchments adjacent to and containing the Santos CSG fields. In the Upper Dawson catchment the endangered (and EPBC Act listed) macrophyte salt pipewort (*Eriocaulon carsonii*) has been recorded at the Hutton Spring Group on Hutton Creek (Fensham and Fairfax 2004), and the consultant's report suggests that artesian springs elsewhere in the CSG fields may support similar communities, where comparable geomorphic and hydraulic conditions are present. Furthermore the consultant identifies the likely presence of the EPBC critically endangered Boggomoss Snail (*Adclarkia dawsonensis*) in one of the Santos leases to the west of Taroom, but not in any of the Fairview, Arcadia or Roma tenements.

Field investigations commissioned by Santos (Santos Suppl. Part 3, Attach. D5, App. A) identified numerous high value "recharge" and "discharge" spring complexes associated with the Gubberamunda Sandstone, Hutton Sandstone and Precipice Sandstone units. These springs are located near the Taroom and Injune townships and to the north of Roma. Several spring complexes are present within and in close proximity (<30 km) to the Santos development areas, including Lucky Last and Scott's Creek, two high EPBC value springs (see Fig. 2.3-2). Most of the "recharge" and "discharge" spring complexes in and near the Santos Fairview CSG field are artesian flows from the Hutton Sandstone and Precipice Sandstone aquifers. Some of the springs north of Roma are related to the Gubberamunda Sandstone aquifer.

According to Santos (Technical Memorandum, Golder Associates, 10 August 2010 – The impact from Santos CSG Fields on GAB Springs):

> "Two spring complexes located at the south western corner of Fairview and south west of Fairview have been assessed by Fensham and Fairfax for national environmental significance under the EPBC Act and have been classified following Fensham and Fairfax approach as discharge springs. Closer assessment of these springs shows that the spring located to the south western corner of Fairview CSG field is along the Hutton Creek drainage alignment, and at the same location that several GAB ROP recharge and watercourse springs. Additionally, the location corresponds to the outcrop of the Hutton Sandstone. Hence this spring may be of national environmental significance but is not a GAB discharge spring. The second spring, to the south east of Fairview is located at the outcrop of the Hutton Sandstone and should consequently be regarded as a GAB recharge spring. Santos CSG fields are located in what is considered the recharge beds area for the GAB. The GAB recharge area is commonly defined as the area where the GAB sandstone aquifer formations subcrop or outcrop on the eastern margins of the GAB."

The Taroom 1:250,000 Geological Map Sheet Explanatory Notes (Forbes et al. 1967) report that "The mound springs in the Hutton Creek area, north-east of Injune, are probably supplied by artesian water from the Precipice Sandstone, which rises to the surface through joints or small faults." If the latter is correct, then these springs are "discharge" springs, and should be considered under the EPBC Act.

"Recharge" springs with high conservation values occur approximately 30 km north and northeast of Roma, just north of the Santos Roma CSG development area (Fig. 2.3-2), within areas of the Gubberamunda Sandstone outcrop. Springs located within the Santos Arcadia CSG development area are related to the Clematis Sandstone aquifer and occur at the Clematis Sandstone and Moolayember Formation boundary in the Arcadia Valley.

The target formation for the Santos CSG development in the Comet Ridge fields (Fairview, Arcadia and Spring Gully) is the Bandanna Formation of the Bowen Basin, while the Roma CSG field targets the Walloon Coal Measures of the Surat Basin. Springs related to the Gubberamunda Sandstone, Hutton Sandstone and Precipice Sandstone are therefore potentially at risk of impact in the Santos Roma and Fairview CSG development areas and likewise springs associated with the Clematis Sandstone in the Arcadia CSG development area. In the Santos Comet Ridge (Fairview, Arcadia and Spring Gully) CSG fields springs related to the Hutton Sandstone, Precipice Sandstone and Clematis Sandstone are potentially at risk.

It is noted that there is some ambiguity in the definition of discharge springs. Some definitions of natural discharge sites are based on florististic composition rather than hydrogeological characteristics.

In all CSG development areas the radius of influence of groundwater drawdown is expected to extend beyond the boundaries of the CSG fields. Santos provide a predicted zero impact limit at around 250 km from the centre of the Santos Roma CSG development and a predicted zero impact limit at around 100 km from its Spring Gully and Fairview CSG fields (Technical Memorandum, Golder Associates, 10 August 2010 – The impact from Santos CSG Fields on GAB Springs). Drawdown in the Bandanna Formation is expected to result in the inter-aquifer transfer from the overlying Precipice Sandstone and Clematis Sandstone. Drawdown in the Walloon Coal Measures is expected to result in some inter-aquifer transfer from the overlying Gubberamunda Sandstone and Springbok Sandstone, and the underlying Hutton Sandstone and Precipice Sandstone aquifers, into the WCM.

Reduced artesian pressures caused by extraction of artesian groundwater from bores have been identified as a serious problem in the GAB, which have affected other bores and natural discharges, including springs (Habermehl, 1980, 2001, DEWHA 2001, Fensham et al. 2004). The EPBC listed Salt pipewort and Artesian milfoil are known to be associated with artesian springs within the vicinity of the CSG gas fields. Both species require actively flowing artesian water for survival.

Santos (Technical Memorandum, Golder Associates, 10 August 2010 – The impact from Santos CSG Fields on GAB Springs) states that:

- no GAB discharge springs (including mound springs) are located over the Santos tenements and within 100 km of the tenements including within the predicted impact zone;
- all springs located over and near Santos tenements are interpreted as GAB "recharge" springs and that no "discharge" springs are present. Santos concludes that its groundwater extraction activities are likely to have no impact on GAB mound springs and GAB fed GDE;
- in Fairview, there is a potential impact in the Precipice Sandstone limited to the vicinity of the contact zone between the Bandanna Formation and Precipice Sandstone (south

western corner of Fairview). The predicted impact is less than 3 m based on currently available modelling (expected case). Since the Santos gas field operations extract groundwater from the deep confined and the recharge springs derive their water supplies from the shallow perched aquifers (which are unconnected with the deep GAB aquifers), the recharge springs and their associated GDE will suffer no material impact from CSG production; and

- with regard to the EPBC Act, on the basis of this map and current interpretation, there is no evidence that Santos proposed CSG water production have anything but insignificant risk to matters of national environmental significance. Further details will be available in September in the groundwater impact report currently under preparation.

According to these Santos statements the "recharge" springs would not be affected by the lowering of groundwater levels as a result of CSG activities. The occurrence of perched GAB aquifers in the recharge areas is not elaborated on by Santos, nor is the issue of connection between GAB aquifers in the recharge areas and deeper in the GAB.

The drawdown cone of groundwater level depression associated with the extraction of CSG groundwater has the potential to impact on the aquifer pressure of and groundwater flows from artesian springs, which are within the cone of depression from CSG activities. Santos (Appendix P1 Groundwater Deep Aquifer Modelling - Matrixplus) suggests that most springs in the Taroom are a are associated with the boundaries between the Hutton Sandstone and its over- and underlying aquicludes. Santos also suggests that groundwater levels in the Hutton sandstone are unlikely to be affected by CSG operations. Baseflow to the Hutton Creek-Dawson River confluence in the Comet Ridge fields (Fairview, Arcadia and Spring Gully) from groundwater discharge sites and springs in the Precipice Sandstone outcrop area is most likely to be affected by groundwater drawdown in the Precipice Sandstone associated with CSG operations. Predicted drawdown at this locality will be less than 5 m (the 'trigger' value set by the Queensland Government to initiate 'make good' provisions under the Queensland Petroleum & Gas Act) in all cases and will be significantly less than the hydraulic head difference between the aquifer and the river according to Santos. Santos further suggests that, due to artesian conditions persisting in the Precipice Sandstone in this area, there is always positive flow according to their model predictions. However, Santos does not indicate the predicted drawdown, which is important, as even a drawdown of only a few metres may be sufficient to adversely affect the flow from springs. Santos expects that the contributions to the baseflow of the Dawson River and the discharge from springs near the Fairview CSG fields will not be significant as a result of the drawdown in the Precipice Sandstone aquifer. The potential for inter-aquifer transfer from the Gubberamunda Sandstone aquifer is considered to be small by Santos, but it recommends monitoring to validate this assumption.

The groundwater level drawdown cones in the affected GAB aquifers will, during the CSG production period and during the recovery phase, extend beyond the boundaries of the CSG development areas. Santos groundwater modelling indicates that there is a low risk that groundwater levels of springs will be affected. According to the initial 'project case' numerical groundwater simulation model projections, Santos determines that associated water production will have no implications for spring complexes (and their dependent ecosystems).

GA and Dr M.A. Habermehl consider that the risk methodology applied by Santos is appropriate for assessing potential risk to EPBC listed communities. Against the criteria specified in their risk assessment documentation, we suggest that there is a high risk of impact to any EPBC communities within the predicted groundwater drawdown areas. The risk is considered low if none of the springs maintain EPBC communities, however such springs, whether they be "discharge" or "recharge" springs, would still be impacted and the risk is to an environment with the potential to host such community rather than to a community *per se*.

On the basis of the available documentation, GA and Dr M.A. Habermehl consider that the majority of risks of significant impacts to the GAB and other affected surface and groundwater systems have been adequately identified and assessed. However, there are several identified springs (communities) within and in close proximity to their tenements for which the risk has been inadequately assessed. This includes the 'Lucky Last' spring complex in the southwest of the Fairview CSG field, whose classification as a "recharge" spring is considered questionable.

These conclusions, as with the risk assessments themselves, are based primarily on the relative proximity of CSG activities and modelled groundwater drawdown effects to possible spring communities. It should be noted that any variation in the groundwater simulation model predicted lateral and vertical extent of groundwater drawdown, resulting from uncertainties in the modelling, could alter the consequence and hence risk rankings.

Further Analysis

Santos state that a new numerical groundwater simulation model and accompanying report on impacts is currently under preparation and will be available in September (Technical Memorandum, Golder Associates – The impact from Santos CSG Fields on GAB Springs, p. 3). GA and Dr M.A. Habermehl have not had the opportunity to review this document, which was discussed by Santos during the meeting with GA and Dr M.A. Habermehl on 10 September 2010, but not tabled. As such we cannot provide any comment on the adequacy of any further assessment, monitoring or mitigation measures proposed by Santos.

Adequacy of Mitigation Measures and Conditions

Clearly defined monitoring information for the various types of environments (e.g. springs, groundwater bores, etc.) is presented by Santos including information regarding frequency and type of monitoring and analysis (Santos Suppl. Part 3, Attach. D2, pp. 107-110). Trigger mechanisms using water quantity and quality criteria are specified (Santos Suppl. Part 3, Attach. D2, pp. 110-112). However, despite putting in place provision for monitoring springs, Santos do not state how trigger levels will be acted upon with regards to mitigating changes to groundwater flow or quality in springs. Accordingly, GA and Dr M.A. Habermehl consider that the current mitigation measures need further elaboration.

Proposed Measures or Requirements

- Undertake detailed investigations of all springs within the groundwater model predicted drawdown extents. This would include detailed assessments of the EPBC significant Lucky Last and Scott's Creek springs in the vicinity of the Fairview CSG.

- Detail what remedial action might be taken should groundwater drawdown be identified as impacting water quantity or quality in any springs, as all remedial measures currently proposed address only impacts on groundwater bores.

- In order to estimate the potential for impacts caused by groundwater level drawdown, and the appropriate application of trigger values, the elevation of the spring (vent) and the potentiometric surface elevation of the source aquifer in the spring assessed should be determined prior to the onset of CSG groundwater extraction and be monitored throughout the production and recovery stages of the project lifetime.

Summary

On the basis of the available information, GA and Dr M.A. Habermehl consider that Santos have not adequately identified and assessed the risk of significant impacts of groundwater extraction on the EPBC Act listed endangered ecological community '*The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin*'. On the basis of the current information we cannot agree with Santos' assessment that the risks to EPBC communities resulting from groundwater drawdown are low, as the monitoring and mitigation measures are inadequate. We understand a revised groundwater impact report is currently being prepared.

d. Potential for recharge into the GAB to be impacted in these areas due to CSG activities and the likely long-term impact(s).

The potential for recharge into the GAB aquifers to be impacted due to CSG activities can be considered as three separate issues:

- Potential for infrastructure associated with CSG activities located on the GAB intake beds to reduce the amount of recharge due to soil compaction and a reduction in intake bed surface area due to infrastructure footprint.

- Potential for infiltrating recharge water to be contaminated prior to recharging the GAB aquifers.

- The effect on the GAB water balance caused by induced leakage from the GAB aquifers through extraction of associated water from the CSG formations.

It should be noted that a reduction in pressure due to water extraction down-gradient of the GAB aquifer intake beds will not affect the rate at which infiltrating water moves through the unsaturated zone into these aquifers. Hence the rate of recharge will not change. Recharge is a function of rainfall and rock permeability, which regulates the rate that water can enter the rock matrix of the aquifer.

The risk that infrastructure located within the intake beds of the GAB will significantly reduce the amount of groundwater recharge is negligible and is not assessed further. For example, estimates of the surface area covered by each production well drill pod, headworks and infrastructure are in the order of 0.005 km^2. As such, the total area impacted for the maximum 2650 proposed CSG extraction wells will be in the order of 13 km^2. This area is insignificant considering that the GAB intake beds cover an area of several thousand kilometres.

Santos has identified shallow groundwater contamination as a potential issue; specifically contamination from associated water brine ponds and chemical and fuel storage sites associated with processing plants. Santos state that Qld EPA guidelines will be adhered to in respect of the lining of brine ponds and on-site storage of chemicals and that these “best-practice” strategies will prevent on-site contamination.

GA and Dr M.A. Habermehl consider that the shallow groundwater monitoring strategies outlined in the Santos EIS should be sufficient to address any potential shallow groundwater contamination issues.

To assess the impact of associated water production upon recharge in terms of the GAB water balance, data for the latest leakage estimates for aquifers adjoining the coal seams in each development area were requested from Santos.

Information provided by Santos is based upon revised FEFLOW numerical models that include:

- best estimates for coal seam water production;
- boundary conditions that are more representative (and less conservative) than the original EIS modelling;
- additional model layers resulting in better estimates of the time for impacts to occur;
- cumulative impacts (Sean Davidge, pers. comm., 8 September 2010).

It is noted that these revised Santos models have not been assessed by GA and Dr M.A. Habermehl.

The induced leakage estimates from the Santos Roma and Fairview/Arcadia (Comet Ridge) CSG fields are provided in Tables 2.3-1 and 2.3-2 respectively.

Table 2.3-1. Estimates of induced leakage for the Santos Roma CSG field based on Santos modelled

water production scenarios.

Aquifer	Water Production Scenario	Leakage during field operation (ML/day)	Cumulative leakage during field operation (~25 yrs)	Cumulative leakage over total modelled period (~2700 yrs)
Gubberamunda Sandstone	Minimum	0.27	2.6 GL (~0.1 GL/yr)	132 GL (~0.05 GL/yr)
	Maximum	1.92	17.8 GL (~0.7 GL/yr)	738 GL (~0.3 GL/yr)
Hutton Sandstone	Minimum	0.82	7.8 GL (~0.3 GL/yr)	77 GL (~0.03 GL/yr)
	Maximum	4.9	45.3 GL (~1.8 GL/yr)	511 GL (~0.2 GL/yr)

Table 2.3-2. Estimates of induced leakage from the Santos Fairview and Arcadia (Comet Ridge) CSG field based on Santos modelled water production scenarios.

Aquifer	Water Production Scenario	Leakage during field operation (ML/day)	Cumulative leakage during field operation (~85 yrs)	Cumulative leakage over total modelled period (~2700 yrs)
Precipice Sandstone	Minimum	4.65	146 GL (~1.7 GL/yr)	373 GL (~0.14 GL/yr)
	Maximum	10.9	353 GL (~4.0 GL/yr)	491 GL (~0.18 GL/yr)

A comparison of the predicted volumes of groundwater extracted following vertical leakage from the GAB aquifers, including the Gubberamunda, Hutton and Precipice Sandstones with groundwater recharge in the intake beds is summarised in Table 2.3-3. This comparison puts into perspective the likely impacts of associated water extraction on the GAB water balance within the project area. Where sufficient information exists, a comparison has been made of the estimated groundwater recharge in the intake beds and the modelled induced leakage rates from overlying and underlying aquifers into the formations from which CSG associated water will be extracted.

Table 2.3-3. Estimated induced leakage as a percentage of aquifer recharge for Santos CSG fields

considered in the current assessment.

CSG field	Aquifer	Water Production Scenario	Est. annual recharge (ML/yr)	Est. induced leakage (ML/yr)	Leakage as % of recharge
Comet Ridge	Precipice Sandstone	Minimum	5180	1700	33
		Maximum	5180	4000	77
Roma	Gubberamunda Sandstone	Minimum	626	100	16
		Maximum	626	700	111
	Hutton Sandstone	Minimum	8560	300	3.5
		Maximum	8560	1800	21

It should be noted that the comparisons give an order of magnitude estimate only. Estimates of recharge are based on either chloride mass balance calculations undertaken by Kellett et al. (2003) or inferred recharge rates based on the proximity of intake beds to locations with existing chloride mass balance calculations. For the purpose of this comparison the intake area for each aquifer is the area of outcrop equal to the lateral extent of the field area plus a ~20 km buffer either side (a buffer of ~40 km was used for the Precipice Sandstone, Figure 2.3-3). It is recognised that the method used to define the intake bed areas for each field is relatively crude but is sufficiently precise to undertake an order of magnitude comparison. Additional further work would be required to increase the level of accuracy of the recharge rate estimates made in both the Springbok and Precipice Sandstones.

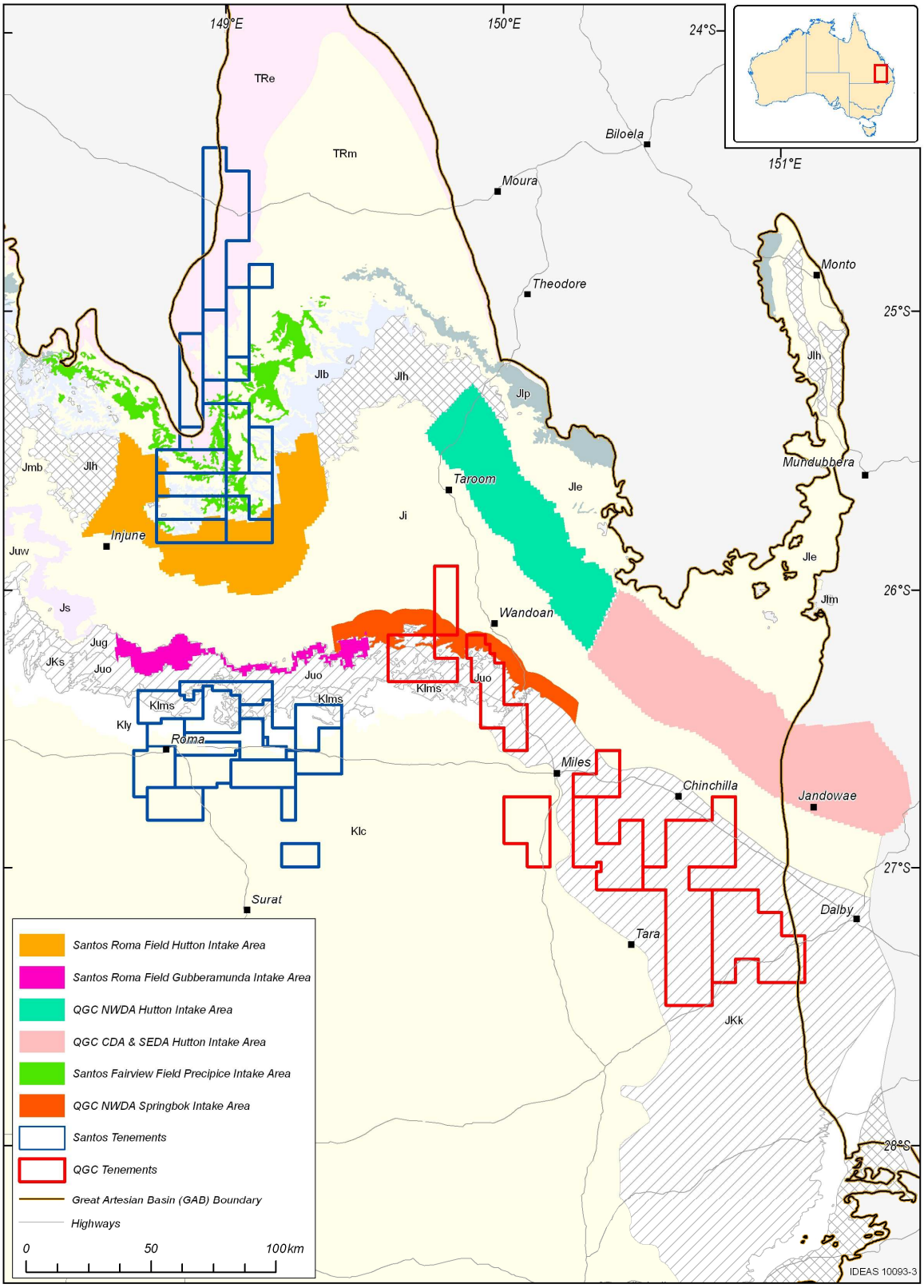


Figure 2.3-3. Location of QGC tenements shown relative to the defined areas of the GAB intake beds used for annual recharge calculations.

Santos – Fairview and Arcadia (Comet Ridge) CSG fields

Induced leakage from the Precipice Sandstone into the Bandanna Formation ranges from 33% to 77% of annual recharge of the aquifer from the area up-gradient of the CSG fields, based on the minimum and maximum (conservative) associated water production forecast scenarios respectively.

The induced leakage and the commensurate reduction in through-flow to hydraulically down-gradient parts of the aquifer is unlikely to significantly impact existing groundwater users within the vicinity of the Comet Ridge Field. Maps provided within the Santos EIS identify 41 registered bores intersecting the Precipice Sandstone, with most being situated hydraulically up-gradient of the modelled drawdown area. The Santos EIS identifies three privately registered bores and one DNRW bore, located in the area surrounding the proposed bore field as exhibiting drawdowns ranging from 7–25 m in the year 2028. However it should be noted that this map appears to omit bores intersecting the Precipice Sandstone located to the south of the Comet Ridge as shown in the Hydrogeological Framework Report for the Great Artesian Basin Water Resource Plan Area (Figure 4, DNRM 2005).

Santos - Roma CSG field

Within the vicinity of the Santos Roma CSG field, induced leakage from the overlying Gubberamunda Sandstone aquifer caused by the associated water production from the Walloon Coal Measures is estimated to be from 16% to 111% of annual recharge of the aquifer from the area up-gradient of the CSG field. This large range is due to differences in magnitude between forecast scenarios for minimum and maximum associated water production. However, Santos has indicated that ~10 ML/day (3650 ML/yr) of treated associated water will be reinjected (recharged) back into the Gubberamunda Sandstone. If this is the case there would in effect be an increase in the annual recharge rate to an estimated 4276 ML/yr, far in excess of the current predicted maximum induced leakage. In this situation an issue that has yet to be identified or addressed is the possibility of overpressurisation in the Gubberamunda Sandstone and additional induced leakage from the aquifer.

Induced leakage from the Hutton Sandstone ranges between 3.5% and 21% of annual recharge to the aquifer from the area up-gradient of the CSG field. Registered bores intersecting the Hutton Sandstone are concentrated to the north of the Santos Roma CSG field adjacent to the intake beds of the Hutton Sandstone. These bores are hydraulically up-gradient of the Roma CSG field and will not be impacted. However, as already identified and assessed by the proponent, a small number of bores are located within and to the south and southwest of the Roma field and are likely to be impacted resulting in drawdown of the groundwater levels.

e. Potential impacts of fraccing on the structural integrity of aquifers and aquitards, and on existing groundwater flow processes.

Santos provides a comprehensive report and risk assessment on their hydraulic fracturing ('fraccing') process. The main physical risk is identified as the deviation of generated fractures out of the coal seam into the surrounding aquifers.

Santos provides several reasons to justify the assessed low risk of fracture deviation out of the coal seam. Firstly, a typical fracture radius is up to 20 m and within this radius there is very limited probability of a fracture intersecting aquifer units. Secondly, the elastic nature of overlying or underlying sedimentary rocks (in contrast to the brittle nature of coal) would be a barrier to fracture propagation even though it is possible for a breach to occur.

According to the EIS documentation, fracture fluid will be injected through perforated holes in a casing and accurately located over the mid-point of the coal seam allowing the fraccing to occur in a very targeted way. Additionally, downhole pressure and fraccing fluid viscosity will be monitored during the process to identify any unexpected fracture propagation.

In conjunction with an adequate number of appropriately instrumented monitoring wells installed in the aquifers and aquitards of interest to monitor the changes of pressure and chemical components, these industry standard monitoring measures are considered to be appropriate for the proposed fraccing activities.

As such, we consider that fraccing represents a low risk to the structural integrity of aquifers and aquitards, and on existing groundwater flow processes, so long as the proponent applies industry standards (e.g. API, 2009) and follows operating procedures as defined by the regulator.

f. Initial advice on the likelihood of materiality of subsidence as the result of the proposals.

Santos identified subsidence as a potential impact of coal seam depressurisation and commissioned an assessment of the potential. The conclusion of the Santos assessment is that predicted settlements would result in up to 0.2 m of subsidence at the land surface within the Roma tenements, and 0.045 m at their Arcadia and Fairview fields. In the absence of appropriate data for the proponent to undertake a full geotechnical assessment of potential subsidence, we interpret the current information to suggest that the likelihood of subsidence is high. However, subsidence assessments for an existing CSG field in the Powder River Basin, USA, which represents a broadly similar geological setting to the Surat Basin, suggest that compression in the coal seams has not been transmitted to the surface due to the strength of materials above the coals. It is expected that such subsidence would be uniform over the area, and would not result in significant impact (Case et al. 2000).

Santos proposes to monitor water pressure in aquifers in the units overlying the coal measures and to install extensometers in key locations to monitor compression of the coal measures. These

measures are considered appropriate for assessment of subsurface subsidence associated with elastic deformation of the coal measures. However, we suggest that the proponent could improve their monitoring program by, in conjunction with relevant State Government agencies and other proponents, establishing baseline and ongoing geodetic monitoring to quantify deformation at the land surface. This should link from the tenement scale to the wider region across which groundwater extraction activities are occurring.

g. Initial advice on the likelihood and materiality of any impact on MDB groundwater or connected surface water resources.

There is no likelihood of impacts on MDB groundwater or connected surface water resources as a result of Santos CSG operations in the Roma area.

The Santos CSG operations in the Roma area are removed from the main river system of the Condamine River as they are located higher in the catchment, near the surface water divide of the Great Dividing Range. The Santos CSG Roma tenements overlie the Lower Cretaceous Coreena and Doncaster Members of the Wallumbilla Formation and the Upper Jurassic Bungil Formation, Mooga Sandstone and Orallo Formation outcrops and sub-crops. These areas are recharge areas for the aquifer sandstones in this region rather than discharge areas. According to their numerical groundwater simulation model predictions, Santos predict that their CSG activities will cause drawdown of the potentiometric surface of the Walloon Coal Measures and on a smaller scale cause drawdowns of the potentiometric surfaces of the Springbok Sandstone and possibly the Gubberamunda Sandstone, but not to any of the hydrostratigraphic units mentioned previously.

The Santos Fairview and Arcadia CGS fields are outside the Murray-Darling Basin, and as such cannot impact MDB groundwater or connected surface water resources.

2.4 COMMENT ON CUMULATIVE IMPACT ASSESSMENTS

The following section provides comment on the cumulative impact assessments of the proposed CSG developments. This was not explicitly requested in the scope of services detailed in the project contract between GA and DEWHA, but its potential significance necessitates some discussion of the extent to which the EISs have considered the issue of cumulative impacts.

All proponents have recognised that the potential impacts of CSG activities are not likely to be restricted to the tenements within which CSG and associated groundwater extraction takes place. APLNG and Santos have attempted to quantify these impacts, whilst QGC has provided a qualitative assessment of the likely impacts. The cumulative assessments focus primarily on the interaction and potential cumulative effects of other existing and proposed CSG operations in the local area. Non-CSG activities with a potential to impact on groundwater, such as underground coal gasification, mining, irrigation and power generation, have also been identified and considered.

APLNG based their cumulative assessment (APLNG Vol. 2, Ch. 25) on available public domain data as well as their own data. The APLNG assessment determined a medium impact on groundwater with generally low risk, with the exception of a high risk of reduced groundwater production rates in landholder bores. In this context, APLNG have proposed an adaptive groundwater monitoring program predicated on risk identification and management to be key in managing potential groundwater impacts, and propose the development of a regional monitoring network assisted by projections from their numerical groundwater flow model (APLNG Vol. 2, Ch. 25, p. 9).

A similar but less substantive assessment was completed by Santos (Santos Suppl. Part 3, Attach. J). The Santos cumulative impact assessment determined a medium impact on groundwater for the CSG fields. The Santos assessment concluded that their activities will require

- mitigation measures
- the application of specific management practices
- specific approval conditions
- and targeted monitoring programs.

Several of the proponents noted both the inability to access detailed data and modelling related to other existing or proposed (CSG) developments, and the inadequacy of publicly available data, as major impediments to providing meaningful assessments of cumulative impact (e.g. QGC Vol. 3, Ch. 10).

We consider that the APLNG and Santos 'cumulative' models represent useful preliminary assessments of potential regional hydrogeological impacts resulting from a range of groundwater extraction activities, and that the APLNG model in particular provides a good starting point for development of a regional model to underpin groundwater impact prediction and management. However, we consider that these cumulative impact assessments are unavoidably inadequate, due to the fact that they do not incorporate the best available information from a number of sources such as confidential drilling and production data from other companies. We recognise, however, that individual proponents are not in a position to access such data.

We consider that a robust cumulative impact assessment is fundamental to informing a risk assessment and the development of an adaptive management framework that includes a regional monitoring strategy. A critical requirement for such a robust cumulative impact assessment is access to data from across the region, and commercial interests dictate that any given company will have limited access to data produced by other companies. A cumulative impact assessment undertaken using only a subset of the existing data is not conducive to developing a robust understanding of the likely impacts of groundwater drawdown and its associated impacts across a region. Furthermore, a robust cumulative impact assessment requires accurate estimates of groundwater extraction, and we note that these are highly uncertain until CSG extraction is underway.

Vink et al's 2008 scoping study of the groundwater impacts of CSG development also identified significant data limitations relating to coal seams and surrounding aquifers, and considered that these must be dealt with to inform policy development in relation to multiple CSG developments. In particular, they reported on the significant variability in gas and water extraction relationships (Figure 2.4-1) between the Surat (Walloon) and Bowen basins (Bandanna, Baralaba and Moranbah). The results of the Vink et al. study accord with our consideration that, in order to assess cumulative impacts of groundwater extraction, predicting the quantity of water production from future CSG development is a necessary but complex issue.

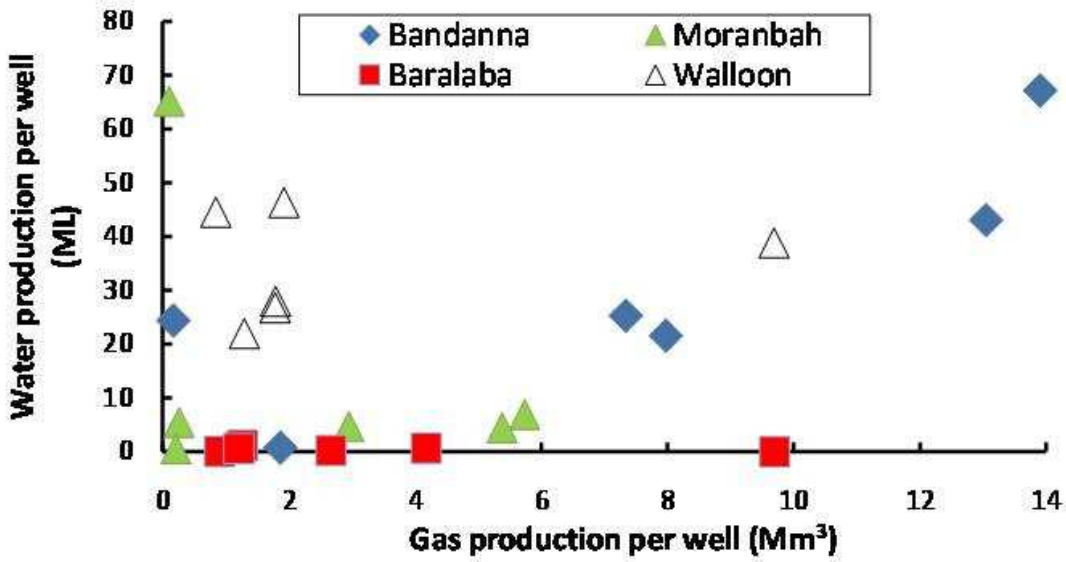


Figure 2.4-1. Gas and water production reported in 2007 from producing CSG tenements in the Bowen and Surat basins. Aggregate production values are reported every 6 months by companies for each tenement (from Vink et al. 2008).

The difficulties in accessing relevant data to complete a robust cumulative impact assessment suggest that governments may need to take a lead role in acquiring, compiling and assessing such data in a commercial-in-confidence setting. This would support the development of a robust cumulative impact assessment that maximised the utility of all existing data without compromising commercial sensitivity. Furthermore it is suggested that in the context of considerable uncertainties

relating to the cumulative impacts of multiple CSG develops, an adaptive management framework be developed within which the data could be analysed and modelled, with the outputs informing the development of appropriate monitoring and mitigation measures and strategies. Vink et al. (2008) reach a similar conclusion regarding the need for an adaptive management approach, where new findings from a number of different lines of evidence can be incorporated into resource planning decisions as the information becomes available. With this in mind, we agree with the proponents that it is imperative that the regional numerical hydrogeological groundwater simulation modelling required to assess cumulative impact of the CGS activities be carried out by the relevant government regulatory authorities.

We note that the Queensland Government's "Blueprint for Queensland's LNG Industry" (DEEDI 2009), and the attested commitment of the proponents and other CSG operators in the south central Queensland region, will promote collaboration to the development of an agreed approach to regional groundwater monitoring and cumulative effects groundwater modelling. The implementation and use of this approach to enable effective impact and risk mitigation will require high levels of collaboration with other project proponents and regulatory authorities over time. This is in agreement with Vink et al.'s (2008) conclusion that there is a critical need for involvement from stakeholders (particularly the CSG industry) in formulating and implementing a monitoring strategy.

2.5 Further Questions

Further questions that should be put to the proponents or QDERM concerning hydrological or water quality impacts on groundwater and surface water systems as would affect matters of National Environmental Significance.

A number of questions have already been put to Qld DERM and the proponents during the course of the assessment. No further questions are proposed at this time.

Questions that should be put to the proponents or QDERM concerning Murray-Darling Basin system impacts.

A number of questions have already been put to Qld DERM and the proponents during the course of the assessment. No further questions are proposed at this time.

2.6 Work Plan and Budget for Additional Work

Work plan and budget for undertaking additional work to fill the critical information gaps, taking into account synergies with the Great Artesian Water Resources Assessment being conducted jointly by GA and CSIRO.

We consider that a number of tasks are necessary for filling critical information gaps relating to the assessment of likely impacts of proposed and potential future CSG operations on matters. These are as follows:

- Undertake a detailed review of the validity of the new models developed by the proponents according to guidelines established in the Murray Darling Basin Commission Groundwater Modelling Guidelines (http://www2.mdbc.gov.au/data/page/127/model_guide.pdf). Without having access to the models to make a preliminary assessment of the magnitude of the work involved in this, we consider that this could be done within approximately 2 months of receiving the models, at a total cost of approximately $100,000.

- Undertake a comprehensive review of the available data relating to measured hydraulic characteristics of all hydrostratigraphic units (aquifers and aquitards), and use this to evaluate the appropriateness of the parameters used in the new models and inform the parameterisation of a regional scale model. Such a review of existing, public domain is planned to be undertaken by GA/CSIRO over the next 6 months as part of the GAB Water Resources Assessment. The scope of incorporating additional, private domain data is not clear without undertaking a scoping of the available data. Our very rough estimates of this task, in the absence of any scoping of the extent of this data, is that this could be done within approximately 3 months.

- Develop a regional scale 3D hydrostratigraphic framework for understanding the connectivity between hydrostratigraphic layers, and in which to set these current, and new EIS proposals. This work is planned to be undertaken to some extent over the next 6 months by GA/CSIRO as part of the GAB Water Resources Assessment, although this will not include the task of incorporating private domain data. Our very rough estimates of this additional task, in the absence of any scoping of the extent of this data, is that this could be undertaken within approximately 3 months additional to the 6 months of the GAB Water Resources Assessment.

- Assess the implications of petroleum and basin analysis work completed in the past few years should be assessed in order to develop a better understanding of the hydrogeology of the Bowen Basin and possible hydraulic connection to the Surat Basin. This exercise requires the acquisition of data identified in the previous tasks, and will take approximately 2 months.

- Undertake preliminary assessment of any new CSG proposals as requested by DEWHA. We consider that this will take approximately 3 months per proposal to enable adequate consideration of the presented information, consultation with proponents and regulators, and acquisition of additional information as required.

- Develop a regional scale, groundwater flow model that incorporates understanding of hydraulic connectivities between hydrostratigraphic layers, and enables the identification of short term and longer term cumulative impacts on groundwater from CSG operations in Qld

and NSW (NOTE: We understand that this work is currently being planned by Qld and that discussions may have been initiated to this effect with NSW).

- Using the groundwater behaviour predicted by the regional scale model, develop a monitoring and management strategy that enables early identification of change before impacts on identified groundwater values occur (NOTE: We understand this work is currently being planned by Qld).

A very draft scoping of the first five of these tasks is summarised in Table 2-6-1 below. We consider that the scoping of the other tasks will require considerable consultation with other organisations and is not possible at this stage. We note that the information in this table is very approximate and would require more detailed scoping to confirm the timeframes and costs.

Table 2.6-1. Estimated induced leakage as a percentage of aquifer recharge for Santos CSG fields considered in the current assessment.

Task	**Approximate timeframe**	**Approximate cost**
1. Detailed review of the validity of the new and revised models	1 month	$50,000
2. Comprehensive review of the available data relating to measured hydraulic characteristics of all hydrostratigraphic units	3 months	$100,000
3. Regional scale 3D hydrostratigraphic framework	6 months (after completion of Task 2)	$200,000
4. Hydrogeology of the Bowen Basin	4 months (after completion of Task 2)	$150,000
5. Preliminary assessment of any new proposals for CSG	3 months (per proposal)	$100,000

3. Conclusions and Recommendations

We have reviewed the content of the Environmental Impact Statements and supporting documentation put forward by the three proponents, along with subsequent additional data and information, supplemented by discussions with the proponents. Based on this information, we consider that, while the Environmental Impact Statements relating to proposed and potential future CSG extraction activities in the Surat and Bowen Basins, Queensland identify and assess a number of potential local scale (project area) groundwater related impacts, there are some matters that require further consideration under the *Environment, Protection and Biodiversity Conservation (EPBC) Act 1999*.

3.1 Key Recommendations

Although we consider that a number of the issues requested by DEWHA have not been fully addressed by the material within the EISs, we note that in many cases the necessary information relating to the impacts of individual operations has either been developed since the submission of the EISs, or can be acquired in the course of subsequent development under an explicit adaptive management strategy. We have noted that the current groundwater modelling is inadequate in terms of scale and detail to address the impacts of multiple CSG developments on groundwater interactions in the GAB and hence on EPBC listed discharge springs communities in the GAB. However, if the following recommendations are implemented, it should be possible to manage the potential groundwater impacts of proposed and potential future CSG extraction activities in the Surat and Bowen Basin, and minimise the risk of unintentional outcomes for the Great Artesian Basin.

We thus make the following key recommendations for a staged process of adaptive management of CSG development.

1. Management of uncertainty

Given the resulting levels of uncertainty in relation to cumulative impacts at the regional scale of a number of CSG developments, a precautionary approach should be taken in relation to approving proposed and potential CSG developments, recognising the fundamental principle that excessive rates of groundwater extraction will have impacts on groundwater and connected surface water systems, and groundwater dependent values such as EPBC listed discharge springs communities in the GAB groundwater dependent ecosystems.

In the absence of sufficient evidence to characterise and quantify these potential impacts or to define excessive rates of extraction, we recommend that proposed and potential CSG development should be undertaken with an explicit requirement to minimise and mitigate any

impacts during production.

2. Refinement of existing models as an initial basis for development

We have noted a number of shortfalls in the models presented in the EISs, but consider that overall these models provide useful preliminary assessments of potential hydrogeological impacts resulting from a range of groundwater extraction activities.

We recommend that the predictions of these models could serve as a preliminary basis for informing initial decisions about the approval of the CSG developments, pending a positive assessment of the validity and implications of the new models we understand have been developed by the proponents since the submission of the EISs.

3. Modelling regional scale impacts of cumulative CSG developments

We consider that the proponents have, for the most part, proposed appropriate mitigation measures to address the short term, local scale impacts of groundwater extraction on groundwater users. However, it is not clear that the measures proposed in the individual proponents' proposals will be adequate to fully address regional scale impacts on EPBC values or aquifer interactions.

We recommend that a regional-scale, multi-state and multi-layer model of the cumulative effects of multiple developments, and a regional-scale monitoring and mitigation approach will be developed to assess and manage these impacts. Such a model could be used to set the parameters for an adaptive management framework in which monitoring and mitigation strategies can be developed that will be applicable at both the project and regional scale. We consider that concerted Commonwealth and State action will be necessary to develop such a model as a high priority.

4. Management of long-term water balance impacts

We emphasise that any groundwater model, no matter how well-parameterised, calibrated and validated, is an interpretation of a groundwater system, and therefore subject to uncertainty. Given that there are shortfalls in the parameterisation and calibration of the models presented in the EISs, we consider that there are high levels of uncertainty in the accuracy of the predicted impacts of CSG development on groundwater behaviour and on EPBC listed ecological communities dependent on discharge from the GAB.

For this reason, **we recommend that measures to mitigate the potential impacts of proposed operations on water balances, such as the re-injection of treated associated water back into appropriate permeable formation(s) to re-establish pre-development pressure levels, be explored as an option and considered as a condition for approval of any development activities.** This needs to be undertaken in conjunction with appropriate measures to forecast and proactively manage any short term impacts, and should enable the reversal of any medium to long term changes in artesian groundwater pressures before they could impact on EPBC listed discharge communities. The design of and volumes involved in these activities should be informed by a regional-scale groundwater model.

3.2 Additional Recommendations

The adequacy of the proponents' hydrogeological models for estimating hydrogeological impacts on and within the Great Artesian Basin (GAB) and other affected surface and groundwater systems (this would include an initial assessment of the potential of one or more aquifers to depressurise and dewater and the likely impacts).

- Adaptive monitoring, data collection, update of numerical groundwater simulation models and re-interpretation of results should be undertaken, with regular updates in quarterly and annual reporting to State and Commonwealth agencies.
- Effort should be aligned between the State and Commonwealth Governments to coordinate the necessary data collation, data collection and modelling efforts to develop such a regional scale model.
- Proponents should provide all data relating to the hydraulic connectivity between aquifers and aquitards to substantiate the model parameterisation.
- The groundwater simulation models should be calibrated against measured piezometer response in areas where CSG development has already commenced.
- The parameterisation and reporting of all numerical groundwater model outputs should conform to the recommendations in the Murray Darling Basin Commission Groundwater Modelling Guidelines.

Potential impacts of groundwater extraction on aquifer interaction (e.g. water flow, cross contamination), vertical recharge, structural integrity and artesian pressure as a result of the CSG activities. This applies to both quantity and quality of groundwater.

- Understanding of the hydrogeology of the Bowen Basin and possible hydraulic connection to the Surat Basin should be improved through the assessment of petroleum and basin analysis work completed in the past few years.
- Hydrogeological, hydrochemistry (including environmental isotopes) and temperature data sets for the Surat Basin should be reviewed and interpreted to characterise vertical and lateral groundwater movement. This data should be used to underpin prediction and assessment of the impacts of CSG development.

Potential impacts of groundwater extraction on the EPBC Act listed endangered ecological community 'The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin.'

- Understanding of the connectivity between all springs and groundwater systems should be improved by surveying elevations of known springs and determining their source aquifers. The likely impacts of drawdown on springs can then be assessed using modelled potentiometric surfaces;

- The current risk assessment, monitoring and mitigation measures for springs within the GAB should be reviewed in light of the degree of uncertainty in the existing modelling results;

- Where spring sites are located within tenements or the modelled limits of aquifer drawdown, the proponents should undertake additional monitoring including quarterly ecological assessments for at least the first 12 months of operations in order to determine the seasonal presence/absence of EPBC Act listed communities;

- The definition of natural springs, as applied under the EPBC Act, should be reviewed by DEWHA with particular reference to the discrimination of 'discharge' versus 'recharge' springs. This will ensure that all natural groundwater discharge sites are adequately assessed in terms of their potential to host EPBC significant communities that can be impacted by changes to groundwater conditions. The hydrogeological processes associated with so-called "recharge" springs are not well understood (in particular, their connectivity with groundwater systems), and it is possible that these springs may be also affected by drawdown from CSG activities.

Potential for recharge into the GAB to be impacted in these areas due to CSG activities and the likely long-term impact(s).

- Further trials should be undertaken to establish the feasibility of large scale re-injection, including assessment of the hydraulic and hydrochemical implications of injecting treated associated water, to offset any potential impacts on GAB water balance.

Potential impacts of fraccing on the structural integrity of aquifers and aquitards, and on existing groundwater flow processes.

- The proponents should adhere to standard operating procedures as defined by the regulator.

Initial advice on the likelihood and materiality of subsidence as the result of the proposals.

- Baseline and ongoing geodetic monitoring programs should be established by proponents in consultation with State Government agencies (e.g. Qld DERM) to quantify deformation at the land surface. This should link from the tenement scale to the wider region across which groundwater extraction activities are occurring.

Initial advice on the likelihood and materiality of any impact on MDB groundwater or connected surface water resources.

- Data should be acquired through drilling and pumping tests to quantify the connectivity between aquifers overlying the Walloon Coal Measures;

4. References

API. 2009. *Hydraulic Fracturing Operations – Well Construction and Integrity Guidelines*. API Guidance Document HF1, First Edition. American Petroleum Institute

Case, J.C. Edgar, T.V. & De Bruin, R. H. 2000 Subsidence potential related to water withdrawal in the Powder River Basin. *Wyoming Geo-Notes* **68** 19-20.

DEEDI. 2009. *Blueprint for Queensland's LNG Industry*. Queensland Government, Department of Employment, Economic Development and Innovation. 10 p.

DERM. 2005. *Wetland Management Profile: Great Artesian Basin Spring Wetlands*. Queensland Government, Department of Environment and Resource Management, accessed 1 September 2010 - http://www.derm.qld.gov.au/register/p01718aa.pdf.

DEWHA. 2001. *The Community of Native Species Dependant on Natural Discharge of Groundwater from the Great Artesian Basin*. Australian Government, Department of the Environment, Water, Heritage and the Arts, accessed 1 September 2010 - http://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=26.

DNRM. 2005. *Hydrogeological Framework Report for the Great Artesian Basin Water Resource Plan Area*. Queensland Government, Department of Natural Resources and Mines. 155 p.

DNRW. 2007. *Great Artesian Basin Resource Operations Plan*. Queensland Government, Department of Natural Resources and Water. 71 p.

Fensham, R.J. & Fairfax, R.J. 2003. Spring wetlands of the Great Artesian Basin, Queensland, Australia. *Wetland Ecology and Management* **11**, 343-362.

Fensham, R.J. & Price, R.J. 2004. Ranking spring wetlands in the Great Artesian Basin of Australia using endemicity and isolation of plant species. *Biological Conservation* **119**, 41-50.

Fensham R. J., R.J. Fairfax & P.R. Sharpe. 2004. Spring wetlands in seasonally arid Queensland: floristics, environmental relations, classification and conservation values. *Australian Journal of Botany* **52**, 583-595.

Fensham R.J, Ponder, W.F. & Fairfax, R.J. 2010. *Recovery plan for the community of native species dependent on natural discharge of groundwater from the Great Artesian Basin*. Report to Department of the Environment, Water, Heritage and the Arts, Canberra. Queensland Department of Environment and Resource Management, Brisbane.

Forbes, V.R., Jensen, A.R., Mollan, R.G., Gregory, C.M. & Exon, N.F. 1967. *Taroom 1:250 000 geological series map sheet SG55-08 - Explanatory Notes*. Geological Survey of Queensland.

Green, P.M. (Ed.). 1997. *The Surat and Bowen basins of south-east Queensland*. Queensland Minerals and Energy Review Series, Queensland Department of Mines and Energy.

Habermehl M.A. 1980. The Great Artesian Basin, Australia. *BMR Journal of Australian Geology and Geophysics* **5**, 9-38.

Habermehl, M.A. 1982. Springs in the Great Artesian Basin, Australia - their origin and nature. *Bureau of Mineral Resources, Australia.*

Habermehl M.A. 2001a. Hydrogeology and Environmental Geology of the Great Artesian Basin, Australia. *In:* Gostin V.A. (ed.), *Gondwana* to *Greenhouse; Australian Environmental Geoscience*. Geological Society of Australia, Special Publication **21**, 127-143; 344-346.

Habermehl, M.A. 2001b. Wire-line logged waterbores in the Great Artesian Basin, Australia – Digital data of logs and waterbore data acquired by AGSO. Bureau of Rural Sciences, Canberra. AND Australian Geological Survey Organisation Bulletin 245 (Report + 3 maps at scale 1:2,500,000 + CD).

Habermehl, M.A. 2006. Artesian Springs of the Great Artesian Basin. *In*: Proceedings of the 6th Great Artesian Basin Springs Researchers' Forum, 23-24 February 2006, Adelaide. Gotch, T.B. & Defavari, J. (Compilers) South Australian Arid Lands Natural Resources Management Board, Adelaide, pp. 1-12.

Habermehl, M.A. & Lau, J.E. 1997. Hydrogeology of the Great Artesian Basin (1:2,500,000 scale map), *Australian Geological Survey Organisation*, Canberra.

Herczeg, A.L. & Love, A.J. 2007. *Review of recharge mechanisms for the Great Artesian Basin*. Report to the Great Artesian Basin Coordinating Committee under the auspices of a Consultancy Agreement: Commonwealth Department of Environment and Water Resources, Canberra. November, 2007. 62 p.

Hillier, J.R. 2010. *Groundwater connections between the Walloon Coal Measures and the Alluvium of the Condamine River*. A report for the Central Downs Irrigators Limited. August 2010

Huxley, W.J. 1982. *Condamine River Groundwater Investigation, The Hydrogeology, Hydrology and Hydrochemistry of the Condamine River Valley Alluvium, Vol. 1*. Queensland Water Resources Commission, Brisbane.

Hodgkinson, J., Hortle, A. & McKillop, M. 2010. The application of hydrodynamic analysis in the assessment of regional aquifers for carbon geostorage: preliminary results for the Surat Basin, Queensland. *APPEA Journal* **50**, 445-462.

Hostetler, S. 2009. FrogTech CSG. FrogTech capability statement (unpublished).

Kellett, J.R., Ransley, T.R., Coram, J., Jaycock, J., Barclay, D.F., McMahon, G.A., Foster, L.M. & Hillier, J.R. 2003. *Groundwater Recharge in the Great Artesian Basin Intake Beds, Queensland*. Final Report for NHT Project #982713 Sustainable Groundwater Use in the GAB Intake Beds. Queensland, BRS, Natural Resources and Mines, Queensland Government.

Lane, W.B. 1979. *Progress Report on Condamine Underground Investigation to December 1978, Volume 1*. Queensland Water Resources Commission, Brisbane.

Middlemis, H., Merrick, N. and Ross, J. 2001. *Groundwater Flow Modelling Guideline*. Report to Murray-Darling Basin Commission, 16 January 2001. Murray-Darling Basin Commission, Canberra. 72 p. + Appendices.

Prescott, J.R. & Habermehl, M.A. 2008, Luminescence dating of spring mound deposits in the southwestern Great Artesian Basin, northern South Australia. *Australian Journal of Earth Sciences* **55**, 167-181.

Radke, B.M., Ferguson, J., Creswell, R.G., Ransley, T.R. & Habermehl, M.A. 2000. The hydrochemistry and implied hydrodynamics of the Cadna-owie - Hooray Aquifer, Great Artesian Basin, Australia. Bureau of Rural Sciences, Canberra. 229 p.

Torgersen, T., Habermehl, M.A., Phillips, F.M., Elmore, D., Kubik, P., Jones, B.G., Hemmick, T. & Gove, H.E. 1991. Chlorine 36 dating of very old groundwater. 3. Further studies in the Great Artesian Basin, Australia. *Water Resources Research* **27**, 3201-3213.

Vink, S., Kunz, N., Barrett, D. and Moran, C. 2008. *Scoping Study: Groundwater Impacts of Coal Seam Gas Development – Assessment and Monitoring*. Centre for Water in the Minerals Industry, Brisbane. 53 p. http://203.210.126.185/dsdweb/v4/apps/web/secure/docs/3944.pdf

Welsh, W.D. 2000. *GABFLOW: A steady state groundwater flow model of the Great Artesian Basin*. Bureau of Rural Sciences, Canberra.

Appendix 1

Geology and Hydrogeology of Surat, Bowen and Great Artesian Basins

The following is a summary of existing geological and hydrogeological information for the Surat, Bowen and Great Artesian Basins within Queensland. This information provides a background to the environment and gives the reader a source of more detailed reference material with regards to some of the issues addressed in this document.

Bowen Basin

The main part of the Permo-Triassic Bowen Basin, which covers an area of 200,000 km^2, outcrops to the north of the younger Surat Basin, but its southern extension unconformably underlies the Surat Basin. The southern part of the Bowen Basin has an area of 50,000 km^2 and contains up to 9000 m of sedimentary rocks. In Early Permian time marine sediments were deposited followed in the Late Permian time by continental deposits including coals of the Bandanna Formation. The Permian sedimentary sequence is over 3500 m thick in places.

In Early Triassic time the Rewan Formation continental mudstones were laid down, followed by fluviatile sandstones of the Clematis Sandstones during the Lower to Middle Triassic, followed by the continental and deltaic mudstones of the Moolayember Formation in the Middle Triassic.

Surat Basin

The Jurassic-Cretaceous Surat Basin is an elongate sedimentary basin, which is part of the hydrogeological Great Artesian Basin and covers 300,000 km^2 in eastern Australia, most of it in Queensland and New South Wales. It contains up to 2500 m of virtually flat-lying sedimentary rocks and is connected across the Nebine Ridge with the Eromanga Basin and to the east across the Kumbarilla Ridge with Clarence-Moreton Basin (Fig. A1-1).

Deposition in the overlying Surat Basin started in the Lower Jurassic with fluviatile sandstones of the Precipice Sandstone. From the Lower Jurassic to the lowermost Cretaceous sediments are essentially terrestrial and cyclic, the sequence is up to 1700 m thick and each of the five cycles is hundreds of metres thick. Each cycle generally commenced with the deposition of coarse sand, grading up into finer sand and silt and ending with deposition of sand, silt, mud and organic material (ultimately coal). These cycles were deposited by streams, swamps, lakes, deltas and shallow seas. Late Jurassic uplift gave the basin its gross structural configuration.

The sequence (Fig. A1-2) consists of the Precipice Sandstone, followed by the mudstones of the Evergreen Formation, the Hutton Sandstone, the sandstones, silts, mudstones and coals of the Walloon Coal Measures, deposited in swamps, lakes and streams. This is overlain by the Springbok Sandstone, the mudstones of the Westbourne Formation, the Gubberamunda Sandstone, mudstones of the Orallo Formation, Lower Cretaceous Mooga Sandstone, and the sediments of the Bungil Formation, which include sandstones, silt and mudstones, deposited in streams, coastal plains and shallow marine environments. Marine sediments of the Rolling Downs Group were laid down, followed by shallow marine, beach and terrestrial sediments during Cretaceous times. The sequence of the Bungil Formation and the Rolling Downs Group is up to 1200 m thick. Erosion took place during the Late Cretaceous and Tertiary and deep-weathering profiles developed. Volcanics (basalts) erupted around the Surat Basin in the Oligo-Miocene and active tectonism at this time increased basinward tilt and exposed parts of the basin units along its eastern and northern margins. The basin's northern margin was subsequently eroded.

Great Artesian Basin

The hydrogeological Great Artesian Basin includes the Surat Basin (Fig. A1-1) and the uppermost part of the Bowen Basin sequence, i.e. the Clematis Sandstone and Rewan and Moolayember Formations. Most of the sandstone units are aquifers and the mudstones represent aquitards or confining beds. Aquifers in the Great Artesian Basin are present in the sandstones of the Clematis and Precipice Sandstones, Boxvale Sandstone Member and the Hutton, Springbok, Hooray, Gubberamunda and Mooga Sandstones and Kumbarilla Beds and Nullawurt Sandstone Member, with isolated aquifers in the Griman Creek Formation. The confining beds or aquitards in the Great Artesian Basin consist of the Rewan Group, Moolayember, Evergreen, Birkhead, Walloon Coal Measures, Westbourne and Orallo Formations, parts of the Bungil Formation, including the Kingull and Minmi Members, Wallumbilla Formation, including the Doncaster and Coreena Members, Griman Creek Formation and their equivalents. A summary stratigraphic column for the Surat Basin and underlying Bowen Basin is presented in Figure A1-2. Groundwater in the most widely exploited confined aquifers within the Lower Cretaceous-Jurassic sequence generally contains 500-1500 mg/L total dissolved solids. Artesian groundwater has pH values which are almost always between 7.5 and 8.5. The artesian groundwater is chemically of the Na-HCO3-Cl type, and these ions contribute more than 90 percent of the total ionic strength of solutes in the main basin area.

Recharge of the aquifers by infiltration of rainfall and through creeks and rivers into the outcropping aquifer sandstones and through unconsolidated sediments overlying the aquifers occurs mainly along the northern and eastern, elevated, margins of the basin, located on the western slope of the Great Dividing Range (Fig. A1-3).

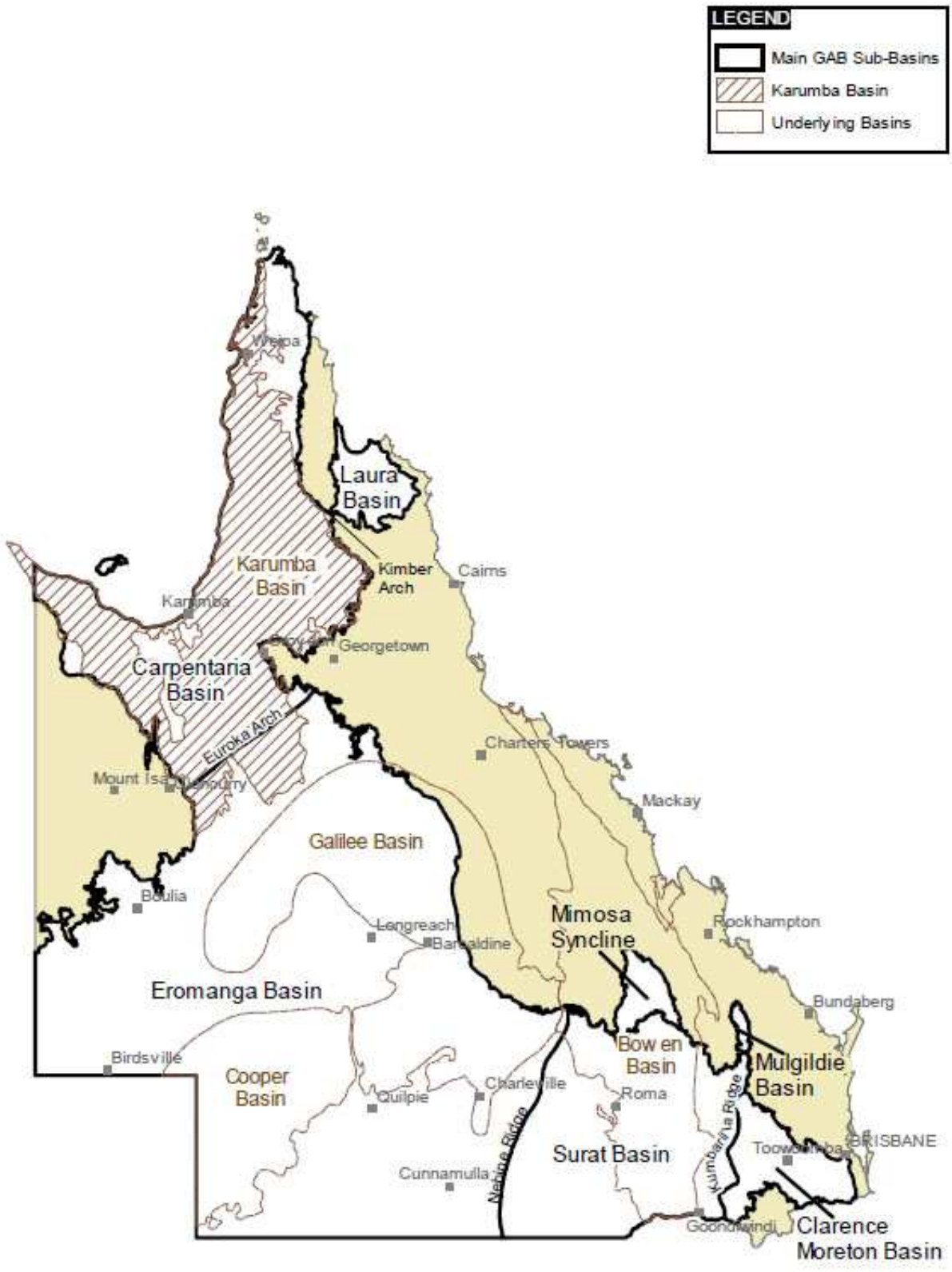


Figure A1-1. Map showing sub-basins of the Great Artesian Basin within Queensland, including the Surat and Bowen Basins, together with the eastern and western boundaries of the Surat Basin as defined by the Kumbarilla and Nebine Ridges (DNRM 2005).

Litho-stratigraphy	Main Rock Types
Condamine Alluvium	Unconsolidated sand, gravel and silt
Tertiary Sediments	Unconsolidated sediments
Griman Creek Formation	Sandstone, siltstone, mudstone conglomerate and coal
Surat Siltstone	Interbedded carbonaceous siltstone, mudstone and lithic sandstone
Wallumbilla Formation	Mudstone, siltstone, sandstone lenses with conglomerate and limestone
Bungil Formation	Mudstone siltstone and lithic sandstone
Mooga Sandstone	Fine to medium grained sandstone and shales
Orallo Formation	Sandstone carbonaceous siltstone mudstone coal
Gubberamunda Sandstone	Medium and coarse quartz sandstone
Westbourne Formation	Shales, siltstones and fine grained sandstone
Springbok Sandstone	Sublabile, lithic sandstone with calcareous cement
Walloon Coal Measures	Shale, siltstone, labile argillaceous sandstone, coal, mudstone, limestone
Hutton Sandstone*	Sandstone, siltstone, shale, conglomerate, coal, oolitic ironstone
Evergreen Formation	Sandstone, siltstone, shale, mudstone (carbonaceous with minor coal), oolitic limestone
Precipice Sandstone	Sandstone, pebbly sandstone, siltstone.
Sedimentary sequences of the Bowen basin	Predominantly sandstone, siltstone, shale and mudstone with Coal measures

Figure A1-2. Simplified stratigraphy of the Surat Basin showing the unconformable relationship with the underlying Bowen Basin sequences (Hostetler, 2009).

Discharge from the Great Artesian Basin aquifers takes place as natural discharge from springs, by vertical leakage from the aquifers upwards to higher aquifers and the regional watertable, by subsurface outflow into neighbouring basins and as artificial discharge by means of free or controlled artesian flow and pumped abstraction from water bores drilled into the aquifers (Habermehl, 1980, 2001a, b). Concentrated outflow from springs occurs from a number of springs in the Surat Basin, where diffuse discharge from the artesian aquifers takes place through the confining beds towards the ground surface. Following development of the region since the 1880s, natural discharge has diminished. Abstraction by water bores and in particular the use by the pastoral industry of flowing artesian water bores caused large-scale lowering of the potentiometric surface and a steepening of the hydraulic gradients. A visible effect of this has been the reduction in flow from springs and in some areas springs have ceased to flow.

Regional groundwater movement in the aquifers in the Great Artesian Basin has been interpreted from the potentiometric surface maps of the aquifers in the Jurassic and Lower Cretaceous sequences (Habermehl, 1980, 2001a, Habermehl and Lau, 1997). In the southern and eastern parts of the GAB flow directions are generally towards the south and south-east. Groundwater movement is slow, and based on hydraulic data probably around 1–5 m/year, as hydraulic conductivities and gradients are low and porosities high (Habermehl, 1980). Groundwater flow rates based on carbon-14 and chlorine-36 studies range from less than 1 m/year to approximately 5 m/year (Calf and Habermehl, 1984; Bentley et al., 1986; Torgersen et al. 1991; Radke et al. 2000; Love et al. 2000; Mahara et al. 2000). Groundwater residence times determined from carbon-14 and chlorine-36 studies range from several thousands of years near the recharge areas to more than one million years near the centre of the Great Artesian Basin. Carbonate spring mound deposits in the Lake Eyre region have dated ages of up to 740,000 years, with some spring deposits probably being older (Prescott and Habermehl 2008).

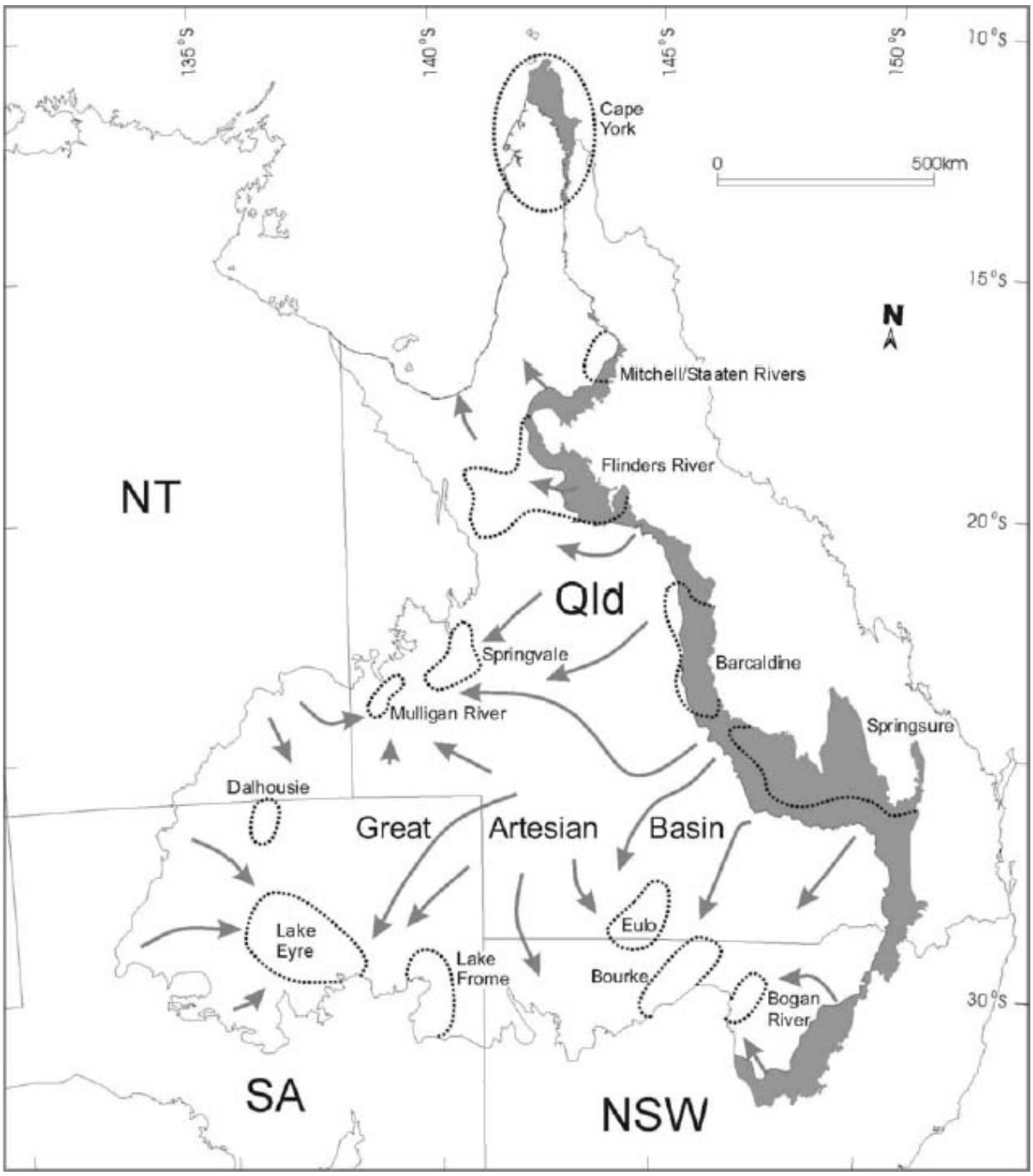


Figure A1-3. Recharge areas, generalised flow directions and spring groups of the Great Artesian Basin (Fensham 2006). Shaded patterns broadly represent the recharge area; arrows represent modelled flow lines after Welsh (2000); dashed lines represent spring groups (updated from Habermehl 1980, 1982).

Coal Seam Gas Production

Coal seam gas extraction in the Surat Basin is from the Walloon Coal Measures (see Fig. A1-2) in the north-eastern and northern parts of the Basin. The Walloon Coal Measures range in thickness from 50-500 m, and the unit consists mainly of siltstones, mudstones and sandstones that separate nine major coal intervals (Green, 1997). The coal seams are up to several metres thick, with maximum thicknesses of about 10 m. The overlying aquifers include the Springbok Sandstone and the Gubberamunda Sandstone, although the latter is separated from the Springbok Sandstone by the Westbourne Formation aquitard. The Walloon Coal Measures are underlain by the Hutton Sandstone and Precipice Sandstone aquifers, the latter being separated from the Hutton Sandstone aquifer by the Evergreen Formation, a regional aquitard.

Coal seam gas extraction involves the reduction of hydrostatic pressure in the coal seams to allow gas production by desorption of methane from the coal. This requires the extraction of groundwater from the coal seams by groundwater production bores. The large amount of groundwater produced, which in most cases is of poor quality, is called associated water. The process of groundwater extraction in the Surat Basin aims to lower the groundwater level to approximately 35 m above the upper coal seam. This is likely to result in a large drawdown in the potentiometric surface of the Walloon Coal Measures, which, over time, extends outside the bounds of the gas field production area. The drawdown of the groundwater levels will propagate vertically through the over- and underlying aquitards or confining beds into the over- and underlying aquifers. Following the cessation of CSG production and the extraction of groundwater after several decades, the groundwater level drawdown cones in the affected Great Artesian Basin aquifers, while reducing in magnitude, may still expand beyond the boundaries of the CSG development areas, and recovery of the drawdown in the affected aquifers may take a considerable time after cessation of CSG operations.

The significant volume of associated water produced by CSG extraction needs to be disposed of in a sustainable and environmentally acceptable manner. Suggested options by the proponents and the Queensland Government authorities include (a) re-injection of treated associated water into selected aquifers following water treatment to suitable water quality standards, (b) use of treated associated water in plantations and other agriculture enterprises, and (c) discharge of treated associated water into surface water or shallow groundwater systems.

Appendix 2

Environmental Impact Statements (EIS) and related documentation

The relevant information underpinning this advice is contained within the main Environmental Impact Statement report volumes of the APLNG, QGC and Santos EIS documents, several of the appendices, a range of technical supplements provided by the proponents, along with a number of other relevant publications. Contrary to the initial list of relevant documents provided by DEWHA, consideration of the issues raised requires reference to a significantly wider range of information. The list of documents below identifies the information sources which GA and Dr M.A. Habermehl have either identified or referred to in relation to this more detailed assessment.

Australia Pacific LNG (APLNG) Environmental Impact Statements

http://www.aplng.com.au/our-eis

* Not provided and not requested by DEWHA for original review

- Volume 2 – Gas Fields
    - Chapter 3* – Project Description (77 pages)
    - Chapter 9* – Water Quality & Aquatic Ecology (40 pages)
    - Chapter 10 – Groundwater (59 pages)
    - Chapter 11* – Surface Water (49 pages)
    - Chapter 12* – Adaptive Associated Water Management (23 pages)
    - Chapter 23* – Matters of National Environmental Significance (168 pages)
    - Chapter 24* – Environmental Management Plan (114 pages)
    - Chapter 25* – Cumulative Impact Assessment (25 pages)

- Volume 5 – Attachments
    - Attachment 17* – Aquatic Ecology, Water Quality and Geomorphology Impact Assessment – Gas Fields. Prepared by Hydrobiology for WorleyParsons. (195 pages)
    - Attachment 18* – Aquatic Ecology, Water Quality and Geomorphology Impact Assessment – Gas Transmission Pipeline. Prepared by Hydrobiology for WorleyParsons. (146 pages)

- Attachment 21 – Groundwater Technical Report - Gas Fields. Prepared by WorleyParsons for APLNG. (280 pages)
- Attachment 22* – Surface Water and Watercourses - Gas Fields. Prepared by WorleyParsons for APLNG. (238 pages)
- Attachment 23 – Conics IQQM Model [Hydrologic Modelling of Permeate
- Discharge to Condamine River]. Prepared by Conics for Origin Energy. (41 pages)
- Attachment 24 – Adaptive Associated Water Management - Gas Fields (83 pages)
- Attachment 25 – Water Resource Technical Report – Gas Transmission Pipeline. Undertaken by WorleyParsons. (41 pages)

- APLNG response to Geoscience Australia questions - August 2010. 52 p.

Queensland Gas Company/British Gas (Queensland Curtis LNG project)

Queensland Curtis LNG Draft and Supplementary Environmental Impact Statements

http://qclng.com.au/eis/draft-eis/

- Volume 2 – Project Description
  - Chapter 7 – Gas Field Component Operations + Supplement (48 pages)
- Volume 3 – Environmental Assessment of Gas Field Component
  - Chapter 8 – Aquatic (Freshwater) Ecology + Supplement (15 pages)
  - Chapter 9 – Surface Water + Supplement (21 pages)
  - Chapter 10 – Groundwater + Supplement. Overview of the potential impacts of the CSG field activities on groundwater. (35 pages)
  - Chapter 11 – Associated Water Management + Supplement (91 pages)
- Appendix 3.2 – Groundwater Study – Northwest Development Area. Prepared by Golder Associates for QGC. (184 pages)
- Appendix 3.4 – Gas Field Groundwater Report: Parts 01-13. Prepared by Golder Associates for QGC. (292 pages)
- *QGC Groundwater Study Surat Basin, Queensland. Prepared by Golder Associates for QGC (163 p. + 10 p.) + Groundwater Modelling for CSG Extraction – QGC. Prepared by Golder Associates

for QGC. (46 p.) + QGC Groundwater Quality Assessment. Prepared by Golder Associates for QGC. (33 p.)*

- QGC Environmental Authority Application: North West Development Area – Supporting Information. (165 pages)
- QGC Pipeline Licence Application – South East and Central Development Area Supporting Information (52 pages)
- QGC response to DEWHA request for further information related to Groundwater issues. (14 pages)
- Assessment of subsidence due to coal seam gas extraction. Prepared by Golder Associates for QGC, 20 August 2010. 5 pages.
- Response to DEWHA 300810 – Attachment 3 – Geodetic Monitoring. 1 page.

Santos (Gladstone LNG Project)

Gladstone LNG Environmental Impact Statement

(http://www.glng.com.au/Content.aspx?p=90)

- Section 3 – Project Description (98 pages)
- Section 6 – Coal Seam Gas Field Environmental Values and Management of Impacts
    - Section 6.1 – Assessment Methodology (2 pages)
    - Section 6.4 – Nature Conservation (62 pages)
    - Section 6.5 – Surface Water (21 pages)
    - Section 6.6 – Groundwater (75 pages)
    - Section 6.7 – Associated Water Management (27 pages)
- Appendix N4 – Aquatic Flora and Fauna. Prepared by frc environmental for URS. (299 pages)
- Appendix P1 – Shallow Groundwater. Prepared by URS for Santos. (178 pages)
- Appendix P2 – Deep Groundwater. Prepared by Matrixplus for Santos. (145 pages)

Gladstone LNG Supplementary Environmental Impact Statement
(http://www.glng.com.au/Content.aspx?p=96)

EIS Response to Submissions

- Coal Seam Gas Field Environmental Values and Management of Impacts (83 pages)
- Appendix G – EPBC Act Report (13 pages)
- Appendix P – Groundwater (3 pages)
- Appendix Q – Associated Water Management Strategy (3 pages)

Supporting Documentation

- Attachment B1 – Coal Seam Gas Field Revised Environmental Management Plan. (46 pages)
- Attachment D2 – Groundwater and Associated Water Impact Management Plan. Prepared by Golder Associates for Santos. (208 pages)
- Attachment D3 – Associated Water Management Plan. (68 pages)
- Attachment D5 – Nature Conservation. Supplementary Assessment of Potential Impact to Ecological Values. Prepared by URS for Santos. (171 pages)
- Coal Seam Hydraulic Fracturing Fluid Environmental Risk Assessment: Response to the Coordinator General Requirements for Coal Seam Gas Operations in the Surat and Bowen Basins, Queensland. Prepared by Golder Associates for Santos. (424 pages)
- Technical Memorandum – The Matter of the Impact from Santos CSG Fields on the GAB Springs. Golder Associates, 10 August 2010. (3 pages)
- Assessment of subsidence due to coal seam gas extraction. Prepared by Golder Associates for Santos, 1 September 2010. 12 pages.

12.

Australian Government

Department of Sustainability, Environment, Water, Population and Communities

PROPOSED Approval

To develop, construct, operate and decommission the Coal Seam Gas Field component of the Queensland Curtis LNG Project, including expansion of the QGC operated coal seam gas fields in the Surat Basin as described in referral EPBC 2008/4398.

This decision is made under sections 130(1) and 133 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

person to whom the approval is granted	Queensland Gas Company Ltd (QGC) and BG International Limited (BG)
proponent's ABN (if applicable)	ABN: 089 642 553 (QGC) ABN: 72 114 818 825 (BG)
proposed action	To develop, construct, operate and decommission the coal seam gas field component of the Queensland Curtis LNG Project, including expansion of the QGC operated coal seam gas fields in the Surat Basin, to supply gas for the Queensland Curtis LNG Project to the proposed Queensland Curtis LNG Plant located on Curtis Island: • as described in the proponent's referral received under the EPBC Act on 18 August 2008; and • as described in the proponent's Environmental Impact Statement and Supplementary Environmental Impact Statement.
proposed decision	To approve the proposed action for each of the following controlling provisions: • Listed threatened species and communities (sections 18 and 18A, EPBC Act) • Listed migratory species (sections 20 and 20A, EPBC Act)
conditions of approval	This approval is subject to the conditions specified below.
expiry date of approval	This approval has effect until 31 October 2060.
name and position	The Hon Tony Burke MP Minister for Sustainability, Environment, Water, Population and Communities
signature	Not for signature (draft only)
date of decision	No date (draft only)

Proposed conditions

Proposed conditions

Project area

1. The project area is the area identified at Figure 1, with a maximum gas field development area of 26,760 ha, within the following petroleum tenures (as they are at the date of the decision to which these conditions are attached):
   - ATPs 610, 621, 632 (portion of), 647, 648, 651, 676 and 768 (portion of);
   - PLs 179, 201, 228, 229, 171,180, 211, 247;
   - PLAs 212, 257, 259, 261, 262, 263, 273, 274, 275, 276, 277, 278, 279.

Infrastructure limits

2. Impacts must be limited to a maximum of 6,000 production wells and impacts related to associated gas field development.

Constraints Planning and Field Development

Protocol for Constraints Planning and Field Development

3. Before the commencement of gas field development, the proponent must develop a Constraints Planning and Field Development Protocol (the Protocol).

4. The Protocol must apply for the life of the project and include the principles of:
   a. avoiding direct and indirect impacts on MNES;
   b. mitigating and managing direct and indirect impacts to minimise cumulative impacts on MNES;
   c. active site remediation and rehabilitation of impacted areas to promote and maintain long-term recovery of MNES.

5. The Protocol must:
   a. classify the following as being within the proponent's highest environmental constraint class - Zone 4a (or should the proponent's classification be revised, an equivalent high environmental constraints class):
      i. all listed threatened ecological communities;
      ii. all listed flora species; and
      iii. those listed threatened and migratory fauna species habitats as identified in management plans required under these conditions,

which where relevant may be described in terms of specific niche habitat types;

Note: The proponent's approach to environmental constraint class Zone 4a and related impact avoidance and mitigation is described in volume 3, chapter 7 (7.6.2.4) of the proponent's Environmental Impact Statement (dated July 2009). The protocol conditions do not apply to the other constraints that the proponent has included in environmental constraint class - Zone 4a unless these are relevant to MNES.

b. take into account all current survey data and available information and maps of all MNES relevant to the project area as described within environmental constraint class Zone 4a;

c. require the undertaking and documentation of planning and pre-clearance site assessments and field ecological surveys in proposed gas field development areas where constraint class Zone 4a is likely or found. The pre-clearance site assessments and ecological surveys must identify and assess options relating to potential gas field development impacts on MNES and provide recommendations to inform the proponent's decision to develop the project area;

d. to avoid direct and indirect impacts on MNES, including fragmentation and edge effects, require the proponent to determine the location of proposed infrastructure in accordance with the following:

i. preferentially avoid native vegetation that may provide habitat for listed species and utilise previously cleared or previously utilised areas;

ii. exclude exploration and production wells from within areas identified as environmental constraint class Zone 4a; and

Note: Directional drilling and multiple drill holes from one well pad are options to avoid well site and related infrastructure disturbance to environmental constraint class Zone 4a.

iii. either:

(1) exclude other <u>non linear</u> infrastructure from the no impact zone; or

(2) where the location of non linear infrastructure in the no impact zone cannot be avoided, only authorise the siting of that infrastructure in that zone where field ecological surveys demonstrate that there will <u>not</u> be any adverse impact on any MNES, including habitat for any listed species;

iv. either:

(1) exclude <u>linear</u> infrastructure from the impact risk zone; or

(2) where the location of linear infrastructure in the impact risk zone cannot be avoided, only authorise the siting of that infrastructure in that zone where field ecological surveys demonstrate that there will be <u>minimal</u> adverse impact on any MNES, including habitat for any listed species.

e. require the proponent to plan for and decide the extent that proposed linear infrastructure may impact on MNES in accordance with the following:

i. all linear disturbance within environmental constraints class Zone 4a for MNES and the impact risk zone must be:

(1) limited to 6 metres in width for single lane track;

(2) limited to 15 metres if there are one or two parallel gas or water gathering lines;

(3) limited to 20 metres if there are three, four, or five parallel gas or water gathering lines;

(4) limited to 25 metres if there are six, seven or eight parallel gas or water gathering lines;

(5) limited to 30 metres if there are greater than eight parallel gas or water gathering lines.

ii. gas and water trunkline rights of way, water distribution pipeline rights of way, the Upstream Infrastructure Corridor (UIC), and other major linear infrastructure disturbance corridors within environmental constraints class Zone 4a and the impact risk zone must be:

(1) limited to 30 m in width where there are one or two gas and water trunklines, underground 33kV power lines and fibre optic cables in parallel;

(2) limited to 30 metres plus an additional 4 metres for every additional gas or water trunkline in parallel with the initial one or two gas or water trunklines, underground 33kV power lines and fibre optic cable;

(3) limited to disturbance in the corridor described for the UIC.

iii. where feasible, gas trunklines, pipelines for associated water and other transmission lines must be co-located to reduce total disturbance on MNES.

Note: Any area of a disturbance referred to in this condition would be subtracted from the disturbance limits specified elsewhere in these conditions.

f. support bioregional corridors for listed threatened species and migratory species, and connectivity for listed threatened ecological communities;

g. either:

(A) ensure site assessments and field ecological surveys:

i. are undertaken in accordance with the Department's survey guidelines in effect at the time of the survey. This information can be obtained from http://www.environment.gov.au/epbc/guidelines-policies.html#threatened;

Field Code Ch

ii. take into account and reference previous ecological surveys undertaken in the area and relevant new information on likely presence or absence of MNES;

iii. are undertaken by a suitably qualified ecologist approved by the Department;

iv. document the survey methodology, results and significant findings in relation to MNES.

v. apply best practice site assessment and ecological survey methods appropriate for each listed threatened species, migratory species, their habitat and listed ecological communities;

Note: Best practice includes applying the optimum timing and frequency of site assessments and surveys to determine presence or absence of listed threatened species or migratory species or their habitat, or a listed threatened ecological community.

vi. apply the mapping of environmental constraints class Zone 4a; the infrastructure location requirements; minimum no impact zones; impact risk zones; and the width requirements for linear infrastructure corridors described in e);

vii. reports are published by the proponent on the internet before commencement and provided to the Department on request; OR

(B) assume the presence of listed threatened species or migratory species, in which case the proponent must prepare management plans in accordance with the requirements of Condition 7 .

QGC Comment: Please refer to similar proposed amendment to the pipeline conditions. There is no prejudice to species so long management plans are prepared.

~~g.~~h. require species and ecological community management plans which include:

i. relevant avoidance and mitigation measures to be applied;

ii. measures for protecting each listed threatened species and migratory species and their habitat, and each listed threatened ecological community not previously assessed by the proponent, should one or more be found in the project area at any time over the life of the project. Any such management plans must be developed in a timeframe to be approved by the Department. Notification of additional MNES found must be provided to the Department in writing within 10 business days. Measures must include the development of a management plan consistent with requirements under condition 8; and

~~h.~~i. ~~the proponent must~~ ensure constraints planning and field development decisions are made in accordance with the Protocol (including any relevant species and ecological community management plans) before final selection of specific sites for gas field development within the project area.

6. The Protocol must ensure relevant information on MNES is available and used by the proponent to support field development and management decisions throughout the life of the project.

Management plans for listed species and ecological communities

7. Before commencement of the gas field development the proponent must develop management plans addressing each listed species and listed ecological community that, as indicated through assessment or more recent information, may be potentially impacted by gas field development within the project area or external to it, as a result of gas field development. The management plans must address as a minimum, the ecological communities and species and their habitat as specified in Table 1 and 2 of these conditions:

Table 1: Species potentially impacted by gas field development for which management plans are required

Species	EPBC status	Habitat type
Dasyurus hallucatus (Northern Quoll)	Endangered	Habitat generally encompasses some form of rocky area for denning purposes with surrounding vegetated habitats used for foraging and dispersal. Preferred habitat of rocky hills and escarpments, open forest and open woodland
Chalinolobus dwyeri (Large-eared Pied Bat, Large Pied Bat)	Vulnerable	Usually found in proximity to cliff lines and escarpments and sandstone outcrops where shallow caves appear to be used as roosts, although the species is also known to use tree hollows. Known to forage in adjoining woodlands including Brigalow ecological communities
Turnix melanogaster (Black-breasted Button-quail)	Vulnerable	Drier low closed forests, particularly semi-evergreen vine thicket, low microphyll vine forest, araucarian microphyll vine forest and araucarian notophyll vine Forest
Erythrotriorchis radiatus (Red Goshawk)	Vulnerable	Eucalypt woodland, open forest, gallery rainforest, swamp sclerophyll forest and rainforest margins, usually in association with large tracts of forest. Prefers a mosaic of vegetation types and permanent water.
Rostratula australis (Australian Painted Snipe)	Vulnerable	Potentially any wetland and farm dams with suitable vegetation cover, temporary and permanent lakes, swamps and claypans. Favours freshwater swamps and samphire salt marshes.
Delma torquata (Collared Delma)	Vulnerable	Eucalypt or acacia dominated woodland including Brigalow ecological communities and open forest where it is associated with suitable microhabitats (exposed rocky outcrops or a sparse understorey of tussock grass, shrubs or semi-evergreen vine thickets).
Geophaps scripta scripta (Squatter Pigeon (Southern))	Vulnerable	Grassy woodlands and open forest that are dominated by eucalypts, open grassy pastures in association with cattle grazing marshes, acacia growth and disturbed habitats (i.e. around stockyards, along roads and railways, and around settlements).
Denisonia maculata (Ornamental Snake)	Vulnerable	Brigalow (Acacia harpophylla) woodland growing on clay, cracking clay soils and sandy soils, riverside woodland and open forest growing on natural levees and other riparian habitats. Shelters under fallen timber and in soil cracks. Known from cleared

Table 1: Species potentially impacted by gas field development for which management plans are required		
Species	**EPBC status**	**Habitat type**
		grazing and cropping lands where suitable soils exist.
Furina dunmalli (Dunmall's Snake)	Vulnerable	Brigalow (Acacia harpophylla) forest and woodland growing on cracking black clay and clay loam soils (usually on heavy clay soils). Also known to occur in eucalypt and callitris woodland with fallen timber and ground litter
Nyctophilus timoriensis (Eastern Long-eared Bat)	Vulnerable	River red gum forest, semi-arid woodlands, savannahs and open woodlands, often in association with riverine environments in Brigalow Belt of inland Queensland.

Note: Table ~~13~~ 1 is derived from Table 2 *EPBC Act Listed Ecological Community and Flora Species Impacts;* Table 3 *MNES Fauna Species Requiring Offset Consideration;* and *Table 2 Determination of EPBC Act Listed Fauna Species Impacted* of the *Unidel QCLNG Project Revised Terrestrial Offsets and Implementation Report QGC020-ENV-RPT0002 24 June 2010* and from the DEWHA Listed threatened species profiles available on the Department's website.

To the extent that the requirements of Condition 8 are satisfied for each species, a single species management plan maybe prepared for this purpose.

8. The management plans required under condition 7 must be developed by a qualified ecologist approved in writing by the Department and as a minimum address the following as is relevant to each MNES:

   a. current legal status (under EPBC Act);

   b. known distribution;

   c. known species' populations and their relationships within the region;

   d. extent of ecological community fragmentation within the region and if appropriate minimum patch size for that community.

   e. species' biology and reproduction;

   f. species' habitat, essential habitat and microhabitat including associations with geology, soils, landscape features and associations with other native fauna and/or flora or ecological communities, and where relevant specific niche habitat descriptions that can be meaningfully applied in constraints planning and used in field ecological surveys;

      Note: This information is to be used to assist site assessment and ecological surveys in determining avoidance and mitigation options and identifying any area of potential impact to a species' habitat that must be accounted for against a disturbance limit.

      To the extent that the requirements of Condition 8 are satisfied for each species, a single Species Management Plan maybe prepared for this purpose.

      QGC Comment: This is simply replicating what appears in the pipeline conditions concerning Management Plans.

   g. threats to MNES relating to the development and management of land within the gas fields including from the development, operation and

decommissioning of infrastructure within the gas fields; and from extraction, use and disposal of associated water whether the threat is within or outside the gas field development area;

Note: This section may also indicate that a species or its habitat can co-exist with specific types of gas field operations.

h. relevant management practices and methods to minimise impact and recover from impact that should include:

   i. site rehabilitation timeframes, standards and methods;

   ii. use of sequential clearing to direct fauna away from an impact zone;

   iii. re-establishment of native vegetation in linear infrastructure corridors;

   iv. welfare and safe handling of fauna specimens requiring relocation from impact sites;

   v. handling practices for flora specimens;

   vi. translocation practices and monitoring for translocation success;

   vii. monitoring methods including for rehabilitation success and recovery;

i. surface and ground water quality and quantity requirements, including relevant downstream environmental quality parameters;

j. reference relevant conservation advice, recovery plans, or other policies, practices, standards or guidelines relevant to MNES published or approved from time to time by the Department.

Note: The management plans must include sufficient detail to inform field development decisions, ongoing management and decommissioning, and management external to the project area to minimise impacts on MNES through the life of the project.

9. Each species and ecological community management plan must be submitted for the approval of the Minister. Commencement_ of gas field development must not occur without approval of each plan in writing. Approved species and ecological community management plans must be implemented.

10. The proponent must establish a program for routine review of the species and ecological community management plans to be undertaken by a qualified ecologist approved by the Department (with other experts as appropriate) to take into account any new information available to the proponent, including any information and advice provided by Commonwealth or Queensland Government agencies, or available from other CSG proponents.

11. The Minister may require through a request in writing the periodic review of the species and ecological community management plans, either by the Department; or alternatively by an independent qualified ecologist, or other experts, approved by the Department.

12. Independent review of plans will be at the financial expense of the proponent. Once independently reviewed, plans must be submitted for written approval by the Department. Approved plans must be implemented.

Record of impacts

13. If an impact occurs (which may include a presumed impact where the species is presumed to be present) to a MNES during gas field development, operation, or decommissioning the proponent must:

    a. record the impact by reference to:

        i. the location, specific site and type of infrastructure or activity;

        ii. each MNES subject to disturbance;

        iii. the related site assessment or field ecological survey documentation and recommendations, or the decision that the particular MNES was presumed to be present;

        iv. the disturbance limit set under condition 26;

        v. the total area of actual disturbance;

        vi. the remaining disturbance limit for each affected MNES;

        vii. the reasons for the decision including justification for the action taken, description of the efforts taken to avoid impact, and explanation why other constraints might justify the impact on MNES; and

        viii. actions and commitments by the proponent to remediate, rehabilitate, or make good any unauthorised disturbance.

        Note: This condition applies to any impact on MNES, whether or not a disturbance limit has been set, and whether or not the impact has been decided by the proponent under the Protocol based on other physical constraints.

    b. record the information to a standard which can be independently audited.

Site remediation, rehabilitation and recovery plan

14. Where a direct or indirect impact has occurred to MNES (which may include a presumed impact where the species is presumed to be present) the proponent must under the Protocol apply remediation, rehabilitation and recovery measures appropriate for each MNES to restore connectivity or rehabilitate disturbed areas to pre-clearance quality or better, and to minimise cumulative impacts throughout the life of the project.

15. Before commencement of gas field development the proponent must develop a Remediation, Rehabilitation, Recovery and Monitoring Plan. The Plan must:

    a. include site remediation measures including timeframes and standards for preventing erosion and stabilising disturbed soil in impact areas;

    b. include measures to support recovery of listed species' habitat and recovery of listed ecological communities affected by gas field development;

    c. include responses to threats to MNES from the proponent's operational activities and land management activities including the disposal and use of associated water, damage by livestock, and impacts from feral animals and weeds;

    d. provide for fire prevention and management regimes during construction, operation, and decommissioning to protected MNES;

    e. include performance measures and related monitoring to assess site remediation, rehabilitation and recovery;

f. provide for reporting on the implementation of the Remediation, Rehabilitation, Recovery and Monitoring Plan including monitoring and performance to a standard which can be independently audited;

g. reference relevant conservation advice, recovery plans, species management plans, or policies, practices, standards or guidelines endorsed or approved from time to time by the Department.

16. The Remediation, Rehabilitation, Recovery and Monitoring Plan must be submitted for the approval of the Minister. Commencement of gas field development must not occur without approval of this Plan. The approved Remediation, Rehabilitation, Recovery and Monitoring Plan must be implemented.

17. The proponent must establish a program to routinely review the Remediation, Rehabilitation, Recovery and Monitoring Plan by an independent qualified ecologist, or other experts, approved by the Department to take into account any new information available to the proponent, including any information and advice provided by Commonwealth or Queensland Government agencies, or available from other CSG proponents.

18. The Minister may require through a request in writing the periodic review of the Remediation, Rehabilitation, Recovery and Monitoring Plan by the Department, or alternatively by an independent qualified ecologist, or other experts, approved by the Department. Plans must be approved by the Department in writing.

19. Independent review of plans will be at the financial expense of the proponent. Once independently reviewed, plans must be submitted for written approval by the Department. Approved plans must be implemented.

Approval and Review of Protocol

20. The Protocol must be submitted for the approval of the Minister. Commencement of gas field development must not occur without approval in writing. The approved Protocol must be implemented.

21. The Protocol and related plans must be reviewed and updated to take into account the findings of the *Cumulative Impact Assessment Report* required by the Queensland Government. This may be done after approval of The Protocol. Reviewed and updated Protocols and plans must be submitted for approval in writing by the Department. Once approved, updated Protocols and plans must be implemented.

22. The Department may require through a request in writing that the Protocol and related plans be revised or amended before approval. Any such request must be acted on within the time frame specified.

23. Within 3 years of the Protocol being approved, and every 3 years thereafter, the proponent must review the Protocol, and seek the approval, by the Department, of the revised Protocol. The review must take into account all relevant studies, policies, standards, guidelines and advice relating to CSG

activity published or provided to the proponent by the Commonwealth or Queensland governments, or published or provided by other proponents undertaking similar activities, or published or provided by other parties, including any findings of an audit against conditions, or plans or other documentation required under the conditions of this approval.

24. The Department may specify in writing any additional requirement for periodic review including to align with Queensland Government requirements.

25. The approved Protocol must be incorporated into the proponent's management procedures, operational plans and other relevant documentation and kept current for the life of the project.

Disturbance limits

26. The following maximum disturbance limits in Table 2 and Table 3 below apply to authorised unavoidable impacts on MNES as a result of exploration, development, operation and decommissioning within the project area, and external to it, ('whole of project' disturbance limits) illustrated in Attachment 1 and all associated activities for the life of the project.

Table 2: Disturbance limits for listed threatened ecological communities		
Ecological community	**EPBC Act status**	**Disturbance limit (ha)**
Brigalow (*Acacia harpophylla* dominant and co-dominant)	Endangered	73 ha
The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin	Endangered	0 (No disturbance authorised)
Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions	Endangered	0 (No disturbance authorised)
Natural Grasslands of the Queensland Central Highlands and the northern Fitzroy Basin	Endangered	0 (No disturbance authorised)

Note: Table 2 is derived from Table 2 *EPBC Act Listed Ecological Community and Flora Species Impacts* of the *Unidel QCLNG Project Revised Terrestrial Offsets and Implementation Report QGC020-ENV-RPT0002 24 June 2010*).

Table 3: Disturbance limits for listed species			
Species	**EPBC status**	**Disturbance limit (ha)**	**Habitat type**
Paradelma orientalis (Brigalow Scaly-foot)	Vulnerable	235* ha of potential habitat	Occurs in a wide range of (dry) forest and woodland habitats, including Brigalow woodland, Vine thicket regrowth and rocky habitats on sandstone ridges to flats and gently undulating plains with clay, loam or sand. Not tolerant of clearings. Specific habitat where species found includes remnant Brigalow woodland with sparse tussock grasses on grey cracking clay soils.

Table 3: Disturbance limits for listed species			
Species	**EPBC status**	**Disturbance limit (ha)**	**Habitat type**
Egernia rugosa (Yakka Skink)	Vulnerable	343* ha of potential habitat	Open dry sclerophyll forest or woodland, Brigalow, shrublands, lancewood forests on sandy and open textured soils. Dense ground cover, cavities in soil-bound root systems of fallen trees and beneath rocks, hollow logs and animal burrows are considered to provide suitable microhabitat for this species
Philotheca sporadica	Vulnerable	10 ha	Open to closed shrubland to closed woodland. Shallow sandy to clay loams or shallow texture contrast soils with loamy surfaces and medium clay subsoils. Ironstone gravel usually present within soil column. Some sites have duricrust surfaces.

* Disturbance limits for Brigalow Scaly-foot and Yakka Skink potential habitat are as per the methodology applied in *Unidel QCLNG Project Revised Terrestrial Offsets and Implementation Report QGC020-ENV-RPT0002 24 June 2010*

Note: Table 3 is derived with information from Table 2 *EPBC Act Listed Ecological Community and Flora Species Impacts;* Table 3 *MNES Fauna Species Requiring Offset Consideration;* and *Table 2 Determination of EPBC Act Listed Fauna Species Impacted* of the *Unidel QCLNG Project Revised Terrestrial Offsets and Implementation Report QGC020-ENV-RPT0002 24 June 2010* and from the DEWHA Listed threatened species profiles available on the Department's website.

Offsets

Plan to secure offsets

27. Within 6 months of the commencement of gas field development the proponent must prepare an Offset Plan to provide an offset area for the approved disturbance limits relating to MNES within the project area. The offset area to be secured must be an area of private land which includes at least:

a. 80 ha of *Philotheca sporadica* habitat; and

b. either,

i. 146 ha of remnant Brigalow (*Acacia harpophylla* dominant and co-dominant); or

ii. 438 ha of high value regrowth Brigalow (*Acacia harpophylla* dominant and co-dominant);or

iii. 584 ha of vegetation that is not remnant Brigalow (*Acacia harpophylla* dominant and co-dominant) that has elements of

regrowth, with site selection in accordance with the strategic offset site identification approach in the Unidel QCLNG Project Revised Terrestrial Offsets and Implementation Report QGC020-ENV-RPT0001, 24 June 2010; and

~~b.~~c. 343 ha of potential *Egernia rugosa* (Yakka Skink) habitat which includes micro habitat required for the species; and

~~c.~~d. 235 ha of potential *Paradelma orientalis* (Brigalow Scaly-foot) habitat which includes micro habitat required for the species.

28. The Offset Plan must include details of the offset area including: the timing and arrangements for property acquisition, maps and site description, environmental values relevant to MNES, connectivity with other habitats and biodiversity corridors, a rehabilitation program, and mechanisms for long-term protection, conservation and management.

29. The Offset Plan must be submitted for the approval of the Minister within 6 months of the commencement of gas field development. The approved Offset Plan must be implemented ~~within 30 business days of approval~~.

QGC Comment: Condition 27 has been amended to reflect what QGC believes is more than reasonable compensation for unavoidable impacts to 73 hectares of Brigalow. QGC believes offsets of 2:1 where remnant Brigalow is provided or 6:1 for high value regrowth or 8:1 for Brigalow regrowth that is not high value is more than reasonable compensation and that a cumulative total equating to 16:1 is unreasonable. Condition 29 has been amended so that there is no conflict with condition 32 which requires securing of the offsets within 2 years of commencement.

30. If the approved Offset Plan cannot be implemented because of failure of arrangements to secure the necessary area of private land then the proponent must submit for the Minister's approval an alternative Offset Plan. The alternative Offset Plan must provide at least an equivalent environmental outcome to those specified under condition 27(a) to (f). The approved alternative Offset Plan must be implemented.

31. If the proponent proposes any action within a proposed offset area, other than actions related to managing that area as an offset property, approval must be obtained, in writing from the Department. In seeking Departmental approval the proponent must provide a detailed assessment of the proposed action including a map identifying where the action is proposed to take place and an assessment of all associated impacts on MNES. If the Department agrees to the action within the proposed offset site, the area identified for the action must be excised from the proposed offset and alternative offsets secured of equal or greater environmental value in relation to the impacted MNES.

32. The proponent must secure the offset within 2 years of commencement.

Offset Area Management

33. Within 12 months of securing the offset area required under the approved Offset Plan, the proponent must develop an Offset Area Management Plan which must specify measures to improve the environmental values of the offset area in relation to MNES, including;

a. the documentation and mapping of current environmental values relevant to MNES of the area;

b. measures to address threats to MNES including but not limited to grazing pressure and damage by livestock and adverse impacts from feral animals and weeds;

c. measures to provide fire management regimes appropriate for the MNES;

d. management of revegetation areas to the stage where habitat is established or improved for listed species and revegetation areas meet the criteria for 'remnant status' for that threatened ecological community;

e. measures to ensure as an objective, that as revegetation areas meet the criteria applicable at the time for 'remnant status', application is made to have the revegetation areas reclassified as 'remnant vegetation' in accordance with the relevant Queensland legislation;

f. monitoring, including the undertaking of ecological surveys to assess the success of the management measures against identified milestones and objectives;

g. performance measures and reporting requirements against identified objectives, including trigger levels for corrective actions and the actions to be taken to ensure performance measures and objectives are met.

34. Within 12 months of securing the offset area the Offset Area Management Plan must be submitted for the approval of the Minister. The approved Offset Area Management Plan must be implemented.

Rehabilitation Area Offset

35. Within 2 years of the commencement of gas field development the proponent must secure a Rehabilitation Area Offset of at least 700 hectares of privately held property to compensate for indirect impacts on MNES. The proponent must:

a. obtain ownership or a legally binding agreement from a landowner over an area of property to re-establish areas of the threatened Brigalow (Acacia harpophylla dominant and co-dominant) ecological community and associated listed migratory and listed threatened species' habitat; and

b. notify the Department in writing within 30 business days of securing the Rehabilitation Area Offset.

Note: The Rehabilitation Area Offset is an additional area to the Offset area required under condition 27.

36. The Rehabilitation Area Offset must:

a. be within historical distributions of the ecological community (before clearing occurred) and as close as possible to the project area;

b. include intact elements of remnant and/or high value regrowth of the Brigalow (*Acacia harpophylla* dominant and co-dominant) ecological community; and

c. include or have potential for providing habitat and micro habitat requirements for listed migratory and threatened species (i.e. those in Table 3 that relate to this ecological community).

37. If, within 2 years of the commencement of gas field development the Rehabilitation Area Offset has not been secured, then the proponent must within 30 business days, notify the Minister and provide for the Minister's approval an alternative offset measure. The alternative must provide at least an equivalent environmental outcome to those specified in relation to the Rehabilitation Area Offset. The approved alternative must be secured and implemented in accordance with conditions 35 and 36.

Rehabilitation Area Plan

38. Within 2 years of the commencement of gas field development, the proponent must prepare a Rehabilitation Area Plan for the offset required under condition 35.

39. The Rehabilitation Area Plan must provide for commitments and actions to lead to the increase in the spatial extent and improvement in the condition of existing remnants, and for the establishment of new self sustaining, functional 'remnant vegetation' communities, consistent with that which existed prior to clearing and with the capacity to provide habitat for the species identified in condition 26 as unavoidably impacted by the action.

40. The Rehabilitation Area Plan must include:

a. details of the area to be rehabilitated including location and maps;

b. documentation including mapping of current environmental values relevant to MNES of the area;

c. where revegetation through planting seedlings and/or seeds is intended details of appropriate species and ratios of species relevant to historically occurring listed migratory and threatened species' habitat and the Brigalow (Acacia harpophylla dominant and co-dominant) ecological community;

d. the source and provenance of the seed and/or seedlings which will be used;

e. measures to address threats to MNES including but not limited to grazing pressure and damage by livestock and adverse impacts from feral animals and weeds;

f. measures to provide fire management regimes appropriate for the MNES;

g. monitoring measures including ecological surveys to measure the establishment and ongoing success of the revegetation based on a comparison with high quality habitat for listed migratory and threatened species and ecological community reference sites;

h. performance measures and reporting requirements against identified objectives, including trigger levels for corrective actions and the actions to be taken to ensure performance measures and objectives are met.

41. Within 2 years of the commencement of gas field development the Rehabilitation Area Plan must be submitted for the approval of the Minister. The approved Rehabilitation Area Plan must be implemented.

42. To ensure the long term protection of the Rehabilitation Area the proponent must:

    a. manage the Rehabilitation Area to a stage where it meets the criteria for 'remnant vegetation' for the Brigalow (*Acacia harpophylla* dominant and co-dominant) ecological community.

    b. When areas of revegetation meet criteria applicable at the time for 'remnant vegetation' ensure application is made to have the revegetation areas remapped and reclassified as 'remnant vegetation' in accordance with the relevant Queensland legislation. The management measures must continue to be implemented in areas not meeting the criteria for 'remnant status' until this has been achieved (or until approval to cease the management regime is provided by the Minister in writing);

    c. define corrective actions which will be undertaken if performance measures and reporting indicate that successful rehabilitation has not been achieved;

    d. identify persons responsible and arrangements for implementing the Rehabilitation Area Plan and for reporting on performance; and

    e. notify the Department in writing of the reclassification of areas within the Rehabilitation Area as 'remnant vegetation' within 30 business days of the reclassification occurring.

~~43. If the proponent proposes any action within a proposed offset area, other than actions related to managing that area as an offset property, approval must be obtained, in writing from the Department. In seeking Departmental approval the proponent must provide a detailed assessment of the proposed action including a map identifying where the action is proposed to take place and an assessment of all associated impacts on MNES. If the Department agrees to the action within the proposed offset site, the area identified for the action must be excised from the proposed offset and alternative offsets secured of equal or greater environmental value in relation to the impacted MNES.~~

QGC Comment: This repeats condition 31.

CSG Water Management

43. The proponent must :-

(i). take all reasonable measures to ensure that CSG water, including extracted groundwater, treated or amended CSG water, and any associated waste water, brine crystals and/or solids generated as a result of treating or amending water have no significant impact on any MNES during ~~or beyond~~ the life of the project including for a period of 100 years thereafter; and

(ii)~~.~~, if any such impacts do arise, apply identified measures (identified in the Coal Seam Gas Water Monitoring and Management Plan) to mitigate such impacts

Notifications and requirements about construction, operation, brine management and environmental management plans

44. The proponent must notify the Department in writing when developing or reviewing construction, operational, groundwater, CSG water, brine management, salinity management, environmental management, or other plans where the scope of the plans relates to potential significant ~~potential~~ direct, indirect or cumulative impacts on MNES, or involves management of MNES. The proponent must in the notification indicate the relevant components of such plans relating to MNES and their management, and the timeframe for development and approval of the plans under Queensland Government requirements.

45. Where the scope of the plans relates to potential significant impact on MNES, or involves management of MNES the plans must be submitted to the Minster for approval of those components. Approved components of plans must be implemented.

Coal Seam Gas Water Monitoring and Management Plan

46. The proponent must, within ~~6~~ 12 months from the date of the approval, or such other time as agreed in writing by the Minister, develop and submit for the approval of the Minister a Coal Seam Gas Water Monitoring and Management Plan that sets out an adaptive management framework for its project. The plan must also ~~address and~~ include~~s~~ at least:

QGC Comment: 12 months is necessary for developing the Water Monitoring and Management Plan. 6 months is inadequate to accommodate the necessary studies to properly inform the plan.

Beneficial re-use options

a) Beneficial re-use options which the proponent may pursue in addition to any reuse options being applied during the development of this Plan must be identified in detail,

QGC Comment:
It is essential that production be permitted to commence soon after approval is given. This is necessary to inform the Plan and the adaptive management framework QGC is committed to developing and modifying as necessary over the life of the project.

During development of the Plan QGC intends to pursue a number of identified re-use options, which are considered to be good beneficial re-use options and which will not result in adverse impacts.

For the Southern and Central development areas QGC intends to dispose of water to the Chinchilla Weir in collaboration with SunWater. There are no MNES springs located within these development areas.

To the extent the Plan will address beneficial re-use options it will both review re-use options being used during development of the Plan and consider other viable options that may be pursued.

It is acknowledged that following completion of the investigation with respect to CSG water re-injection any identified beneficial re-use options, including those being used to that point in time, may need to be altered to accommodate re-injection.

CSG water reinjection and use

a. To cater for the possibility of de-watering activities resulting in depressurisation of aquifers and thereby potentially ~~-~~impacting MNES, the proponent must also submit as part of the CSG Water Monitoring and Management Plan a methodology for investigating water reinjection and use and other possible methods of addressing risk of depressurisation of aquifers.~~.~~

b. ~~to avoid or minimise risks of direct or indirect impacts on MNES, the proponent must provide a plan for re-injection of treated CSG water back into appropriate permeable aquifers to re-establish pre-development pressure levels and water qualities, in conjunction with appropriate measures to forecast and proactively manage any short-term impacts~~The objective of the investigation is ~~to consider~~ to assess the degree of hydraulic connectivity of the Walloon Coal Measures with the GAB aquifers to ~~the~~ consider the feasibility and possible impacts of reinjecting CSG Water back into ~~appropriate~~ permeable aquifers to re-establish pre-development pressure levels as appropriate and to investigate other methods of achieving the same result.~~.~~ The investigation is to consider:

i. ~~;~~Hydraulic connectivity testing;

ii. The feasibility of reinjecting back into the aquifers which may be impacted by dewatering of Coal Seams;~~.~~

iii. ~~Hydraulic Connectivity testing and~~

iv. R~~r~~einjection trials;

v. Water quality for water to be reinjected and water quality of potential receiving ground water systems;

~~i.~~ (iv) potential impact on MNES associated with depressurisation of aquifers

vi. effectiveness of reinjection or other methods of restoring aquifer pressure as ~~a~~ mitigation measures and potential impacts of such measures.

~~Note: The design of these reinjection activities must be informed by an approved regional-scale groundwater model and an approved hydrochemical model.~~

c. The Coal Seam Gas Water Monitoring and Management Plan is to be submitted for amendment and approval by the Minister following completion of the investigation to incorporate any reinjection or other measures found by the investigation to be feasible and not to have any adverse impacts (Amended Plan).

d. The Amended Plan is to be submitted within 3 years of treated CSG Water becoming available in acknowledgement of the need to integrate production data and reinjection field testing into the investigation. The Amended Plan must also set out the circumstances in which reinjection may commence including the method and location of re-injection.~~.~~

~~b.~~e. T~~t~~o avoid or minimise risks of direct or indirect impacts on MNES, all CSG water to be re-injected must be treated to equal to, or better than, the water quality of the receiving groundwater system and be reinjected into Bowen or Surat aquifers to assist in restoring pressure and / or potentiometric heads within affected aquifers;

f. ~~where the proponent can demonstrate that a particular coal seam aquifer from which CSG water is being extracted is not hydraulically connected to other aquifers, then the Plan must specify the details of that particular coal seam aquifer and be accompanied by the evidence in support of the proponent's conclusion that the aquifer is not hydraulically connected~~ If as a result of the investigation negligible hydraulic connectivity is confirmed to exist and/or the extent of hydraulic connectivity is such that the impact on MNES will be insignificant, the Amended Plan need not contain any mandatory requirement for reinjection. The proponent must specify details of the particular coal seams and aquifers studied.

g. Prior to submission of the Amended Plan the proponent will have results of the investigation ~~-~~peer reviewed and submit the investigation and the results of the peer review to the Minister.~~;~~

Note: For the avoidance of doubt pending submission and approval of the Amended Plan the proponent may continue to manage CSG Water in accordance with the beneficial reuse options identified in the Plan.

~~c. if the Minister is satisfied that a coal seam aquifer from which CSG water is being extracted is hydraulically not connected to other aquifers, the Minister may approve a plan that provides for CSG water from that coal seam aquifer to be disposed of other than by re-injection;~~

QGC Comment: As drafted the reinjection requirements of the draft approval are unworkable. They assume reinjection is both feasible in all

cases and devoid of adverse impacts in all cases. This is not known. The above redrafting allows all interests (those of the Commonwealth, the State and the proponent to be reconciled). It also facilitates the proper ongoing development of an adaptive management framework that all parties agree is desirable. — The Geoscience Australia Report in considering reinjection in connection with possible impacts on MNES noted that; "*...measures to mitigate the potential impacts of proposed operations on water balances, such as the reinjection of treated associated water back into appropriate permeable formations to re-establish pre-development pressure levels, be explored as an option and considered as a condition for approval of any development activities.*" The suggested redrafting is not intended to diminish the potential relevance of reinjection, rather it is intended to achieve ~~precisely~~ what ~~was~~ QGC believes was recommended by Geoscience Australia, ie. the investigation (exploration) of reinjection as a management measure (option). This is also consistent with the requirements and preferred approach of the State. In the timeframe proposed by QGC for the Amended Plan, it is extremely unlikely that any impacts on MNES associated with depressurisation could occur. In addition the timeframe allows for the regional cumulative model to be developed by Queensland Water Commission and applied to the investigation.

QGC's initial production is to be in the south and central development areas. The closest MNES springs are over 100km to the North of these development areas (50km north of the QGC northern development area). QGC will not be commencing production in the northern area until late 2013. Until then there will only be very minor extraction of water associated with well appraisal testing in the Northern area.

~~the proponent may only have, own, hold, take, or otherwise utilise sufficient CSG water as required to undertake the approved activities within the approved project area;~~

QGC Comment: In view of the above suggested redraft, this condition is not necessary. In any event it represents an unreasonable restraint on use of CSG Water in connection with other potential reuse options and uses permitted under State legislation.

h. the proponent may not conduct activities that result in a loss of surface water or groundwater from the Condamine Alluvium other than where the proponent is permitted by State legislation to do so.

QGC Comment: It is anticipated that QGC will require some groundwater to be obtained from shallow aquifers for construction and related purposes. Extraction will be pursuant to licensed bores.~~;~~

Groundwater monitoring and management

~~d.~~i. a water quality and quantity groundwater monitoring plan to monitor the aquifers underlying the project area using a statistically and hydrogeologically valid, best practice bore monitoring network across the project area and the cumulative projected area of hydraulic impact;

~~e.~~j. the monitoring plan must address at least:

i. the aquifers to be monitored and the rationale for selection;

ii. the number and locations of monitoring bores and their flow, pressure, head, and water quality characteristics;

iii. the frequency of the monitoring and rationale for the frequency;

iv. baseline data for each monitoring site for comparison of monitoring results over the life of the project;

v. the approach to be taken to analyse the results including the methods to determine trends to indicate potential impacts;

vi. threshold values that protect relevant MNES (such as reporting or control line values for additional investigation, more intensive management action, make good, and cease operations) at which management actions will be initiated to respond to escalating levels of impact, including increasing levels of drawdown, contamination of groundwater, or subsidence;

vii. references to standards and relevant policies and guidelines;

viii. mechanisms to monitor, avoid, minimise, manage, and respond to risks; and

ix. performance measures, annual reporting to the Department, and publication of reports on the internet;

Surface water monitoring and management

~~f.~~k. a water quality and quantity surface water monitoring plan that includes at least:

i. identification of the surface and aquatic systems to be monitored and their environmental values, water quality, and environmental characteristics, and the rationale for selection;

ii. the number and locations of monitoring sites upstream and downstream of proposed discharge of CSG water (whether treated water, amended water or raw water), including test and reference sites upstream and downstream and before and after any proposed impacts;

iii. the frequency of the monitoring and rationale for the frequency;

iv. baseline data for each monitoring site for comparison of monitoring results over the life of the project;

v. the approach to be taken to analyse the results including the methods to determine trends to indicate potential impacts;

vi. threshold values that protect relevant MNES (such as reporting or control line values for additional investigation, more intensive management action, make good, and cease operations) at which management actions will be initiated to respond to escalating levels of impact and designed to protect water quality and the associated environmental values of surface and aquatic systems;

vii. water treatment and amendment methods and standards;

viii. water storage locations and volumes;

ix. water use or disposal options and methods (whether for beneficial use or not) including frequency, volumes, quality and environmental values documented for each receiving environment;

x. brine storage locations and volumes and brine crystal waste management;

xi. emergency water discharges, their volumes and quality;

xii. references to standards and relevant policies and guidelines; and

xiii. performance measures, annual reporting to the Department, and publication of reports on the internet;

Fracing

g.l. the estimated number and the spatial distribution of boreholes where fraccing may be necessary, an annual review of the estimate, and recording of actual use;

h.m. details of constituent components of any fraccing agents and any other reinjected fluid(s), including brine, and their toxicity as individual substances and as total effluent toxicity and ecotoxicity, based methods outlined in the National Water Quality Management Strategy;

CSG Water Management and response actions

i.n. mechanisms to avoid, minimise and manage risks and response actions that can be taken by the proponent where:

i. threshold values for surface environmental values specified in the Plan are exceeded;

ii. threshold values specified in the Plan for aquifer draw down or aquifer contamination are exceeded;

iii. significant subsidence or surface deformation occurs, particularly if it impacts on surface or groundwater hydrology; and

iv. there are any unforeseen emergency discharges.

46. ~~The Coal Seam Gas Water Monitoring and Management Plan must be submitted for the approval of the Minster. Commencement of gas and water extraction must not occur without approval of the Plan in writing. The approved Plan must be implemented.~~

QGC Comment: It is unreasonable to restrict production pending approval of the Plan. The Plan (initial Plan) is intended to be submitted and approved within 12 months of this approval. During that time QGC will comply with the Groundwater Monitoring Plan required by condition 9 (Appendix 2, Part 2 of the Coordinator General's Report). Further during that 12 month period only an insignificant fraction of the total CSG Water production associated with the QCLNG Project will have occurred.

Note: The Queensland Coordinator-General also requires surface water and groundwater monitoring and management. The proponent may incorporate requirements into plans that meet both Queensland and Commonwealth requirements.

Regional groundwater model

47. ~~It~~ It is recognised that the Queensland Water Commission (QWC) will develop a regional scale ~~To avoid or minimise direct or indirect impacts on MNES, the proponent must:~~

47. ~~develop a regional scale,~~ multi-layer, transient groundwater flow model of the cumulative effects of multiple CSG developments.

48. The proponent must contribute to development of that model by:

i) Contributing data generated by the proponent's monitoring activities

ii) Contributing data relevant to the proponent's existing modelling

iii) Contributing data generated from the proponent's Coal Seam Gas Water Monitoring and Management Plan including the Amended Plan~~;~~

iv) Contributing data generated for purposes of the baseline analysis required by condition 60(b);

~~i)~~v) Contributing in such other ways as agreed between the proponent and the QWC (or its successor agency)

~~a. develop and implement an adaptive management framework, applicable at both the project scale and regional scale, that includes monitoring and mitigation approaches to assess and manage the impacts of CSG developments, which takes into account the groundwater model of cumulative impacts required under (a); and~~

~~b.~~a. ~~contribute data as requested over the life of the Project to inform a Basin-scale multi-layer, transient groundwater flow model of the cumulative effects of multiple CSG developments in the Surat and Bowen Basins.~~

~~Note 1: In the absence of sufficient evidence to characterise and quantify potential impacts at the regional scale, this condition requires the model to be developed as an early warning system, informed by any other regional cumulative hydrological modelling, such that any hydrological changes can be identified at an early stage and appropriate, effective remedial actions implemented before irreversible environmental impacts on MNES.~~

~~Note 2: Condition 9, Part 2, Appendix 2 of the Queensland Coordinator-General's report of 24 June 2010, provides for the proponent to provide a regional groundwater model.~~

~~48. The model required under condition 49 (a) must:~~

~~a. use the best hydrostratigraphic and hydrogeological information available at the time, to identify the likely cumulative impacts of multiple CSG developments across the Surat and Bowen Basins;~~

~~b. detail all data relating to the hydraulic connectivity between aquifers and aquitards used to substantiate the model parameterisation;~~

~~c. be calibrated against measured piezometer responses in areas where CSG development has commenced;~~

~~d. in relation to the reporting of model outputs – conform to the recommendations of the former Murray Darling Basin Commission Groundwater Modelling Guidelines;~~

~~e. include:~~

~~i. water balances for the major aquifers affected by the CSG operations including the expected timeframe of any changes in water balance and pressure;~~

~~ii. recharge versus extraction volumes for those aquifers;~~

~~iii. details of justification for and assumptions regarding aquifer seal integrity (i.e. thickness and distribution of aquitards);~~

~~iv. quantification of hydraulic connectivity between different units (aquifers and aquitards) through drill stem and pump testing; and~~

~~v. quantification of the impacts of reinjection on aquifer water balances.~~

~~f. provide for adaptive monitoring, through six-monthly reporting of monitoring results and new data, and annual updates of numerical simulation models and re-interpretation of results to relevant Queensland Government and Commonwealth agencies.~~

~~49. The model required under condition 49 (a) must be provided at the same time it is provided to fulfil requirements of the Queensland Government.~~

~~50. The model required under 49 (a), may comprise the proponent's contribution to a regional groundwater model developed by the Queensland Water Commission (or its successor agency), as agreed between the proponent and the Commission.~~

49. Following completion of the QWC model the proponent must further develop and implement its adaptive management framework for its Project that includes monitoring and mitigation approaches to assess and manage the impacts of its CSG development which takes into account the QWC groundwater model outputs. The proponent may comply with this condition by reviewing and amending its existing monitoring and management plans to have regard to relevant outputs of the QWC model.

QGC Comment: The existing condition 52 recognises that the QWC will develop the appropriate regional groundwater model and that QGC's obligations with respect to developing a regional model may be discharged through its contribution to the QWC model. It is not within the capacity of QGC to itself develop the model contemplated by conditions 49 and 50. Those conditions are not capable of implementation. The above redraft more effectively captures the reality of what will occur and the proponent's contribution to what will occur. QGC is more than comfortable with urging QWC to develop a model consistent with the specifications outlined in the conditions 49 and 50. In relation to the new suggested condition 50 this condition is intended to commit QGC to ensuring the QWC regional cumulative model informs its adaptive management framework.

Cumulative Impact Assessment

~~51.~~50. On the same date that an assessment of cumulative impacts is provided in accordance with requirements imposed by the Queensland Government, or such other time agreed in writing by the Minister, the proponent must provide a copy of that report to the Minister.

~~52. In addition to meeting any requirements imposed by the Queensland Government, the assessment of cumulative impacts provided to the Minister must also address the following, in relation to potential impacts on MNES:~~

~~a. cumulative impacts relating to all listed species and listed ecological communities within and outside project area, including *The community of native species dependant on natural discharge of groundwater from the Great Artesian Basin*;~~

~~b. any surface water and groundwater environmental values, including groundwater pressures and groundwater hydrochemistry which, if altered, may have an impact on listed species and ecological communities within and outside project area;~~

~~Note: These requirements may also be included together with the detailed assessment of cumulative impacts required under condition 1, Part 2, Appendix 2, of the Coordinator-General's reported dated 24 June 2010.~~

51. Within 3 years of the date of the assessment referred to in condition 50~~that the assessment of cumulative impacts is provided to the State~~, the proponent must review that assessment in the light of the most up-to-date information and the QWC regional ~~transient~~ groundwater model ~~required under condition 49 (a)~~.

In undertaking the review the proponent must consider:

i. cumulative impacts relating to all listed species and listed ecological communities within and outside the project area, including *The community of native species dependant on natural discharge of groundwater from the Great Artesian Basin*; and

ii. any surface water and groundwater environmental values, including groundwater pressures and groundwater hydrochemistry which, if altered, may have an impact on listed species and ecological communities within and outside project area;

to ~~The~~ the extent that the QWC regional groundwater model facilitates an examination of those matters referred to in (i) and (ii) above.

~~53.~~52. The proponent must provide the review referred to in condition 53 to the Minister and at the same time publish the review on its website.

Note: These conditions provide that, if the Minister believes that it is necessary or desirable for the better protection of a relevant controlling provision for the action, the ofMinister may request the proponent to make, within a period specified by the Minister, revisions to a plan approved under these conditions. The Minister may make such a request in the light of the cumulative impacts assessment, or the review of the cumulative impacts assessment. Section 136(1)(b) of the EPBC Act additionally provides that the Minister may revoke, vary or add to a condition of this approval if the action has a significant impact that was not identified in assessing the action, and if the Minister relevantly believes it is necessary.

QGC Comment: The information required by the original condition 54 (a) and (b) in the timeframe required (namely, the same timeframe as provision for the report to be given to the Queensland Government), could not feasibly be prepared. This would substantially delay commencement of production that would be highly detrimental to the Project.

Consequently QGC suggests providing this information as part of what is contemplated as part of condition 55 (now condition 52). By that time the review could take advantage of what is likely to be the substantial additional data available about cumulative impacts. QGC continues to maintain however that the conclusions it reached in its EIS are sound.

Groundwater assessment, mitigation and monitoring

~~54.~~53. The proponent must provide to the Minister a copy of the groundwater assessment required under condition 9 ('Groundwater assessment, mitigation and monitoring'), Part 2, Appendix 2 of conditions imposed by the Queensland Coordinator-General in his report dated 24 June 2010. In addition, as part of a staged process of adaptive management of CSG development, the proponent must also include the following in relation to subsidence:

a. baseline and ongoing geodetic monitoring programs to quantify deformation at the land surface within the proponent's tenures. This should link from the tenement scale to the wider region across which groundwater extraction activities are occurring and any relevant regional program of monitoring;

b. modelling to estimate the potential hydrological implications of the predicted surface and subsurface deformation; and

c. measures for linking surface and sub-surface deformation arising from CSG activities.

~~55.~~54. When requested by the Department, the proponent must provide to the Department all geodetic monitoring data and related information from the program. This data must be provided within 30 days of request, or in a timeframe agreed to by the Department in writing.

55. Any program required under condition 5~~3~~6 must be submitted to the Minister ~~for~~. ~~approval. Production cannot commence until the plan is approved. The approved plan must be implemented~~..

QGC Comment: The assessment required under condition 9, Part 2, Appendix 2 of the Coordinator General's Report must be submitted to the Coordinator General for review prior to the commencement of petroleum activities. For the Commonwealth to impose an additional approval requirement means production could not commence as planned.

Springs assessment, mitigation and monitoring

56. As a precautionary approach, the proponent must, within the first 9 months following this approval ~~before commencement~~, survey for, reconfirm, and notify the Minister of the presence or absence of any springs proximal to the project area and within 50 kilometres of QGC tenements.~~modelled limits of aquifer draw-down, including the Dawson River 8 springs north of Taroom; the Cockatoo Creek springs east of Taroom; and the Scott's Creek springs northeast of Roma.~~

Note: To avoid doubt, this survey should report on both discharge and recharge springs, as EPBC listed species may occur at either.

QGC Comment: 100 km overlaps with at least 2 other proponents' tenements. In addition a survey of 100km is considered to be very onerous and unnecessary as springs within that radius are well beyond QGC tenements and are highly unlikely to be impacted by QGC activities.

57. If presence of *The community of native species dependant on natural discharge of groundwater from the Great Artesian Basin*, or listed threatened species that are reliant on springs, is confirmed by a survey under condition 5~~6~~9, then the proponent must, ~~before commencement~~:

a. protect the ecological community and/or listed threatened species from gas field development activities by establishing and maintaining a minimum 200 m employee/contractor exclusion zone from the relevant springs within QGC's project area, unless such access is required in an emergency, for environmental management, or for monitoring purposes;

Note: The Constraints Planning and Field Development Protocol will also apply.

b. prepare a management plan for all the relevant springs which includes:

i. a specific monitoring and remediation program to protect the species identified in this condition occurring within the project area ~~environmental values and cumulative impacts on any components~~

~~within the project area~~ and within modelled limits of aquifer draw-down that may arise from CSG water extraction, including identifying trigger levels and responses in the case of changes to groundwater flow or quality in each relevant spring;

ii. a baseline analysis of four 3-monthly samplings to determine the seasonal presence or absence of all relevant springs, and to establish: the existence, ~~dispersion~~ distribution and extent of listed threatened species; aquatic macro-invertebrates; aquatic plants; water quality characteristics; spring physical parameters including seasonal variation, depth, and flow rate; aquifer source including hydrochemical and isotopic analysis, and comparison of water levels with respect to source aquifer potentiometric surface;

QGC Comment: Baseline analysis will commence for known Springs during the 9 month survey and will be completed within 12 months of starting.

During that time, production will commence in the Southern and Central development fields. However, the Springs are more than 100 kilometres distant and the amount of water that will be extracted is such that no impact from water extraction on these baseline surveys is expected.

~~ii.~~iii. ongoing monitoring on a 6 monthly basis (to cover high and low rainfall seasons) over the life of the project in the region relevant to each spring;

~~iii.~~iv. analysis and calibration of the monitoring results against the baseline data (collected under (ii) of this condition) as the CSG water and gas extraction occurs over the life of the project;

~~iv.~~v. threshold values (such as reporting or control line values for additional investigation, more intensive management actions, make good, and cease operations) at which management actions will be initiated to respond escalating levels of impact and designed to protect *The community of native species dependent on the natural discharge of groundwater from the Great Artesian Basin* and listed threatened species in the case of changes to groundwater pressure, flow, or water quality in GAB springs;

~~v.~~vi. specific mechanisms to avoid, minimise, and manage risks, and response actions that can be taken by the proponent where:

(1) any threshold values for surface environmental values are exceeded;

(2) any threshold values for aquifer drawdown, water quality change, or aquifer contamination are exceeded;

(3) subsidence or surface deformation occurs, particularly if it impacts on surface or groundwater hydrology; and

(4) any unforeseen emergency discharges occur;

~~vi.~~vii. established best practice standards, policies and guidelines; and

~~vii.~~viii. performance measures, reporting to the Department, and publication of reports on the internet.

Note: Individual species and ecological community management plans are also required in accordance with condition 8.

~~58. Any management plan required under condition 60 (b) must be submitted to the Minister for approval. Production cannot commence until each plan is~~

~~approved. The approved plan must be implemented. The approved plan must be published on the internet within 20 business days of being approved by the Minister.~~

QGC Comment: Given the ~~-~~small fraction of total volumes likely to be extracted in the time taken to prepare management plans for the Springs, there is not expected to be any adverse impacts on water balance (aquifer depressurisation) during that period. It is therefore not considered necessary to delay commencement of production pending approval of the plans.

60 (a) has been amended in recognition that QGC may not be able to gain access to areas outside its tenements.

60(b)(i) has been amended to simply make it clearer.

61 has been deleted to remove conflicting timing of submission of the plan.

~~59.~~58. The results of the baseline analysis under 57~~60~~ (b) must be ~~incorporated~~ made available to QWC as part of the proponents obligations under condition ~~into the regional groundwater model required under condition~~ 49 ~~(a)~~.

Discharge, disposal or use of CSG salts, brine concentrates and heavy metals / metalloids

~~60.~~59. Concentrated CSG salts and other brine concentrates derived from CSG water may only be disposed of in conformity with condition 5 (Brine Management Strategy), of Appendix 2, Part 2 of the Coordinator General Report dated 24 June 2010 and the requirement that the preferred disposal strategies will not have any significant impact on MNES.~~;by either:~~

~~a. injection into deeper, underlying confined aquifers of equivalent water chemistry; or, failing that,~~

~~in secure contaminated waste disposal facilities that are licensed, operated, and monitored in accordance with the requirements of the Queensland Government.~~

QGC Comment: The Coordinator General condition is very comprehensive in this regard. It is unreasonable to limit what is available to QGC under State law. The Commonwealth's interests are properly addressed by ensuring potential impact on MNES are considered in the choice of options.

Note: This condition does not preclude the harvesting of salts and heavy metals for commercial purposes.

Note: Salt disposal within the Murray-Darling Basin must be in accordance with the requirements for salinity management and accountability set out in the *Water Act 2007* and the *Basin Salinity Management Strategy*.

Notification of threshold breaches and response actions

~~61.~~60. Within 10 business days of the proponent identifying monitoring outcomes that indicate a risk of reduction in groundwater pressure or water quality, the proponent must notify the Minister in writing of the trend and the proponent's response action. Within 20 business days of the notification, one or more approved response actions must be initiated by the proponent and the action to be taken published on the internet with the notification to the Minister.

~~62.~~61. Within 10 days of a surface or groundwater threshold value (for example, water quality, environmental value, pressure, head, volume, or flow) being exceeded, the proponent must advise the Minister in writing of the circumstances, the threshold exceeded, the immediate action taken by the proponent, and proposed action to remedy the breach and avoid a subsequent breach.

~~63.~~62. Immediate action may include a range of measures including but not limited to further monitoring and investigation, the ceasing of water / gas extraction and / or water discharge or use in the area affected or such other measures as may be appropriate until investigations can be completed to determine the cause and remedial action. The proponent's proposed response action must be notified to the Minister in writing.

~~64.~~63. The Minister may direct in writing that the proponent cease water / gas extraction and/or water discharge or use in the area affected, and if the Minister is not satisfied that the action proposed or taken by the proponent will remedy the situation, or make good any environmental loss, the Minister may direct the proponent to implement alternative action at the expense of the proponent. The proponent will be provided with a reasonable opportunity to comment on any such direction before it is required to be implemented.

Decommissioning Plan

~~65.~~64. Within five years of the commencement of gas field development, the proponent must develop a Decommissioning Plan. The Plan must:

a. require the progressive removal or reuse of infrastructure where gas field operations cease during the project life;

b. establish management practices and safeguards to minimise environmental disturbance;

c. ensure MNES are not impacted by progressive decommissioning, or final decommissioning of gas field infrastructure;

d. define rehabilitation actions for the infrastructure sites following decommissioning including for:

i. optimising habitat and habitat connectivity for MNES;

ii. enhancing pre-construction environmental quality; and

iii. ongoing management during rehabilitation.

~~66.~~65. The Decommissioning Plan must be submitted for the approval of the Minister. The approved Plan must be implemented.

Survey data

~~67.~~66. All survey data collected for the project must be collected and recorded so as to conform to data standards notified from time to time by the Department. When requested by the Department, the proponent must provide to the Department all species and ecological survey data and related survey information from ecological surveys undertaken for MNES. This survey data must be provided within 30 days of request, or in a timeframe agreed to by the Department in writing.

Publication of Protocol and Plans

~~68.~~67. The Protocol and all plans approved by the Minister under these conditions must be published on the proponent's website within 30 business days of approval by the Minister.

~~69.~~68. The Department may request the proponent to publish on the internet a plan in a specified location or format, and with specified accompanying text. The proponent must comply with any such request.

Notification of commencement

~~70.~~69. Within 20 business days of commencement, the proponent must advise the Department in writing of the actual date of commencement.

~~71.~~70. If, at any time after five years from the date of this approval, the Minister notifies the proponent in writing that the Minister is not satisfied that there has been commencement of the action, the action must not commence without the written agreement of the Minister.

Request for variation of plans by proponent

~~72.~~71. If the proponent wants to act other than in accordance with a plan approved by the Minister under these conditions, the proponent must submit a revised plan for the Minister's approval.

~~73.~~72. If the Minister acting reasonably approves the revised plan, then that plan must be implemented instead of the plan originally approved.

~~74.~~73. Until the Minister has approved the revised plan, the proponent must continue to implement the original plan.

Revisions to plans by the Minister

74. If the Minister believes that it is necessary or desirable for the better protection of a relevant controlling provision for the action, the Minister may request the proponent to make, within a period specified by the Minister, revisions to a plan approved under these conditions. ~~Without limiting this condition, the Minister may also make such a request following an inquiry under s.255AA of the *Water Act 1970*.~~

QGC Comment: Matters arising under 255AA of the Water Act are not matters within the purview of the EPBC Act.

75. If the Minister makes a request for revision to a plan, the proponent must, subject to the proponent having a reasonable opportunity to consider the request and confer with the Minister about it:

a. comply with that request; and

b. submit the revised plan to the Minister for approval within the period specified in the request.

76. The proponent must implement the revised plan on approval of the Minister.

77. Until the Minister has approved the revised plan, the proponent must continue to implement the original plan.

Minimum timeframes for consideration of plans

78. For any plan required to be approved by the Minister under these conditions, the proponent must ensure the Minister is provided at least 20 business days for review and consideration of the plan, unless otherwise agreed in writing between the proponent and the Minister.

Compliance with State environmental and other authorities

79. The proponent must comply with all environmental authorisations issued by the State, including conditions of an environmental authority issued under the EP Act.

Provision of State plans

80. If a condition of a State approval requires the proponent to provide a plan then the proponent must:

a. provide the plan to the Department or Minister on request, within the period specified in the request; and

b. prepare and combine plans that meet both Queensland Government and Commonwealth requirements relevant to the controlling provisions for this approval where this is efficient, and in doing so clearly identify the

respective responsibilities and how these are being addressed in relation to these conditions.

Timeframes

81. If these conditions require the proponent to provide something by a specified time, a longer period may be specified in writing by the Minister.

Auditing

82. On the request of and within a reasonable period specified by the Department, the proponent must ensure that:
    a. an independent audit of compliance with these conditions is conducted; and
    b. an audit report, which addresses the audit criteria to the satisfaction of the Department, is published on the Internet and submitted to the Department.

83. Before the audit begins, the following must be approved by the Department:
    a. the independent auditor; and
    b. the audit criteria.

84. The audit report must include:
    a. the components of the project being audited;
    b. the conditions that were activated during the period covered by the audit;
    c. a compliance/non-compliance table;
    d. a description of the evidence to support audit findings of compliance or non-compliance;
    e. recommendations on any non-compliance or other matter to improve compliance;
    f. a response by the proponent to the recommendations in the report (or, if the proponent does not respond within 20 business days of a request to do so by the auditor, a statement by the auditor to that effect);
    g. certification by the independent auditor of the findings of the audit report.

85. The financial cost of the audit will be borne by the proponent.

86. The proponent must:
    a. implement any recommendations in the audit report, as directed in writing by the Department after consultation with the proponent;
    b. investigate any non-compliance identified in the audit report; and
    c. if non-compliance is identified in the audit report - take action as soon as reasonably practicable to ensure compliance with these conditions.

87. If the audit report identifies any non-compliance with the conditions, within 20 business days after the audit report is submitted to the Department the proponent must provide written advice to the Minister setting out the:

a. actions taken by the proponent to ensure compliance with these conditions; and

b. actions taken to prevent a recurrence of any non-compliance, or implement any other recommendation to improve compliance, identified in the audit report.

Note: To avoid doubt, independent third party auditing may include audit of the proponent's performance against the requirements of any plan required under these conditions.

Reporting non-compliance

88. The proponent must, when first becoming aware of a non-compliance with these conditions, or a plan required to be approved by the Minister under these conditions:

a. report the non-compliance and remedial action to the Department within five business days;

b. bring the matter into compliance within a reasonable time frame specified in writing by the Department.

Record-keeping

89. The proponent must:

a. maintain accurate records substantiating all activities associated with or relevant to these conditions of approval, including measures taken to implement a plan approved under these conditions; and

b. make those records available on request to the Department. Such records may be subject to audit by the Department or an independent auditor in accordance with section 458 of the EPBC Act, or used to verify compliance with these conditions.

Note: Audits or summaries of audits carried out under these conditions, or under section 458 of the EPBC Act, may be posted on the Department's website. The results of such audits may also be publicised through the general media.

Financial assurance

90. The proponent must:

a. provide the Minster with a financial assurance in the amount and form required from time to time by the Minster for activities to which these conditions apply; and

b. review and maintain the amount of financial assurance based on proponent reporting on compliance with these conditions, and any auditing of the activities.

91. The financial assurance is to remain in force until the Minister is satisfied that no claim is likely to be made on the assurance.

Note: The financial assurance may be used for rehabilitation of habitat and other purposes not addressed adequately by the proponent during the life of the project.

Annual Environmental Return

92. The proponent must produce an Annual Environmental Return which:

    a. addresses compliance with these conditions;

    b. records any unavoidable impacts on MNES, mitigation measures applied to avoid impacts on MNES; and any rehabilitation work undertaken in connection with any unavoidable impact on MNES;

    c. identifies all non-compliances with these conditions; and

    d. identifies any amendments needed to plans to achieve compliance with these conditions.

93. The proponent must publish the Annual Environmental Return on the Internet within 20 business days of each anniversary date of this approval.

Publication by the proponent

94. Where in these conditions, the proponent is required to publish plans, reports, data or any other document, the requirement is to be read subject to the proponent's obligations to third parties concerning confidentiality and intellectual property.

Dictionary

~~94.~~95. In these conditions, unless otherwise indicated:

Brigalow means for the purposes of the application of the Constraints Planning and Field Development Protocol the presence of the Brigalow (*Acacia harpophylla* dominant and co-dominant) ecological community includes Brigalow regrowth that retains the species composition and structural elements typical of that found in the undisturbed listed regional ecosystems but does not include:

a. vegetation that has been comprehensively cleared (not just thinned) within the last 15 years

b. vegetation in which exotic perennial plants have more than 50% cover, assessed in a minimum area of 0.5 ha (100 m by 50 m) and

c. individual patches of Brigalow that are smaller than 0.5 ha;

Clearance of native vegetation means the cutting down, felling, thinning, logging, removing, killing, destroying, poisoning, ringbarking, uprooting or burning of native vegetation;

Commencement means any physical disturbance including clearance of native vegetation, new road work, and the establishment of well sites to develop the gas field project area. Commencement does not include minor physical disturbance necessary to undertake preclearance surveys ~~or~~ to establish monitoring programs, or associated with the mobilisation of the plant, equipment, materials, machinery and personnel prior to the start of gas field development;

Conditions means these conditions attached to the approval of the action;

CSG means coal seam gas;

Department means the Australian Government department responsible for administering Part 4 of the EPBC Act;

Environmental constraints class Zone 4a means habitat for listed threatened species and migratory species described in management plans for these matters and listed ecological communities identified through ecological field surveys, listed threatened ecological communities, which includes matters for which there is a disturbance limit specified in Tables 2 and 3 under condition 26. For the purposes of these conditions, environmental constraints class Zone 4a it does not include other constraints identified by the proponent unless these relate to MNES;

EP Act means Environmental Protection Act 1994 (Qld);

EPBC Act means the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*;

Gas field development means all activities associated with the development of the gas fields including (but not limited to) site clearance and site preparation; development of exploration and production wells; development of water and gas transmission pipelines; infrastructure access road construction; construction of workers accommodation and office facilities; construction of gas compression stations; construction of pumping stations; construction of water treatment facilities; and construction of water storage dams;

Impact risk zone means the area within 200 metres from the perimeter of class Zone 4A;

Linear infrastructure means infrastructure including (but not limited to) gas and water gathering lines, low and high pressure gas and water pipelines, roads and tracks, power lines and other service lines;

Listed means those species, ecological communities or other identified matters of environmental significance listed for protection under Part 3 of the EPBC Act;

Minister means the Minister responsible for Chapter 4 of the EPBC Act, and may include a delegate of the Minister under s.133 of the EPBC Act;

MNES means matters of national environmental significance, being the relevant matters protected under Part 3 of the EPBC Act;

No impact zone means the area within 300 metres from the perimeter of class Zone 4A;

Non-linear infrastructure means infrastructure including (but not limited to) exploration and production wells, compressor stations, regulated dams, reverse osmosis plants, brine encapsulation facilities, workers camps, and maintenance facilities;

Plan includes a report, study, protocol or strategy (however described);

Production means extraction of coal seam gas or associated water other than for exploration purposes;

Proponent means the holder of the approval to which these conditions relate, and includes any person acting on behalf of the proponent;

Referral means a referral under the EPBC Act including any amendment of the referral.

Regulatory agency means agencies administering the EPBC Act and the EP Act (Qld);

Trunkline rights of way means the linear construction footprint required to install gas and water trunklines, underground 33 kV power lines, above ground 33 kV power lines, fibre optic cable and gas and water gathering lines. Trunkline rights of way may contain between one and ten gas and water trunklines, between one and ten power lines, between one and ten fibre optic cables and between one and up to twelve gathering lines running in parallel;

***Upstream Infrastructure* Corridor (UIC)** is a linear corridor linking the Ruby CPP, Jordan CPP, Kenya WTP, Bellevue CPP and the Condamine Power Station. The UIC will contain multiple linear infrastructure items running in parallel, including gas trunklines, water trunklines, gas gathering lines, water gathering line, water distribution pipelines, above ground 132 kV power lines, above ground 33 kV power lines, below ground 33 kV power lines and fibre optic cable. The UIC and the infrastructure to be contained within the UIC along various sections of the UIC is shown in Figure 2 to these conditions;

Water distribution pipelines means pipeline used to transfer treated or raw water ~~from a water treatment plant~~ to a user of that water or to transfer brine between facilities that manage brine;

Water gathering lines means pipelines used to transfer water between wells and regional storage ponds (RSPs);

Water trunklines means pipelines used to transfer water between regional storage ponds and water treatment plants.

~~95.~~96. Unless otherwise indicated, words in these conditions have the same meaning as in (in the following order of priority):

a. the EPBC Act; and

b. the EP Act.

~~96.~~97. Unless the contrary is indicated, in these conditions:

a. words in the singular number include the plural and words in the plural number include the singular; and

b. condition headings are inserted for convenient reference only and have no effect in limiting or extending the language of the condition to which they refer.

Queensland Government

Department of
Infrastructure and Planning

Our ref: 10/47529

18 OCT 2010

The Honourable Tony Burke MP
Minister for Sustainability, Environment, Water,
Population and Communities
PO Box 6022
House of Representatives
Parliament House
Canberra ACT 2600

Confidential

Dear Minister

I refer to your letter dated 1 October 2010 to the Honourable Stephen Robertson MP, Minister for Natural Resources, Mines and Energy and Minister for Trade, advising of your proposed decisions to approve coal seam gas (CSG) extraction, associated pipelines and liquefied natural gas (LNG) facilities on Curtis Island near Gladstone.

The Queensland Government appreciates the advance notice of your proposed decision. To support the finalisation of your decision, I wanted to provide supporting information in relation to two key matters in relation to my conditions under the *State Development and Public Works Organisation Act 1971*, being:

- restrictions on the management of coal seam water
- environmental offsets for World Heritage values on Curtis Island.

Coal Seam Gas Water Management

I note that the proposed EPBC approval conditions include requirements that:

- the primary mechanism for managing coal seam water must be re-injection to other aquifers in the region
- any disposal of the coal seam water other than by re-injection can only be allowed where the proponent demonstrates to the Minister's satisfaction that the coal seam gas aquifer is not hydraulically connected to other aquifers
- the proponent must not conduct any activities that result in a loss of surface or ground water from the Condamine alluvium.

Executive Building
100 George Street
PO Box 15009
City East Queensland 4002
Telephone +61 7 3227 8548
Facsimile +61 7 3224 4683
Website www.dip.qld.gov.au

ABN 25 166 523 889

It is recognised there are several advantages in pursuing re-injection as the primary means of managing coal seam water. These advantages include: mitigating adverse impacts on aquifers and reducing potential 'make good' requirements for production bores and springs by re-establishing groundwater levels; reducing storage pond requirements and the associated surface impact; and contributing to a sustainable approach though storing water for future use.

The major issue, however, is that specifying re-injection of coal seam water as the primary management mechanism is overly restrictive and may not be technically feasible or appropriate in all situations. In certain locations, re-injection could lead to unintended consequences and a more flexible approach, as adopted by the Queensland Government, is recommended.

In October 2008, the Queensland Government released the *Queensland Coal Seam Gas Water Management Policy*. The policy included, among other policy principles, the intention for a CSG Water Management Plan (CWMP) to be incorporated into the Environmental Management Plan (EMP) required for a Level 1 environmental authority application.

The content requirements for a CWMP have been included in the Department of Environment and Resource Management (DERM) guideline: *Preparing an environmental management plan (EM Plan) for Coal Seam Gas (CSG) activities*. The guideline sets out preferred and non-preferred management options for CSG water. These are:

Category 1 – preferred management options include:

- injection where detrimental impact unlikely
- untreated use where detrimental impact unlikely
- treatment to an agreed standard for agricultural, industrial and potable uses.

Category 2 – non-preferred management options include:

- disposal via evaporation dams
- disposal via injection where detrimental impact is likely
- disposal to surface waters
- disposal to land.

The CSG water management options in each category are currently not in any preferred order; however, I note that the DERM guideline is to be amended to specify re-injection as a first priority, subject to technical and economic feasibility. Industry has been consulted on these amendments and your officers have been appraised of this approach.

Finally, I note the specific condition that "...the proponent must not conduct any activities that result in a loss of surface or ground water from the Condamine alluvium." While the importance of managing risk to the Condamine Alluvium is acknowledged, the condition as currently framed may be an unworkable requirement with measurement difficulty.

Ground water management

Amendments to the Queensland Government's regulatory framework for managing groundwater impacts are currently being prepared. It is intended that the provisions of the *Water Act 2000* will be expanded to provide for the Queensland Water Commission (QWC) to manage groundwater monitoring and develop regional groundwater models for declared cumulative management areas (where water level impacts of CSG producers overlap). It is anticipated that QWC's regional groundwater models will incorporate all the gas fields located within the Surat Basin and will be used to predict collective impacts of CSG water extraction on water levels to assist in the design of the future water level monitoring network and management responses.

In the proposed regulatory framework under the *Water Act 2000* for managing groundwater impacts, CSG producers will have an obligation to undertake an assessment of all springs within an area likely to have a drawdown of 0.2 metres or more, and accordingly propose and implement a strategy to minimise or mitigate impacts on these springs. The new regulatory framework provides for a risk-based adaptive management approach to spring impact management.

The Queensland Government's proposed new arrangements to protect groundwater resources in CSG extraction areas are currently out for consultation with stakeholders and industry. It is noted a copy of the exposure draft has been provided to your Department.

Scientific panel of experts

It is also worth noting that the Queensland Government is also currently preparing to establish a panel of experts to provide advice to both the QWC and DERM on a range of CSG issues including:

- supporting DERM in its role in assessing applications and conditioning environmental authorities in relation to the disposal of CSG water
- supporting QWC in its role associated with the management of cumulative impacts from CSG water extraction in cumulative management areas.

This panel is expected to be operational by December this year.

Environmental Offsets for World Heritage Values on Curtis Island

I note the proposed condition and offset ratio associated with the LNG facility leases on Curtis Island consists of land that contains similar World Heritage values. This requirement generates significant complexities which would impact on its practical application and enforcement.

The LNG proponents are contractually obliged to contribute to rehabilitation and management of the (approximately) 4590 hectare Environmental Management Precinct of the Gladstone State Development Area on Curtis Island. This precinct has been established in a similar way to a national park in that it is approved by the Governor in Council of Queensland, and can only be amended or removed with approval from the Governor in Council.

The Queensland Government has also commenced consultation to change the boundaries of the Gladstone State Development Area, to, amongst other things, preserve more of the environment. This boundary adjustment proposes to protect an additional 274 hectares of environmentally sensitive land in two separate Environmental Management Precincts. Under the proposal, the 189 hectare Kangaroo Island would be wholly redesignated as an Environmental Management Precinct and an extra 85 hectares will be added to the existing Environmental Management Precinct on Curtis Island.

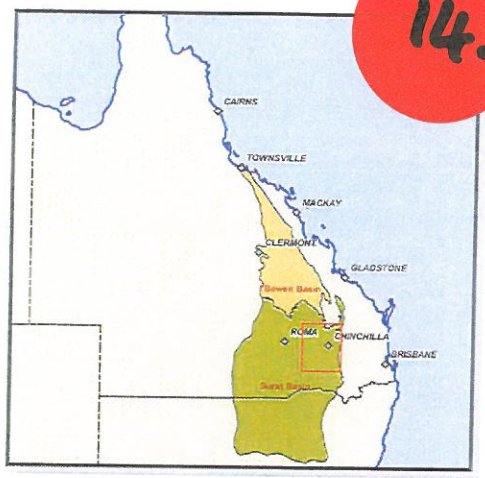
I am advised the Queensland Government is fully prepared to consider raising the conservation status of appropriate land within the Environmental Management Precinct on Curtis Island (or other land as secured by proponents). However, the Commonwealth Government's requirement for this land to be established as national park would appear to be a condition beyond the power of the proponent to control. Additionally, while a permanent form of conservation tenure can be established, you will appreciate that the Queensland Government must reflect the actual environmental values in a declaration under the *Nature Conservation Act 1992* (Qld). Additional flexibility could be provided by changing the required tenure to "permanent conservation status under the *Nature Conservation Act 1992* (Qld)", or similar.

I trust this information is of assistance. If you require any further information, please contact Dr Geoff Dickie, Deputy Coordinator-General, Department of Infrastructure and Planning, on (07) 3224 6944 who will be pleased to assist.

Yours sincerely

Graeme Newton
Coordinator-General
Director-General

14.



Environmental Authority Applications

GDA

N

0 4.5 9 18 27 36

Kilometers

Map Projection: GDA 94 SCALE: 1:625,000 (A3)

DATA SOURCE: Towns, Railways, Roads - GA
PLs, ATPS - DME

- Towns
- Major Roads
- Railway
- Project EA
- QCLNG EIS Tenement Boundary

Environmental Authority Areas
- Reporting to Bellevue CPP
- Reporting to Jordan CPP
- Reporting to Ruby CPP
- Reporting to Wolleebee Creek CPP
- Future Reduced Scope Project EA

QGC
A BG Group business

DATE: 07/03/2011 | MAP NO: M_05429_01
CREATED BY: TG | REV NO: A

QGC's Project areas

Note these project areas are very large and involve a number of tenures- in total they add to over 76 tenements covering 643,773 hectares or more than 1,590,000 acres

Ruby Project Area (12 tenement blocks- covering 91,464 hectares):
Sean, David, Poppy, Ruby, Isabella, Barney, Clunie, Jen, Broadwater, Cougals, Glendower, Harry

Jordan Project Area (19 tenement blocks- covering 144,818 hectares):
Tarsha, Madeleine, Wyalla, Anais, Owen, Jade, Aurora, Kenya East, Jammat, Margaret, Jordan, Michelle, Clesete, Will, Ridgewood, Myrtle, Aberdeen, Teviot, Marie Rae

Bellevue Project Area (8 tenements- covering 61,281 hecatres):
Avon Downs, Bellevue, McNulty, Justin, Andrew, Lila, Arvin, Grace

Woleebbe Creek Project Area(16 tenements – covering 109,928 hectares)
Cassio, Acrux, Polaris, Kathleen, Cam, Ross, Woleebee Creek, Mamdal, Peebs, Marcus, Pinelands, Connor then parts of Carla, Lawton, Alex and Paradise Downs

What was previously known as Kenya or Central Project has now become Walloon Fairway Project Area and included new areas to the west of Kenya Project Area in the process (31 tenements – covering 236,282 hectares)
Berwyndale, Berwyndale South, Matilda-John, Lauren, Codie, Kenya, Katie, Argyle, Mekah, Mable, Arlington, some of the other tenures have no names as yet just Bris and a number (see attached map)

Of the above,

- Ruby and Jordan are granted – QGC are challenging for a change in conditions applying to both these areas
- Bellevue and Woleebee Creek have only just been granted IRR process still open to original submitters only
- Kenya Central has been granted, Walloon Fairway which replaces it has been granted and is under IRR, QGC are challenging for a change in conditions.

15.

QGC
A BG Group business

12 July 2011

Attn: Ms Anne Bridle

Secretary of the Basin Sustainability Alliance
PO Box 180
DALBY
QLD 4405

Dear Ms Bridle

NOTICE OF APPLICATION FOR INTERNAL REVIEW

I am writing to advise that QGC Pty Limited (**QGC**) is today applying for internal review of the Department of Environment and Resource Management's (**DERM**) decision to grant environmental authority PEN 101252910 pursuant to section 310M of the *Environmental Protection Act 1994* (**EP Act**).

A copy of QGC's application and submission supporting the application is **attached**. We are making the application to ensure that the conditions of the Environmental Authority are well defined, achievable, certain and reasonable. Where possible, we have offered alternative suggestions to achieve this aim. We fully support the Object of the EP Act and are committed to conducting our activities in a manner that minimises environmental harm.

Pursuant to section 521(4) of the EP Act, you may make a submission on the application for internal review to DERM within 5 business days after the application is made. If you have any questions about our submission or would like more information, please call me on or email me at !

Yours faithfully,

Tracey Winters

General Manager Environment

Department of Environment and Resource Management

Application form

Section 521 — *Environmental Protection Act 1994*

Review of original decision

This form is to be used when a person is dissatisfied with an original decision made by the Department of Environment and Resource Management (DERM) under schedule 2 of the Environmental Protection Act 1994 *and is seeking a review of that decision under section 521 of the Act. Please answer the questions on this form in order, unless instructed to go to another question and label attachments alphabetically (e.g."Attachment A").*

OFFICIAL USE ONLY

DATE RECEIVED

FILE REF

PROJECT REF

COMPLETE FORM ☐ CORRECT AA ☐

COMPLETE FEE ☐

ENTERED BY [SIGNATURE]

DATE

For a list of the people who were given notice of the original decision, contact your local Department of Environment and Resource Management (DERM) office (refer to the information sheet *Contact details for environmental licensing — including Council areas*)

Application details

1. Applicant name

Principal Holder: QGC Pty Limited

2. Responsible person

Tracey Winters

3. What is the original decision you want reviewed?

Grant of Application for level 1 environmental authority (Chapter 5A activities), subject to certain conditions.

4. When did you receive the notice of the original decision?

After close of business on Friday 13th May 2011.

5. What is the reference number for the original decision?

EA No. PEN 101252910
Ref 351997/BNE 44800

6. When did you give notice of this application to the other people who received notice of the original decision?

Notice of this application, and a copy of the supporting document will be sent to all submitters before close of business on 12 July 2011.

Department of Environment and Resource Management
www.derm.qld.gov.au ABN 46 640 294 485

Queensland Government

7. Declaration

Note: If you have not told the truth in this application you may be liable for prosecution under the relevant Acts or Regulations.

- I apply for the review of the original decision made by the administering authority as detailed in this application.
- I have given notice of this application to the other people who received notice of the original decision, informing them that submissions about this application must be received within 5 business days after this application is submitted.
- I have given a copy of this application and supporting documents to the other people who received notice of the original decision.
- I do solemnly and sincerely declare that the information provided is true and correct to the best of my knowledge. I understand that it is an offence under s480 of the EP Act to give to the administering authority or an authorised person a document containing information that I know is false, misleading or incomplete in a material particular.
- I understand that all information supplied on or with this application form may be disclosed publicly in accordance with the *Right to Information Act 2009* and the *Evidence Act 1977*.

APPLICANTS SIGNATURE	
APPLICANTS NAME Tracey Winters	DATE 12 July 2011

If you have any queries about how to complete this form correctly or need guidance on supporting information required please contact the help desk on 1300 130.372

8. Applicant checklist

- ☒ Application form(s) completed and signed
- ☒ Supporting information or accreditation attached (if applicable)
  - ☒ Each specific decision that you want reviewed
  - ☒ Reasons why you believe each decision is unreasonable or inappropriate
  - ☒ Documentation supporting your reasons

To access a list of statewide licensing contact points for DERM visit our website at www.derm.qld.gov.au for a copy of the information sheet *Contact details for environmental licensing — including Council areas.*

Please return your completed application to:

Permit and Licence Management
Department of Environment and Resource Management

GPO Box 2454
BRISBANE QLD 4001

Enquiries: **1300 130 372**
Facsimile: (07) 3896 3342
Email: palm@derm.qld.gov.au

Submissions in support of Internal Review of Conditions imposed as part of Environmental Authority PEN101252910 (Ruby)

1 Introduction

1.1 The DERM has granted and issued QGC with Environmental Authority (EA) No. PEN101252910 (**Ruby EA**) for Level 1 Chapter 5A activities under s.310M of the Environmental Protection Act 1994 (EP Act) to be conducted on certain petroleum tenements identified in the EA.

1.2 These submissions are in support of QGC's internal review application in respect of certain conditions sought to be imposed by the DERM on the EA. The DERM Application form – Review of original decision, invites an applicant for review to give reasons why each decision is considered unreasonable or inappropriate.

1.3 The DERM's jurisdiction with respect to the imposition of conditions is informed by the Object (section 3) of the of the EP Act, being "to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends". Further, the DERM's jurisdiction with respect to the imposition of conditions is set out in section 310O of the EP Act and involves the test of "necessary or desirable". The QCLNG EIS Coordinator-General Report dated June 2010 (**CG Report**) is also relevant to this EA. Conditions imposed by the DERM must not be inconsistent with the Coordinator-General's conditions (s.310O(5)(b)).

Other matters relevant to imposition of conditions relate to:

(a) Finality;

(b) Understandability or certainty;

(c) Implementability;

(d) Whether they have the effect of frustrating or unduly limiting the approval actually given; and

(e) Reasonableness.

In formulating these submissions QGC has had regard to the above matters. QGC has also had regard to conditions more recently imposed on the Woleebee Creek environmental authority PEN 101741410 (**Woleebee Creek EA**) granted in respect of the QCLNG project, where relevant. QGC's aim is to ensure an Environmental Authority that is workable and that conditions are genuinely "necessary or desirable" to fulfil the Object of the EP Act.

1.4 QGC completely supports the Object of the EP Act and is committed to conducting its operations in a manner that minimises environmental harm and where possible enhances environmental values. QGC will monitor the environmental effects of its activities and is committed to taking steps to mitigate or make good adverse impacts in a timely manner. We are also

committed to achieving full compliance with our regulatory obligations and QGC is making this application to ensure that the conditions are well defined, achievable, certain and reasonable.

1.5 Whilst this internal review application relates to a review of conditions proposed for the Ruby EA, QGC provides the following information for completeness.

2 Additional Advice about the approval

2.1 In the application for this environmental authority, QGC identified that it would be undertaking chemical storage and gravel extraction which comprise ERA 8 (5) and 16 (2)(d) and (3)(c) respectively.

To avoid misunderstandings in the future, QGC requests that these ERAs be acknowledged in the table on page 2 of the environmental authority.

3 Condition A1

Issues

3.1 QGC seeks an amendment to the following rows of Schedule A Table 1 as identified below:

Schedule A, Table 1 – Authorised Petroleum Activities

Tenure number/s	Petroleum activities and infrastructure	Number of existing activities	Number of proposed activities	Maximum capacity (where applicable)	Maximum disturbance (hectares)
	Seismic (kms)	200	1000	N/A	144 ha
	Total Compressor Stations, including:	0	13	N/A	129 ha
	Central Processing Plants (CPP)	0	1	N/A	45 ha
	Field Compressor Stations (FCS)	0	12	N/A	84 ha

4 Condition A8 – A11

Issues

4.1 QGC requests that 3 new conditions be added under the heading of Operational Plan as follows:

(Ax) For the first six (6) months from the date of issue of the environmental authority, all activities must be undertaken in accordance with the 'Operational Plan to the End of 2014' (the Interim Operational Plan) contained within the *Ruby Area – Environmental Management Plan, Supporting Information, June 2010.*

(Axx) Notwithstanding Condition (Ax), where there is conflict between the commitments contained in the (Interim) Operational Plan and the conditions of this environmental authority, the conditions of this environmental authority prevail.

(Axxx) Within six months of the issue of the environmental authority, a revised Operational Plan must be developed that provides detailed information about the activities to be carried out under this environmental authority.

4.2 This requires consequential amendments to:

(a) conditions (A9) and (A10), to insert "required by condition (Axxx)" after the reference to 'Operational Plan' in both conditions; and

(b) condition (A11), to be replaced by "the holder of this environmental authority must implement the Operational Plan required by condition Axxx within six months of the issue of the environmental authority".

Reasons

4.3 QGC requires 6 months to update the existing Operational Plan to ensure that it fully meets the requirements of conditions (A8) to (A13).

4.4 QGC's request to include conditions allowing for activities to be undertaken in accordance with the 'Operational Plan to the End of 2014' (the Interim Operational Plan) contained within the *Ruby Area – Environmental Management Plan, Supporting Information, June 2010* is consistent with the conditions imposed on the Woleebee Creek EA.

5 Condition B2

Issues

5.1 QGC requests that 3 new conditions be added under the heading of Erosion and Sediment Control Plan as follows:

(Bx) For the first six months from the date of issue of the environmental authority, an Interim Erosion and Sediment Control Plan must be implemented for the activities to be undertaken under this environmental authority.

(Bxx) The Interim Erosion and Sediment Control Plan must:

(a) prevent or minimise the release of contaminants from disturbed areas to avoid environmental harm from being caused;

(b) include similar types of measures and devices as described in Condition (B6); and

(c) be consistent with the Soil Erosion and Sediment Control Management Plan contained within the *Ruby Area – Environmental Management Plan, Supporting Information, June 2010.*

(Bxxx) A revised Erosion and Sediment Control Plan, which has been certified by a suitably qualified person, must be developed within six months of the date of issue of this environmental authority.

Reasons

5.2 QGC require 6 months to update the existing Erosion and Sediment Control Plan to ensure that it fully meets the requirements of conditions (B2) to (B4), particularly with respect to detailed soil sampling and analysis requirements.

5.3 QGC's request to include conditions allowing for activities to be undertaken in accordance with the Interim Erosion and Sediment Control Plan is consistent with the conditions of the Woleebee Creek EA, and will still ensure that appropriate erosion and sediment control measures are implemented.

6 Condition B9

Issues

6.1 QGC requests the condition read:

"Despite Conditions (B7) and (B8), linear infrastructure activities such as those relating to the construction of pipelines, access tracks, powerlines, communication cables and roads may be undertaken within 200 m of and in a wetland, lake or spring, or within 100 m of and in a watercourse where there is no reasonable and practicable alternative (e.g. trenchless methods) for:

(a) a maximum period of 10 business days; or

(b) such other time as is permitted by any relevant statutory Code or Guideline for undertaking works in a watercourse, provided:

(i) the relevant statutory Code and/or Guideline is complied with; and

(ii) the administering authority is notified and provided details of the relevant statutory Code and/or Guideline under which the works may extend beyond 10 business days; and

(iii) the administering authority is notified prior to the commencement of the works beyond the ten day period; or

(c) such other time as the agreed to in writing by the administering authority."

6.2 For the purposes of clarity, QGC also requests a footnote to the condition as follows:

"Footnote: Examples of relevant Codes or Guidelines include the Code for self-assessable development (Temporary waterway barrier works) September 2010 and the Guideline – activities in a water course, lake or spring associated with mining activities – v.2 December 2010"

Reasons

6.3 The reason for the first aspect of the requested change is to make it clear that it is not the linear infrastructure itself that is limited by the timeframes specified later in the condition, but rather the construction of that infrastructure.

6.4 In relation to the timeframe, QGC notes that the construction of linear infrastructure may commonly take longer than 10 business days in various circumstances, often because of delays due to rain and for other construction reasons, including equipment failures, industrial action etc.

6.5 In the event that construction times in a watercourse might take somewhat longer than 10 business days as the drafting currently stands, it would be necessary to seek an amendment to the condition, or a Transitional Environmental Program (**TEP**), to enable such work to proceed. This could not be done in any reasonable timeframe and could result in even longer periods of disturbance. Further, under the *Sustainable Planning Act 2009* and the *Fisheries Act 1994* construction activities are permitted to be undertaken within a water course for up to 21 days in tidal areas and 42 days in non-tidal areas under the self assessable code for waterways barrier works. The code is extensive and sets out a range of measures to minimise impacts.

6.6 The condition as drafted deprives QGC of the opportunities available to others undertaking works in water courses in other circumstances. To that extent the condition discriminates. The existence of the code also demonstrates that longer periods for construction work in water courses ought to be acceptable provided the code is complied with.

6.7 The Coordinator-General's condition 18, Appendix 2, Part 2 for the gas fields provides that where a riverine protection permit is not required, activities in watercourses are to be undertaken in accordance with the "Guideline - Activities in a watercourse, lake or spring associated with mining operations" unless otherwise authorised by the administering authority.[1]

6.8 This condition recognises that a particular guideline may be followed in certain circumstances. The Guideline does not restrict activities in a water course to 10 days. The condition also recognises that the administering authority (DERM) should have discretion in terms of matters pertaining to activities in a water course. QGC has sought to reflect this discretion in its suggested redrafting of condition B9 as it relates to time limits for activities in a water course.

6.9 The imposition of a 10 day time limit is inconsistent with condition 18, Appendix 2, Part 2 of the Coordinator-General's conditions. However, QGC would be prepared to accept it, in the context of its suggested revision of condition B9.

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[1] Sections 49(b), 50(b), 51(b) of the Water Regulation 2002 provide that destroying vegetation, excavating and placing fill in a watercourse are permitted for the purposes of section 814 to the extent they are carried out under "a licence, petroleum lease or authority to prospect under the *Petroleum and Gas (Production and Safety) Act 2004* ..."

6.10 QGC also notes that each of the Commonwealth Approvals imposed under the *Environment Protection and Biodiversity Conservation Act 1999* contains a condition that enables the Minister to extend a specified time period in the approval in writing. A similar approach would obviate the need for impracticable and unnecessary amendment applications to extend time where it is necessary to do so.

QGC submits the condition, with respect to the 10 business days is neither necessary nor desirable because:

(i) there is no greater risk of environmental harm occurring over a period of 8 days compared to a period of 12 days (for example);

(ii) a period of 10 days is arbitrary;

(iii) other regulatory instruments (codes and guidelines) recognise longer periods, or no set periods, for the undertaking of construction work in water courses are acceptable;

(iv) it is not desirable that a strict time period apply in such circumstances where matters beyond the control of QGC or its contractors might result in more than 10 business days being required, in which case an amendment application would need to be made during which time construction would cease involving considerable down time and cost; and

(v) recognising means by which the 10 days can be extended (by compliance with a relevant code or in accordance with permission granted by the administering authority) is both necessary and desirable from an operational point of view and aligns with the approach taken by the Commonwealth.

6.11 In addition the proposed amendment is consistent with the corresponding condition imposed on the Woleebee Creek environmental authority.

7 Condition B19

Issue

7.1 The condition requires that Polycyclic Aromatic Hydrocarbons are not added by design to any stimulation fluids to be injected into the target gas producing formation. In this and subsequent conditions, the concept of "target gas producing formation" is used when referring to a key element in the design and control of well stimulation processes. QGC seek a clarification of the term to be consistent with the geological context to which it applies.

7.2 The phrase "target gas producing formation" is too broad a concept to reflect what is being intended with respect to coal seam gas activities. The phrase should be deleted wherever it is used in the EA and the following concept substituted:

"Target coal seam gas producing formation".

Reasons

7.3 The condition as drafted is not necessary or desirable because:

(i) It uses too broad a concept of "gas producing formation". The appropriate concept in the current context is "target coal seam gas producing formation".

(ii) It is desirable that the concept be as accurate as possible.

7.4 In addition the proposed amendment is consistent with the corresponding condition imposed on the Woleebee Creek environmental authority.

8 Condition B24

Issue

8.1 This condition requires a Stimulation Risk Assessment. Parts of the Assessment required are problematic for the reasons identified below.

8.2 First of all, the expression "target gas producing formation" is used. The more accurate expression would be "target coal seam gas producing formation".

8.3 Secondly, in relation to B24(m) QGC seeks to change that part of the condition to:

"(m) Practices and procedures to ensure that the stimulation activities are designed to be contained within the barriers of the target coal seam gas producing formation having regard to its identification under B24(j)."

Reasons

8.4 The reason for this change is to reflect what will be a derived understanding of "barriers" to the formation pursuant to B24(j) that contain both producing and non-producing intervals that are fractured and propped by the stimulation process.

8.5 The well stimulation process can therefore be designed within the target coal seam gas producing formation which will be comprised of both producing and non-producing intervals. The effect of the change is to make a clear identification of the barriers that limit well stimulation but in such a way as to not frustrate the approval.

8.6 Part of the purpose of the Stimulation Risk Assessment is to help in the design, across a range of considerations, of the stimulation activity. Part of its purpose is also to identify limits to and barriers of a coal seam gas producing formation stimulation impact zone. That is part of the outcome of B24(j) in particular. The intention is to limit the impact of stimulation activity to that stimulation impact zone which is able to be understood after carrying out an assessment of the "barriers" that limit a particular coal seam gas producing formation.

8.7 As presently drafted, B24(m) does not properly identify how the Stimulation Risk Assessment works in terms of planning stimulation activities within a particular area, i.e., the area of a target coal seam gas producing formation as

limited by known "barriers". The proposed amendment gives greater accuracy to the concepts in (m).

8.8 In addition the proposed amendment is consistent with the corresponding condition imposed on the Woleebee Creek environmental authority.

8.9 Therefore the condition as presently drafted is not necessary or desirable because:

(i) it is uncertain;

(ii) it lacks precision; and

(iii) it does not properly reflect part of the intention or workings of the Stimulation Risk Assessment.

9 **Condition B25**

Issues

9.1 Condition B25 requires the stimulation risk assessment be carried out for every well that is to be stimulated. This fails to recognise that a stimulation risk assessment for one well might be completely applicable to other wells in the geological/hydrogeological vicinity of that well.

9.2 QGC requests the amendment of condition B25 to provide as follows:

> *"The stimulation risk assessment must be carried out for every well or group of wells in an area of like geological and hydrogeological characteristics to be stimulated prior to stimulation activities being carried out at that well."*

9.3 The suggested amendment simply recognises that wells in a common location will share common characteristics of the type dealt with in condition B24, e.g.

(a) naturally occurring geological faults;

(b) seismic history of the region;

(c) proximity of overlying and underlying aquifers; and

(d) the environmental values of groundwater in the area,etc....

9.4 In those cases, it would be reasonable to apply the results of a stimulation risk assessment conducted for one well to the other wells sharing those common characteristics.

9.5 In addition the proposed amendment is consistent with the corresponding condition imposed on the Woleebee Creek environmental authority.

9.6 QGC submits that the condition as presently drafted is neither necessary nor desirable because:

(a) it fails to recognise that the work required under Condition B24 with respect to a particular well is likely to have equal application to a number of wells in a common area and therefore need not be replicated for each well;

(b) the cost of carrying out a stimulation risk assessment for every well, as currently required by condition B25, fails to have regard to a relevant consideration namely that part of the "standard criteria" that requires a consideration of financial implications of requirements under the EA in circumstances where there is no environmental benefit in conducting the same stimulation risk assessment for every well. (See section 310N).

10 Condition B26

Issue

10.1 Consistent with the corresponding condition imposed on the Woleebee Creek EA, QGC seeks the following amendment to condition B26:

(B26) Stimulation activities must not negatively affect water quality at:

(a) any active landholders' groundwater bores (subject to access being permitted by the landholder) that are located within a two (2) kilometre horizontal radius from the location of the stimulation initiation point; and

(b) any active landholders' groundwater bores within 200 metres vertically of the stimulation initiation point; and

(c) any other bore that could potentially be adversely impacted by the stimulation activity(ies) in accordance with the findings of the risk assessment required by Conditions (B23) and (B24).

10.2 In light of the amendment sought to condition (B26), QGC requests that the definition of stimulation impact zone be deleted from the Schedule L.

10.3 The current Condition B26 requires that stimulation activities must not result in a change in water quality other than that within the stimulation impact zone of the target gas production formation. The stimulation impact zone defined in the condition (150m maximum) will place an unreasonable burden on gas field activities.

10.4 This means no change to water quality beyond 150m radial distance from the stimulation target location is permitted.

10.5 This is an impossible condition and will mean that well stimulation cannot be undertaken in the gas field, and would effectively frustrate QCLNG project approvals, including this EA, and the Coordinator-General's Report. The condition should be deleted.

10.6 To the extent that during de-watering of the coal seam gas producing formation, a nearby bore may be impacted, the *Water and Other Legislation Amendment Act 2010* requires appropriate measures to be taken.

10.7 A water monitoring strategy required as part of an Underground Water Impact Report (**UWIR**) under section 370 of the Water Act 2000 (**Water Act**) must include a strategy for monitoring changes in the water level or the quality of water in aquifers in the area because of the exercise of rights (Water Act section 378 (1)).

10.8 The UWIR must include a summary of information about all water bores in a relevant area including the number of bores, and the location and authorised use or purpose of each bore.

10.9 Impacts on water quality should be addressed in the Make Good Obligations set out in Chapter 3 Part 5 Division 1 of the Water Act. Section 421 of the Water Act confirms that a make good measure under the Water Act includes ensuring the bore owner has access to a reasonable quantity and quality for the bore's authorised use or purpose.

10.10 A "change" in water quality is not defined. A change could be interpreted as any minor or insignificant change to any one parameter that can be assessed as part of water quality, irrespective of whether this change is likely to cause environmental harm.

10.11 If this condition were imposed, it would require QGC to assess any potential changes in water quality at any distance greater than 150 metres from the stimulation initiation point. There are no well diagnostic methods that can differentiate between water quality at distances greater than 150 metres and less than 150 metres from a stimulation initiation point. Therefore there would be no means to ensure compliance with this condition other than limiting well stimulation to less than 150 metres from the stimulation initiation point.

Reasons

10.12 The condition as presently drafted including the definition of "Stimulation Impact Zone" is not necessary or desirable because:

(i) the distance of 150m is arbitrary and is unreasonable;

(ii) it is impossible to guarantee that there will be no change in water quality from stimulation activities beyond the stimulation impact zone of 150m which means the condition will frustrate the approval inherent in the Environmental Authority. It is incapable of consistent implementation;

(iii) water quality may be affected by a variety of processes not attributable to stimulation;

(iv) imposing a radial limit of 150 metres ignores part of the purpose of the Stimulation Risk Assessment which is to help design stimulation activities and identify the potential stimulation impact zone. The stimulation impact zone should not be radially limited but rather limited by the "barriers" noted as a result of B24(j) investigations;

(v) a consequence of the condition is likely to be the limiting of stimulation activities to an impractically small area from the stimulation initiation point. While this may not have been intended it is a consequence of the condition and the present definition.

(vi) as presently drafted the condition and the definition has the effect of substantially frustrating the approval inherent in the EA by potentially

limiting an essential part of gas field activity to unrealistic and potentially uneconomic proportions;

(vii) it would have the result of impacting gas field development by increasing well numbers and decreasing well spacings, causing further surface impacts.

(viii) it fails to appreciate that existing Water Act provisions deal with the issue of water quality.

11 Condition B27

Issue

11.1 The condition as currently drafted prohibits the causing of any connection between aquifers as a result of stimulation activities.

11.2 As is recognised elsewhere in the EA, the appropriate approach should be to require that all reasonable and practicable measures be taken to ensure that stimulation activities do not cause the connection of the coal seam gas producing formation and another aquifer.

The risk of causing aquifer connectivity is low, but will be a matter considered as part of the Stimulation Risk Assessment. Well stimulation will be designed appropriately having regard to that Assessment. QGC requests the condition be amended to provide as follows:

(B27) All reasonable and practicable measures must be taken to ensure that stimulation activities do not cause the connection of the target coal seam gas producing formation and another aquifer.

Reason

11.3 The condition as presently drafted is not necessary or desirable because the risk is low and well stimulation will be designed having regard to that risk.

12 Condition B30

Issue

12.1 The condition requires rectification measures to be taken immediately if the holder becomes aware that stimulation activities have resulted in a change in water quality (other than that within the stimulation impact zone) or that stimulation activities have caused the connection of the target coal seam gas producing formation and another aquifer.

12.2 There are two issues in relation to this condition. Firstly, it should require the taking of all "reasonable and practicable" rectification measures consistent with section 319 of the EP Act and secondly, the word "immediately" should be qualified by a footnote to acknowledge the need to assess and implement what might be appropriate rectification measures in the circumstances. A footnote as follows would suffice for the latter concern:

> *"Footnote: it is understood that some lead time might be required to assess and implement what might be appropriate rectification measures in the circumstances."*

Reason

12.3 It should be remembered that in relation to water quality issues, the 2010 amendments to the Water Act remain relevant (see section 409 in relation to make good obligations).

12.4 The suggested footnote is consistent with case law on the issue (see *Dorsman v Nichol Supreme Court of Northern Territory*[2]) where the relevant case law is canvassed and confirms "immediately" should be construed as having regard to all the relevant circumstances of a particular case.

Under those reasons, QGC submits the condition as presently drafted is not necessary or desirable because:

(a) it leaves the meaning of "immediately" potentially open to different interpretations and therefore uncertain in the context in which it is used;

(b) it does not recognise that rectification measures should be those measures which are "reasonable and practicable" in the circumstances; and

(c) it does not recognise that any rectification measures entail an engineering process, requiring appropriate due diligence and the application of professional standards of care.

13 Condition (C2)

Issue

13.1 QGC proposes that condition (C2) be amended as follows:

(C2) The hazard assessment required under Condition (C1) must occur in any of the following situations:

(a) prior to the design and construction of the dam;

(b) prior to any change in its purpose or its stored contents;

(c) for a dam assessed and certified as a high or significant hazard dam, at least biennially after its construction;

(d) for an existing low hazard dam, within 1 year of the date of grant of this environmental authority.

Reasons

13.2 The proposed amendment allows a reasonable timeframe for QGC to undertake the assessment required by condition (C1), which comprises a substantial body of work. The timeframe sought is consistent with that provided for in conditions imposed on the Woleebee Creek EA.

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[2] (1978) 20 ALR 231

14 Condition (C5) and definition of 'Low Hazard Dam'

Issue

14.1 QGC submits that the definition of 'Low Hazard Dam' should be replaced with the definition contained in the draft Guideline 'Dams Constructed as Part of Environmentally Relevant Activities', version 1:20 – 6-2011, dated June 2011, which supports the 'Manual for Assessing Hazard Categories and Hydraulic Performance of Dams as Constructed as Part of Environmentally Relevant Activities Pursuant to the Environmental Protection Act 1994', dated June 2011. The definition should therefore be as follows:

"Low hazard dam means any dam that is:

1. *Not a high or significant hazard category as assessed using the Manual for Assessing Hazard Categories and Hydraulic Performance of Dams; and*
2. *That contains contaminants in concentrations which exceed the values or range shown in Table 3 of the Manual for Assessing Hazard Categories and Hydraulic Performance of Dams at any time when the contained volume within the dam is greater than 50% of the dam crest volume, where the dam crest volume is less than 2.5ML."*

1.1 QGC also seeks the deletion of condition (C5).

Reasons

14.2 The proposed amendment to the definition of low hazard dam will ensure consistency with the recent version of the guideline associated with the Manual for Assessing Hazard Categories and Hydraulic Performance of Dams.

14.3 The current definition of low hazard dam covers a significant number of very minor dams, sumps and turkey's nest dams.

14.4 The definition would require significant design and construction (e.g. HDPE liner) for small ponds and sumps (i.e. backyard swimming pool size) with a very low risk of environmental harm. The measures required would be disproportionate to the risk that could possibly arise from the quantity stored or the duration of storage. For example, drill sumps generally exist for about 15 days. The water in the sump may trigger Table 3 in the Manual as referenced in the condition, most likely for minor exceedance of the salinity trigger value. Lining each sump with HDPE liner is excessive for the risk posed by the very short amount of the time the water is in the sump and the level of contaminants found in the water, which have a low risk of causing serious or material environmental harm.

14.5 Condition (C5) is not necessary or desirable because it requires monitoring and imposes construction standards which are not proportionate to the risks associated with the relevant dams. Further, condition (C1) adequately manages the potential risk caused by such dams.

15 Condition D6

Issue

15.1 Condition D6 requires the holder of the Environmental Authority, when carrying out petroleum activities, to demonstrate that:

(a) impacts on areas of vegetation or other areas of ecological value were avoided, minimised or mitigated (in order of preference);

(b) significant isolation, fragmentation or dissection of tracts of vegetation that may result in a reduction in the current level of ecosystem functioning, ecological connectivity (i.e. stepping stone or contiguous bio-regional/local corridor networks) and/or resulted in an increase in threatening processes (e.g., potential impacts associated with edge effects or introduced species) were avoided;

(c) disturbances to land that may otherwise result in land degradation were minimised;

(d) for land that is to be significantly disturbed by the petroleum activities:

(i) the top layer of the soil profile is removed;

(ii) soils are stock piled in a manner that preserve their biological and chemical properties;

(iii) soils are used for rehabilitation purposes; and

(iv) the clearing of mature trees was avoided.

15.2 The Coordinator-General's Report for the QCLNG Project requires that a Constraints Planning and Field Development Protocol (the Protocol) be developed (Appendix 2 Part 2 Condition 2). The Commonwealth Department of Sustainability, Environment, Water, Population and Communities (**DSEWPC**) approval for the QCLNG Project gas fields requires the preparation, and approval by the Minister of a Constraints Planning and Field Development Protocol (Conditions 3, 4, 5, 6, 20, 21, 22, 23 and 24).

15.3 Appendix 2, Part 2 Condition 2 of the CG Report requires that various environmental and social constraints are incorporated into the Protocol, including areas with ecological value and high value agricultural land. The conditions of approval from DSEWPC on the Protocol require the inclusion of matters of national environmental significance (MNES) in the Protocol.

15.4 Condition A14 of the EA requires that QGC implement the Protocol.

15.5 QGC has developed a Protocol that addresses the requirements of the CG and DSEWPC. The objective of the Protocol is to enable selection of the optimal location for infrastructure after consideration of environmental and social constraints. The Protocol:

(a) identifies all environmental and social constraints in the gas fields;

(b) assigns a constraint ranking (no go, very high, medium, or low) to each infrastructure type (e.g. plant, wells, pipeline, ponds) for every constraint; and

(c) directs the selection of the location of every infrastructure item to minimise environmental and social impacts.

15.6 Environmental constraints include Category A, B and C Environmentally Sensitive Areas (**ESAs**). QGC has also developed an environmental and social constraints GIS system to facilitate the selection of the optimal location of infrastructure. Implementation of the Constraints Protocol is the primary management measure QGC has adopted to minimise environmental and social impacts when locating a gas field infrastructure. This has been done in direct response to regulatory conditions as described above. All infrastructure must undergo a review and approval of the proposed location against the constraints mapped in the GIS.

15.7 QGC is concerned that Conditions D6 (and D14) do not recognise that QGC has been required to develop this Protocol by the Coordinator-General, DSEWPC and by DERM.

15.8 Further, the requirements of D6 go further than what is required by the Coordinator-General and DSEWPC conditions referred to above. It is confusing and impractical to set one set of conditions to achieve a desired end and then in the EA to impose another set of conditions that places other requirements on the holder in relation to substantially the same issues. This gives rise to a conflict with the Coordinator-General conditions and fails to adequately recognise both the Coordinator-General conditions and the DSEWPC conditions for the gas fields.

15.9 Consistent with the corresponding condition imposed on the Woleebee Creek EA, this condition should be amended to provide as follows:

> *"The holder of the environmental authority, when carrying out the petroleum activities must be able to demonstrate that all reasonable and practicable measures were taken to:*
>
> *(a) avoid, minimise or mitigate (in order of preference) impacts on areas of vegetation or other areas of ecological value ;*
>
> *(b) avoid significant isolation, fragmentation or dissection of tracts of vegetation that may result in a reduction in the current level of ecosystem functioning, ecological connectivity (i.e. stepping stone or contiguous bioregional/local corridor networks) and/or resulted in an increase in threatening processes (e.g. potential impacts associated with edge effects or introduced species);*
>
> *(c) minimise disturbances to land that may otherwise result in land degradation;*
>
> *(d) ensure that for land that is to be significantly disturbed by the petroleum activities:*

(i) *the top layer of the soil profile is preserved*

(ii) *soils are stockpiled in a manner that preserve their biological and chemical properties;*

(iii) *soils are used for rehabilitation purposes; and*

(e) *avoid or minimise the clearing of mature trees."*

15.10 The above drafting recognises the reasonable requirement of taking "reasonable and practicable" measures as is recognised elsewhere in the EA and in section 319 of the EP Act, with respect to avoiding environmental harm.

15.11 Further, the condition, in some respects, is inconsistent with other conditions of the EA. For example, Condition D15 recognises allowances for clearing for limited petroleum activities in certain areas including in particular the Upstream Infrastructure Corridor. The Upstream Infrastructure Corridor will necessarily involve the clearing of mature trees. Every effort will be made to minimise the need to clear mature trees but it may be inevitable that some will need clearing. Condition D6(e) would frustrate the approval to the extent that it allows disturbance in the Upstream Infrastructure Corridor.

Reasons

15.12 The condition as presently drafted is not necessary or desirable because:

(a) it is, in some respects, contrary to the substance and intent of conditions imposed by the Coordinator-General and DSEWPC;

(b) it gives insufficient recognition to what is recognised elsewhere in the EA, namely the desirability of moderating excessively harsh conditions by reference to the concept used in the general environmental duty (EP Act, section 319), i.e., the need to take "reasonable and practicable" measure to avoid environmental harm.

(c) it has the potential to frustrate aspects of the approval inherent in the EA;

15.13 A consequential amendment to Condition D15 should also be made if Condition D6 remains in the suggested alternate form, namely:

"(D15) Notwithstanding Conditions D6, D13 and D14 ...."

16 Condition D8(a)

Issue

16.1 Condition D8(a) precludes the development of non-linear infrastructure (other than wells) on slopes greater than 10%. In general QGC do not propose to locate non-linear infrastructure (other than wells) on slopes greater than 10%. However, where competing environmental and social constraints dictate that the optimal location for infrastructure, to minimise environment and social impacts, is on a slope greater than 10%, then QGC considers it should be permitted to locate a specific item of infrastructure or portions thereof on such a slope greater than 10%. QGC would in those circumstances supply the necessary environmental and geological information to demonstrate the means by which potential environmental impacts would be managed at the specific

site. It is considered that the location of infrastructure on slopes greater than 10% would be rare but the possibility cannot be ruled out.

16.2 QGC requests that the condition be worded as follows

> *"Notwithstanding Condition (D6), significant disturbance to land caused by the carrying out of the petroleum activities must not involve clearing native vegetation or placing fill:*
>
> *(a) on slopes greater than 10% for petroleum activities other than wells, pipelines, access tracks, power lines, communication cables, roads and other infrastructure approved by the administering authority in writing; and*
>
> *(b) in discharge areas."*

Reasons

16.3 As presently framed the condition is neither necessary nor desirable as it:

(a) unnecessarily restricts the siting of limited infrastructure on slopes greater than 10% where other environmental or social considerations establish that such an area is the optimum site;

(b) has the potential to frustrate the approval in significant respects ;

(c) does not have sufficient regard to the Constraints Planning and Field Development Protocol referred to above.

16.4 In addition the proposed amendment is consistent with the corresponding condition imposed on the Woleebee Creek environmental authority.

17 Condition D11

Issue

17.1 The table does not provide for any circumstances in which activities, other than "limited petroleum activities", can be conducted within 500 m of a Class B or C ESA or within 1 km of a Class A ESA. Activities, other than limited petroleum activities, include gas and water trunklines, infield ponds, Central Processing Plants (CPPs) and Field Compression Stations (FCS). By preventing activities, other than limited petroleum activities, from being within 500 m of a Class B or C ESA or within 1 km of a Class A ESA, this condition could result in the optimal location for infrastructure, that minimises environmental and social impacts, being disregarded. QGC uses the Protocol and GIS system to identify the optimal location for infrastructure that minimises environmental and social impacts. This may be within 500 m of a Class B or C ESA or 1 km of a Class A ESA in some cases. QGC proposes that activities, other than limited petroleum activities, be allowed within 500 m of a Class B or C ESA or within 1 km of a Class A ESA, provided this is done in accordance with the Protocol and Condition D14 of the EA.

17.2 Consistent with the corresponding condition imposed on the Woleebee Creek EA, QGC requests the insertion of a new condition within Schedule D to read as follows:

> *"(Dxx) Despite Condition (D11), the infrastructure (and associated activities necessary for construction, operational and maintenance purposes) specified in Schedule D, Table X – Authorised Petroleum Activity(ies) Disturbance and depicted in Appendix 2, Ruby Infrastructure within ESA buffers is permitted in the location specified in Schedule D, Table X – Authorised Petroleum Activity(ies) Disturbance."*

Schedule D, Table X – Authorised Petroleum Activity(ies) Disturbance

Tenure	Description of Infrastructure	Number	Location
PL275	Ruby Camp	1	Entry points: Easting: 288,827 Northing: 6,986,354 Easting: 289,225 Northing: 6,986,301

17.3 QGC also notes that the table refers to Conditions E11 to E16. QGC believes this to be an error. QGC believes what was intended was D12 to D16.

18 Condition D12

Issue

18.1 The condition requires, towards the end of the condition, the avoidance of clearing of mature trees.

18.2 It cannot be guaranteed that absolutely every mature tree can be preserved.

18.3 QGC seeks the inclusion of the words "*where possible*" in the condition so that the condition, towards the end of the condition, reads:

> *"...all significance disturbance to the greatest practicable extent and where possible avoid the clearing of mature trees".*

18.4 This amendment is consistent with the corresponding condition imposed on the Woleebee Creek EA and would simply recognise the reality of work in the field and allow a small measure of flexibility where that is absolutely and necessarily called for.

Reasons

18.5 As presently drafted the condition is not necessary or desirable because:

(i) it has the potential to frustrate the approval inherent in the EA where the clearing of limited numbers of mature trees is absolutely necessary;

(ii) the insertion of the words "where possible" simply align that part of the condition related to mature trees with the rest of the condition which

requires preferential location of activities in certain areas "to the greatest practicable extent".

19 Condition D15

Issue

19.1 As a result of proposed changes to Condition D6, if retained in an amended form, this condition would need to be amended as follows:

> *"Notwithstanding conditions D6, D13 and D14, where limited petroleum activities are proposed ... etc ..."*

19.2 Consistent with the conditions imposed on the Woleebee Creek environmental authority, QGC seeks the insertion of the following after the words 'limited petroleum activities' in (D16):

> "..and other activities authorised in *Schedule D, Table 2 - Authorised Petroleum Activity(ies) Disturbance."*

20 Condition D23

20.1 QGC requests that 3 new conditions be added under the heading of Soil Management Plan as follows:

(Dx) Prior to the commencement of each petroleum activity authorised by this environmental authority, an Interim Soil Management Plan is required to be in place for that activity, which:

(a) prevents or minimises impacts to soils (including Good Quality Agricultural Land); and

(b) includes similar types of measures as described in Condition (D24); and

(c) is consistent with the Soil Contamination Management Plan contained within the *Ruby Area – Environmental Management Plan, Supporting Information, June 2010.*

(Dxx) Notwithstanding Condition (D23), where there is conflict between the contents of the Interim Soil Management Plan and the conditions of this environmental authority, the conditions of this environmental authority prevail.

(Dxxx) Within six months of the issue of this environmental authority, a revised Soil Management Plan which has been certified by a suitably qualified person must be developed.

Reasons

20.2 QGC requires 6 months to update the existing Soil Contamination Management Plan to ensure that it fully meets the requirements of conditions (D23) to (D25), particularly with respect to detailed soil sampling and analysis requirements.

20.3 QGC's request to include conditions allowing for activities to be undertaken in accordance with the Soil Contamination Management Plan is consistent with the conditions of the Woleebee Creek Environmental Authority.

21 Condition D35

Issue

21.1 The management of sewage from the Ruby camp will involve the production of a treated effluent in a sewage treatment plant (STP) and the disposal of that treated effluent on an irrigation disposal area, where suitable species will be irrigated. Effectively the STP and the irrigation disposal area, operating together, provide an integrated treatment system which minimises the impact on the wider receiving environment. There is little benefit in ensuring that the STP (itself) achieves specific nutrient targets given that the effluent irrigation system will treat and remove nutrients.

21.2 The total nitrogen (TN) and total phosphorus (TP) limits (long term 50th percentile) for both TN and TP are 5 mg/L and are unnecessarily stringent for the disposal of the treated effluent via an irrigation scheme. In particular, the nitrogen limit will be extremely difficult to achieve under variable load conditions or without sophisticated operator supervision of daily operation.

21.3 The design of the effluent irrigation scheme will consider the applied nutrient loading together with the hydraulic and salt loadings. In effect, the proposed nutrient limits make no allowance for the nutrient removal that will be achieved within the effluent irrigation scheme.

21.4 There is a similar logic to be considered with the nutrient uptake of phosphorus present in the treated effluent when irrigated to vegetation. Again there is a mass of phosphorus "lost" with any vegetation harvested from the irrigation area. Consideration will also be given to sorption of phosphorus onto soils within the irrigation area. This trapped phosphorus is expected to be a significant proportion of the applied phosphorus. The sustainable effluent irrigation scheme will be designed such that the long-term (circa 25 years) TP application loading will not exceed the adsorptive capacity of the soil.

21.5 Condition (D32) requires that the sewage effluent disposal area be modelled using the MEDLI program or recognised equivalent. The use of the MEDLI model combined with irrigation area investigations will result in the determination of TN and TP levels that can be released without causing environmental harm.

21.6 It should be noted that the condition numbers that follow (D45) revert back to (D43) rather than continue at (D46). This response uses the numbering as it should appear in the EA.

21.7 Condition (D44) requires that the irrigation of treated sewage effluent must be carried out in accordance with the Land Release Management Plan required by condition (D45). Condition (D47) requires that releases to land do not exceed the limits set in Schedule D, Table 2 – Limits for the Disposal of Waste Water to Land.

21.8 There is an inconsistency between the requirements in Schedule D Table 1 of condition (D35) and Schedule D, Table 2 of (D47), particularly with regard to the stipulation of nutrient removal targets (50^{th} percentile) for nitrogen and phosphorus.

21.9 Condition (D46)(d) requires that the Land Release Management Plan must demonstrate control of the build up, from water, waste or other sources, of nutrients or contaminants in the soils or subsoil. Condition (D46)(d) effectively conditions the release of sewage effluent so as control the build up of nitrogen and phosphorus. It is not necessary place limits on the TN and TP levels as required by Condition (D35).

21.10 QGC propose that TN or TP limits are either:

(i) deleted from Schedule D Table 1 – Treated Sewage Effluent Release Limits to Land or

(ii) made consistent with Schedule D, Table 2 - Limits for the Disposal of Waste Water to Land

Reasons

21.11 Condition (D35) does not recognise the integrated nature of the quality of water released from a sewage treatment plant and the disposal of that water in a treated effluent irrigation area and the management of nitrogen and phosphorus in the system as a whole.

21.12 Condition (D35) does not recognise other controls required by the EA to manage nutrient loads from disposal of treated effluent.

22 Condition D45

22.1 QGC requests that 2 new conditions be added under the heading of Land Release Management Plan as follows:

(Dx) Despite Condition (D45), the holder of the environmental authority may develop an Interim Coal Seam Gas Use for Dust Suppression Management Plan which must be implemented prior to the development of the Land Release Management Plan, so long as the plan:

(a) prevents or minimises impacts to soils; and

(b) includes descriptions and measures as described in Conditions (D45); and

(c) ensures compliance with Condition (D47) (incorrectly numbered in Ruby EA draft as (D44), and Conditions (G22) to (G24).

(Dxx) Notwithstanding Condition (Dx), where there is conflict between the contents of the Interim Soil Management Plan and the conditions of this environmental authority, the conditions of this environmental authority prevail.

Reasons

22.2 QGC proposes to operate under an Interim Dust Suppression Management Plan whilst the Land Release Management Plan is being developed to meet the requirements of condition (D45).

22.3 QGC requests the inclusion of conditions allowing for activities to be undertaken in accordance with the Interim Dust Suppression Management Plan. This is consistent with the conditions of the Woleebee Creek Environmental Authority.

22.4 QGC requests that (D46) (should be numbered (D49)) be redrafted as follows:

> *"The holder of this environmental authority must submit the Land Release Management Plan required by Condition (D45) to the administering authority prior to the commencement of any release activities included in that Plan, except in accordance with Condition (Dx)", as referred to in the submission on (D45)."*

This is consistent with the conditions of the Woleebee Creek Environmental Authority.

23 Condition D49 (should be numbered (D52))

23.1 QGC requests that 3 new conditions be added under the heading of Fauna Management Procedures:

(Dx) Prior to the commencement of each petroleum activity authorised by this environmental authority, Interim Fauna Management Procedures are required to be in place for that activity, which:

(a) prevent or minimises impacts to fauna;

(b) are consistent with the objectives included in Condition (D52) (which should be D55); and

(c) are consistent with the Flora and Fauna Management Plan contained within the *Ruby Area – Environmental Management Plan, Supporting Information, June 2010.*

(Dxx) Notwithstanding Condition (Dx), where there is conflict between the contents of the Interim Fauna Management Procedures and the conditions of this environmental authority, the conditions of this environmental authority prevail.

(Dxxx) Within six months of the issue of this environmental authority, Fauna Management Procedures must be developed for the petroleum activities authorised under this environmental authority.

Reasons

23.2 QGC proposes to operate under Interim Fauna Management Procedures whilst the final Fauna Management Procedures are being developed to meet the requirements of condition (D49) (actual (D52)) to (D55) (actual (D58)).

23.3 This is consistent with the conditions of the Woleebee Creek Environmental Authority.

24 Condition D56 (should be numbered (D59))

24.1 QGC requests that 3 new conditions be added under the heading of Pest Management Procedures:

(Dx) Prior to the commencement of each petroleum activity authorised by this environmental authority, Interim Pest Management Procedures are required to be in place for that activity, which:

(a) prevent or minimise impacts to native flora;

(b) are consistent with the objectives included in Condition (D58) (should be numbered (D61)); and

(c) are consistent with the Weed and Pest Management Plan contained within the *Ruby Area – Environmental Management Plan, Supporting Information, June 2010.*

(Dxx) Notwithstanding Condition (Dx), where there is conflict between the contents of the Interim Pest Management Procedures and the conditions of this environmental authority, the conditions of this environmental authority prevail.

(Dxxx) Within six months of the issue of this environmental authority, Pest Management Procedures must be developed for the petroleum activities authorised under this environmental authority.

Reasons

24.2 QGC proposes to operate under Interim Pest Management Procedures whilst the final Pest Management Procedures are being developed to meet the requirements of condition (D56) (actual (D59)) to (D59) (actual (D62)).

24.3 This is consistent with conditions imposed on the Woleebee Creek Environmental Authority.

25 Condition E4

25.1 QGC requests that condition (E4) is relaced with the following 3 conditions:

(Ex) Prior to the commencement of each petroleum activity authorised by this environmental authority, an Interim Noise Management Plan is required to be in place for that activity, which:

(a) minimises noise impacts resulting from petroleum activities; and

(b) ensures compliance with Schedule E, Table 1 – Noise Limits at Sensitive Receptors As $L_{Aeq\ Adj.}$

(Exx) Notwithstanding Condition (Ex), where there is conflict between the contents of the Interim Noise Management Plan and the conditions of this environmental authority, the conditions of this environmental authority prevail.

(Exxx) Within sixty days of the issue of this environmental authority, the holder of the environmental authority must prepare a Noise Management Plan which has been certified by a suitably qualified person.

25.2 The proposed amendment results in a requirement to amend condition (E10) to allow alternative arrangements to be entered into during the operation of the Interim Noise Management Plan, as follows:

> *"Despite Conditions (Ex) and (E8), where alternative arrangements are in place with any affected person as referred to in Condition (E4)(j), the noise limits in Schedule E, Table 1 – Noise limits at Sensitive Receptors as $L_{Aeq,adj}$ do not apply at that location for which the alternative arrangements are in place."*

Reasons

25.3 QGC proposes to operate under an Interim Noise Management Plan whilst the final Noise Management Plan is being developed to meet the requirements of condition (E5).

25.4 This is consistent with the conditions imposed on the Woleebee Creek Environmental Authority.

26 Condition E5 (g)

Issue

26.1 Condition (E5) (g) requires the Noise Management Plan to include procedures for community liaison and consultation.

26.2 The condition refers to:

> "(g) community liaison and consultation procedures including but not limited to consultation for when night time activities (i.e. between 10:00pm and 6:00am) are likely to exceed 25dBA"

26.3 QGC considers this condition fails to acknowledge that noise levels are measured at the receptor.

26.4 Consistent with the corresponding condition imposed on the Woleebee Creek EA, QGC therefore proposes the following amendment to the condition:

> "(g) community liaison and consultation procedures including but not limited to consultation for when night time activities (i.e. between 10:00pm and 6:00am) are assessed to exceed 25dBA at sensitive receptor(s)."

Reasons

26.5 As presently drafted the condition is not necessary or desirable because affected parties have not been considered.

27 Condition E9

Issue

27.1 Condition (E9) provides a methodology for the application of "Adjustments" to the measured noise levels to account for tonal or impulsive noise characteristics.

27.2 The methodology presented in (E9)Table 2 only accounts for a subjective analysis of tonality or impulsivity.

27.3 A quantitative methodology is also recommended for situations where the subjective analysis is unclear or in dispute.

27.4 QGC therefore proposes that the following reference to the Australian Standard 1055.1 Section 6.6 be added as a footnote to Table 2:

> *"Where the application of a tonal or impulsive adjustment as per Table 2 is unclear or in dispute, refer to AS1055.1 Section 6.6 for a quantitative methodology to confirm the applicability of noise adjustments"*

Reason

27.5 As presently drafted the condition is not necessary or desirable because:

(i) It is not consistent with the application of tonal or impulsive adjustments as per the Australian Standard 1055 Part 1 Section 6.6 and the Ecoaccess Planning for Noise Control Guideline as the quantitative methodology has been omitted.

28 Conditions E11 and E12

Issue

28.1 Consistent with conditions imposed on the Woleebee Creek environmental authority, QGC seeks to delete condition (E11) and amend condition (E12) as follows:

(E12) Notwithstanding Condition (E8), emission of any low frequency noise must not exceed the following limits in the event of a valid complaint about low frequency noise being made to the administering authority:

(a) 60 dB(C) measured outside the sensitive receptor; and

(b) the difference between the internal A-weighted and C-weighted noise levels is no greater than 20dB; or

(c) 50 dB(z) measured inside the sensitive receptor; and

(d) the difference between the internal A-weighted and Z-weighted noise levels is no greater than 15 dB.

Reasons

28.2 Condition (E12) (a) requires that low frequency noise be assessed inside the sensitive receptors dwelling.

28.3 Assessing low frequency noise inside a receptor's dwelling may be considered intrusive by many receptors, as the condition stipulates that monitoring must be conducted inside the receptors dwelling at night, typically a bedroom.

28.4 Assessing low frequency noise inside a receptors dwelling may also place additional restrictions on QGC associated with the time taken to obtain permission to access the dwelling.

28.5 QGC therefore seeks to change to an external low frequency noise limit.

28.6 Condition (E12) (a) stipulates a 50dB(Z) internal low frequency noise limit.

28.7 The 'Z' frequency weighting is not considered to be the most appropriate metric to assess low frequency noise using outdoor measurements, as it is more susceptible to the interference from wind turbulence.

28.8 It is considered that the 'C' frequency weighting is more appropriate for assessment of low frequency noise using outdoor measurements. This is supported by G. Hessler in "*Proposed criteria in residential communities for low-frequency noise emissions from industrial sources*", Noise Control Eng J. 2004

28.9 Condition (E12) (b) stipulates that low frequency noise must be assessed inside a sensitive receptors dwelling.

28.10 As per condition (E12) (a) above, many receptors may find the monitoring inside their dwelling to be intrusive and, as such, an external limit is proposed.

28.11 A difference between the A-weighted and Z-weighted noise level of 15dB (as per the condition) is not considered to be representative of low frequency noise impacts.

28.12 The 'Z' frequency weighting is not considered appropriate for monitoring outdoors as it is more susceptible to the interference from wind turbulence, and is also not consistent with low frequency criteria used elsewhere in Australia (NSW Industrial Noise Policy, 2000).

28.13 It is considered that the 'C' frequency weighting is more appropriate for assessment of low frequency noise using outdoor measurements. This is supported by G. Hessler in "*Proposed criteria in residential communities for low-frequency noise emissions from industrial sources*", Noise Control Eng J. 2004.

29 Condition E8

Issue

29.1 The condition, to the extent it deals with noise from drilling activities, needs to be consistent with the Coordinator-General conditions.

29.2 The Coordinator-General conditions require that drilling activities undertaken from 10.00pm – 7.00am to be measured "indoors".

29.3 The following footnote would suffice:

"Footnote

Noise from Drilling activities undertaken from 10.00pm – 7.00am at 30 dBA are to be measured indoors at any relevant Sensitive Receptor."

Reasons

29.4 The condition as presently drafted is not consistent with the Coordinator-General Imposed Condition No. 4 in Appendix 2, Part 2 of his report dated June 2010.[3]

30 Condition F1

Issue

30.1 QGC requests the the word "cumulatively" is deleted from condition (F1).

30.2 The condition notes the EA does not authorise emissions from fuel burning or combustion equipment consisting of using fuel burning equipment that is cumulatively capable of burning at least 500kg of fuel in an hour.

30.3 If the intention is to limit fuel burning, on a cumulative basis, to no more than 500kg of fuel in an hour, that would frustrate the approval when the gas field is in full production or production that requires fuel burning more than 500kg per hour. At various times fuel burning equipment, when fully operational, would burn considerably more than 500kg of fuel in an hour but would not have any adverse air quality impacts. For example each well requires a gas combustion engine for a well lift pump. Individually, emissions are very low for that equipment (Circa 4kg /engine/well/hour) but cumulatively with about 100 wells per block and 12 blocks in the Ruby Area 500kg/hr will be exceeded.

30.4 Should DERM not accept this submission QGC requests that in the alternative that ERA15 (Fuel Burning) be added to the table at item 1 (table of ERAs – Schedule 5 of the Environmental Protection Regulation 2008).

Reasons

30.5 The condition is neither necessary nor desirable because:

(i) it is vague and uncertain;

(ii) it would frustrate the approval being for the operation of a gas field;

31 Conditions (G2A) and (G22A)

Issue

31.1 Consistent with the corresponding conditions imposed on the Woleebee Creek environmental authority, QGC requests the inclusion of the following conditions in Schedule G:

(G2A) Any regulated dam identified in the register maintained under condition (C13) is taken to be an appropriately licensed facility for the purposes of condition (G1) and (G2).

There appear to be two conditions 4 in Appendix 2 Part 2, one relating to noise and one relating to Coal Seam Gas Water Management Plan – the numbering is in error.

(G22A) The holder of this environmental authority may transport treated CSG water, raw CSG water, CSG concentrate or brine to be stored, treated and used in accordance with any environmental authority, to allow the aggregation and management of the waste in accordance with the CSG water management plan.

Reason

31.2 The CSG water management plan developed by QGC makes provision for CSG water to be transported to centralised treatment plants and, from there, disposed of or diverted for beneficial use.

31.3 Conditions (G1) and (G2) in their current form, would prevent CSG water and brine from being transported by pipeline to another petroleum tenement and disposed of in a containment dam at that location. QGC does not believe that this consequence was intended by DERM.

31.4 A CSG water management plan, under which CSG water from the Ruby, Jordan and Bellevue areas is transported to the Kenya area for treatment, has been submitted to the Commonwealth Department of Sustainability, Environment, Water, Population and Communities and Department of Infrastructure and Planning (**DIP**). The proposed amendments, and corresponding amendments to the Ruby EA, simply clarify that the waste conditions do not prevent the implementation of this proposal.

31.5 Proposed conditions (G2A) and (G22A) provide recognition that CSG water and associated products can be transported to other tenements (including tenements covered by other EAs) for treatment, disposal or use in accordance with CSG water management plan.

31.6 Schedule G of the EA is not necessary or desirable in the absence of amendments which clarify that it is not intended to apply CSG water and associated products.

32 Condition (G23)(c)

QGC requests that condition (G23)(c) be deleted.

Construction activities at any particular location typically exceed 3 months in duration. The ability to use CSG water for dust suppression in accordance with the prescribed limits is necessary in order to meet air quality objectives and avoid causing environmental nuisance (in accordance with condition (E1).

Where the quality limits prescribed by condition (G23) and the Dust Suppression Management Plan are complied with, no environmental harm will arise from the use of CSG water for dust suppression for periods of longer than 3 months.

33 Condition (G23A)

Issue

33.1 QGC proposes the insertion of condition (G23A):

(G23A) Despite condition (G23) and (D45), the holder of this environmental authority may use associated water produced from the authorised petroleum activities for the construction of dams.

Reasons

33.2 This condition would obviate the need for water to be hauled significant distances from the water treatment plant to construction within the Ruby area.

33.3 QGC understands that DERM is of the view that the use of CSG water for construction does not require specific authorisation under this EA (see letter from DERM dated 30 June 2011). QGC proposes the inclusion of this condition for the avoidance of doubt.

34 Condition G13 and G14

Issue

34.1 Condition (G13) requires the preparation and implementation of Management Criteria, prior to production of CSG water.

34.2 This does not recognise that QGC commenced production of CSG water under Exploration and Appraisal activities authorised prior to the issue of this EA.

34.3 QGC therefore seeks to replace existing (G13) and (G14) with the following conditions, which are consistent with those imposed on the Woleebee Creek environmental authority:

(Gx) The holder of this environmental authority must develop Interim Coal Seam Gas Management Criteria to be in place for the first sixty days from the date of issue of this environmental authority.

(Gxx) The Interim Management Criteria required by Condition (Gx) must:

(a) be developed in accordance with section 310D (5)(e) of the *Environmental Protection Act 1994*;

(b) include similar matters as described in Condition (G15); and

(c) be consistent with the requirements of this environmental authority.

(Gxxx) Within sixty days from the issue of this environmental authority, revised Management Criteria must be developed and be provided in the form required by the administering authority.

35 Condition G16

Issue

35.1 The condition requires that the holder of the Environmental Authority must ensure the measurable criteria are accepted by the administering authority in writing.

35.2 The condition is not necessary or desirable in that there are no timeframes given for when the DERM must accept the criteria after submission of the measurable criteria. Condition (G9) provides a mechanism for the approval of a similar condition. The same mechanism should apply to these criteria.

35.3 The way the condition is worded does not give QGC the ability to ensure that DERM provides written acceptance of the measurable criteria proposed. As written it is unreasonable.

Reasons

35.4 The condition is not necessary or desirable because:

(i) it is unworkable;

(ii) it lacks finality;

(iii) it is confusing and replicates what is already required by the EP Act.

36 Condition G18

Issue

36.1 The condition requires a water management plan to be prepared and implemented prior to the production of CSG water. The condition then sets out a list of matters the water management plan must address.

36.2 There are a number of difficulties with this condition.

36.3 First of all QGC has not had notice of this condition previously. It is the first time QGC has seen the condition which appears to have been copied from elsewhere. So much is apparent from the error in G18(a)(ii) which refers to conditions W6(a)(i). There is no such condition in the EA.

36.4 The condition:

- is not clear as to its geographical scope;
- confuses waste management issues, ground water issues and surface water issues.

36.5 For example what is meant by "site" in this context. Is it the entirety of the area covered by the EA, in which case the condition requires an immensely onerous undertaking that in some respects replicates what is required elsewhere. The condition may have been copied from a mining EA which would relate to a specific "site", namely the mine site. It is not appropriate to a gas field.

36.6 Earlier conditions of the EA, both in relation to water and waste require a variety of measures with respect to:

- erosion and sediment control;
- storm water management;
- Land Release Management measures;
- a coal seam gas water management plan.

36.7 The Constraints Plan and Field Development Protocol required by condition 2 of Appendix 2, Part 2 of the Coordinator-General Conditions for the gas fields requires an understanding of location of infrastructure in the gas fields.

36.8 Condition 4 of Appendix 2, Part 2 of the Coordinator-General Conditions for the gas fields requires a coal seam gas water management plan that meets all relevant Queensland regulatory requirements.

36.9 Condition 6 of Appendix 2 Part 2 of the Coordinator-General Conditions for the gas fields requires an Operational Plan that, amongst other things, requires "prior to commencement of construction", a construction management plan for petroleum tenure for the gas fields. That Plan is to show location of facilities, discharge points, emission controls, water treatment, sewerage treatment and other petroleum activities proposed to be undertaken on the petroleum lease. It is to contain descriptions of existing and proposed infrastructure as well as maps that record the location of infrastructure including dams, wells, water treatment facilities, etc.

36.10 The Commonwealth gas field approval (no. 2008/4398) issued under the *Environment Protection and Biodiversity Conservation Act 1999* also requires:

- a Constraints Planning and Field Development Protocol which must be updated from time to time (see condition 21);
- a coal seam gas water monitoring and management plan that contains both ground water and surface water monitoring and management requirements.

36.11 While condition G18 is contained in the waste management schedule of the EA, it deals with a broader range of issues. It is in conflict with other conditions imposed by the Coordinator-General, by the Commonwealth and is in conflict with other requirements of the EA.

36.12 A more detailed consideration of each component of the condition follows:

36.13.1 *(a) a description of the water management system, including but not limited to:*

This requirement is unnecessary as it is already required by condition G5-G6 the coal seam gas water management plan and G14-G15, the coal seam gas water management criteria, Appendix 2 Part 2 condition 4 of the CG conditions and s310D of the EPAct1994.

36.13.2 *(i) an objective for protecting the environmental values from impacts from petroleum activity(ies);*

This requirement is unnecessary as it is already covered by condition G6, G15 (c) and s310D(2)(b)(iv) EMP in EP Act.

36.13.3 *(ii)* *measures and means to deliver on the objective required by condition W6(a)(i);*

This requirement is uncertain as condition W6(a)(i) does not exist in the EA. The condition is unnecessary, delivering on water management objectives already required by condition G15 and s310D(2)(b)and(c) EMP in EP Act and s310D(5)(e)(ii) EMP in EP Act.

36.13.4 *(iii)* *a determination of the source and type of contaminants generated on-site;*

This condition is unnecessary as it is already covered in s310C(c) application requirements EP Act.

36.13.5 *(iv)* *a determination of the quality, quantity and use of the water stored on the site; and*

This condition is unnecessary as it is already covered by condition G6 and, G14 and G15 and s310D(5)(a)(b)(c) EMP in EPAct1994 and s310D(5) EMP in EP Act and s376(a) concerning Underground Water Impact Reports (**UWIR**) in Water Act.

36.13.6 *(v)* a determination *of the disposal, re-use, treatment or storage systems used on the site; and*

This condition is unnecessary as it is already covered by condition G6 and, G14 and G15 and s310D(5)(d) EMP in EPAct1994 and s310D(5)(e)(i) EMP in EP Act.

36.13.7 *(vi)* identification *of the location and types of groundwater aquifers; and*

This condition is unnecessary as this information is already required to be submitted to the Queensland Water Commission under s376(b) concerning Underground Water Impact Reports (UWIR) in the Water Act and under the Commonwealth gas field approval requirements for a CSG Water Monitoring and Management Plan.

The information regarding location and types of groundwater aquifers will be much better once baseline assessments are complete. The baseline assessment plan has been submitted to DERM. Any information provided now before the start of production will be at no greater resolution than provided in the QCLNG EIS based on current information.

36.13.8 *(vii) plans which depict:*

- *catchments, flow paths, contours, built drainage and storage infrastructure (including dams);*
- *groundwater contours and location of monitoring bores;*
- *disposal, reuse and treatment systems to be used at the site including any clean water diversion systems; and*
- *location of water quality monitoring sites.*

The EA covers approximately 91500ha of land. The majority of the land is not affected by CSG activities. The majority of the land is not owned by QGC and under land management practices that are out of the control of QGC (farming and grazing practices). The majority of QGC's infrastructure is sited and designed to keep stormwater and overland flow out. Providing plans of catchments, flow paths and contours of the whole EA area is a measure which is not commensurate with the impact of or risk of the activities being undertaken (predominantly well sites).

Section 376(b) of the Water Act concerning Underground Water Impact Reports, and section 394 concerning Baseline Assessments require groundwater monitoring programs and reporting to the Queensland Water Commission who are developing a Regional Groundwater Model. QGC is fully participating in this program. QGC will be better able to map groundwater contours once the baseline bore assessments have been completed. Groundwater monitoring wells into different aquifers are currently being installed. QGC will not have results from the bores monitoring for many months but the location of monitoring bores has been prepared and submitted to DERM with the Groundwater Monitoring Program.

S310D(2) of the EP Act dealing with EMPs covers this point, which is also covered by condition B2 and B3 with the development and implementation of an erosion and sediment control plan which includes managing clean water runoff.

All monitoring locations will be reported through the monitoring programs required under Schedule I. Groundwater monitoring is reported in the groundwater monitoring plan (condition I23), landholder bore location monitoring will be reported through the baseline bore assessment plan (the information collected through this plan will be used for the stimulation monitoring) (condition I12), and regulated dams will be reported through the annual regulated dam water quality monitoring report (condition I40).

36.13.9 *(b)* *a site water balance which includes but is not necessarily limited to, the inflows and outflows of CSG water including the contaminants found in CSG water and which indicates the sources and quality of water for petroleum activity(ies);*

It is possible to develop a model of inflows and outflows of CSG water because the wells and dams and water treatment plants and pipelines will have water meters to record such flows which will aid in development and calibration of a model. However there is no such monitoring system set up for other types of site water, for example rainfall and runoff and this is not relevant to the site water balance for CSG water, because the two water streams are kept separate (other than direct rainfall into CSG water ponds, which is accounted for). There is no such recording of the 'contaminants' found in CSG water other than monitoring with regard to releases and regular monitoring of ponds. It is not necessary or desirable to model every element found in CSG water.

Any other uses or management of water (for example non-CSG water taken from a bore for dust suppression) are low risk activities that do not have the potential to cause significant environmental harm and hence do not warrant such a stringent and onerous modelling condition.

If this condition was to remain it would be limited to CSG water and the salt component (total suspended solids) in the water rather than 'all contaminants'.

36.13.10 *(c)* modelling *of the water management system, which must include, but not be limited to:*

(i) *a demonstration that the system meets the objective and prevents releases of contaminants not in accordance with the conditions of this environmental authority or general environmental duty;*

Models are predictive to assist in management of water. They cannot prevent releases of contaminants per se.

(ii) *development, calibration, and maintenance of a complete site water balance model coupled with a salt balance model that adequately represents all sources of water.*

This condition is uncertain and therefore very difficult to implement. It is reasonable to monitor CSG water balance. However QGC considers it unreasonable and unnecessary to do a model of all sources of water and salt. Generally the majority of the land on the environmental authority encompasses land not owned by QGC with land management practices outside the authority of QGC. Landholders irrigate and provide water

for stock. Water is drawn from the rivers and local bores to undertake activities within the EA area. For the Ruby EA, activities are spread over 91500ha. Modelling all sources of water (e.g. rainfall and runoff) over that expanse of land is not necessary or desirable compared with the predicted limited impact of relatively small well sites within that area (1ha each during construction phase).

36.13 Also there is no warrant for imposing requirements as contemplated by condition G18, prior to the production of CSG water which would commence immediately on development of the gas field. Further, multiple safeguards with respect to coal seam gas water are provided for elsewhere in the EA, in other approvals (including the CG's conditions), in the EP Act and in the Water Act.

36.14 The condition should therefore be deleted. Alternatively, if it is to remain it should be substantially amended to avoid duplication and unacceptable difficulty of implementation. QGC would therefore seek that the following conditions be inserted:

(Gx) The holder of this environmental authority must develop an Interim Water Management Plan to be implemented for the first six months from the date of issue of this environmental authority.

(Gxx) The Interim Water Management Plan required by Condition (Gx) must:

(a) include similar matters as described in Condition (G18); and

(b) be consistent with the requirements of this environmental authority.

(Gxxx) A revised Water Management Plan must be prepared and provided to the administering authority within six months from the date of issue of this environmental authority.

37 Condition G19

Issue

37.1 This condition requires the authority holder to undertake an annual review of the Water Management System required by Condition G18 by 1 May each year and implement measures, practices or procedures to ensure the Water Management System operates in accordance with the objective and the conditions of the Environmental Authority. The condition then goes on to list the matters for review.

37.2 If condition G18 is to be deleted, condition G19 will become redundant and should also be deleted.

37.3 Further, the condition is uncertain. It refers to an annual review of the Water Management System including site water balance and water balance model and then refers to G18 which is not about the Water Management System, but rather, refers to a water management plan (i.e., already covered by Condition

G5 and section 310D of the EP Act). Annual review, reported through the annual return about the Coal Seam Gas Water Management Plan is already a requirement of the EP Act.

37.4 If condition G18 is to be retained in some form then the following more detailed comments on various components of condition G19 are relevant as well;

37.4.1 *(b) a review of the site catchments, containment storage capacity, current storage volumes, system transfer capacity, water quality characteristics and Standard Operating Procedures of all key infrastructure elements of the Water Management System. Factors that influence system behaviour to be considered in the review, include, but are not limited to:*

There are no significant volumes of water stored as part of the petroleum activities other than the CSG Water. Overland flow is not harvested for the purposes of the project and surface water rainfall run off is diverted around key infrastructure and CSGC water dams. The surface water run off and catchments are not linked to the CSG Water Management System. This condition needs clarity and should only be linked to CSG water dams as the key infrastructure elements.

37.4.4 *(i) the design storage allowance requirement and how it is delivered in terms of storage availability across the storages on site;*

All regulated dams are designed in accordance with the Manual for Assessing Hazard Categories and Hydraulic Performance of Dams. All regulated dams have design plans and as constructed certification. All regulated dams operate with mandatory operating levels and mandatory reporting levels. All dam designs are submitted to DERM for assessment. All regulated dams are inspected annually and a report submitted to DERM.

37.4.5 *(ii) protection of available storage from ingress of waters from surface runoff or groundwater infiltration;*

This condition is unnecessary because all regulated dams are built as 'turkey's nests', they all have elevated banks and do not collect surface runoff. Due to the pressure of water held within large dams, it is highly unlikely that groundwater would infiltrate the storage.

37.4.6 *(iii) the leakage or seepage of waters from water storages;*

Regulated dams are not designed to leak or seep, this is an unnecessary condition. C8-C12 requires that regulated dams be designed with a floor and sides of material that contains the wetting front otherwise the dam must be repaired or rehabilitated.

37.4.7 *(iv) reliability of design and 'as constructed' specifications;*

Design plans for all regulated dams are submitted to DERM for approval. They are certified by a suitability qualified person and

inspected annually by a suitably qualified person. This condition is unnecessary as it is already covered by conditions C1 – C35.

37.4.8 *(v) efficacy of surface water management structures (design and 'as-built');*

This condition involves uncertainty as to what the surface water management structures are, that would be designed and 'as-built' other than regulated dams?

37.4.9 *(vi) reliability of climatic data;*

37.4.10 *(vii) assumptions regarding process inputs including contaminant concentrations;*

Contaminant concentrations are not normally included in a water balance model, this would be difficult to implement. This condition is not reasonable if it is requiring a model of every element within coal seam gas water. Certainty is required as to what specific contaminant(s) are required to be modelled (e.g. TSS?).

37.4.11 *(viii) reliance on transfer pumps;*

37.4.12 *(ix) destination of contaminants on release;*

37.4.13 *(x) contingency arrangements against unplanned release*

37.4.14 *(c) an assessment utilising the water balance model to evaluate the water management system capacity and operations in response to changes in CSG production and rainfall events;*

37.4.15 *(d) a determination of the adequacy of the system to prevent unauthorised discharges during AEP 1 in 25, 1 in 50, 1 in 100, 1 in 200, and 1 in 1000 year rainfall events, considering both an operational water balance and the ability to deal with unplanned rainfall events that may occur on site at any time;*

All regulated dams for CSG water are designed to be managed for a 1 in 100 AEP. It is not standard engineering practice to model for greater than 1 in 100 AEP. There is no purpose in modelling for up to 1 in 1000 year rainfall events. Dams capable of coping with a 1 in 1000 year rainfall event would have to be very large and take up more land area and hence have a greater environmental impact. All dams are managed with a mandatory operating level and a mandatory reporting level to deal with operational water balance.

37.4.16 *(e) undertake the application of 'time of concentration' design rainfall events for catchments contributing to individual relevant dams or storages, or to groups of dams or storages; so as to determine the failure outcomes for worst case contaminant release or collapse, and the AEP levels at which such outcomes occur;*

This condition is not relevant to the CSG activity, there are no catchments reporting to regulated dams, therefore this condition is not necessary.

37.4.17 *(f) manage seepage and drainage for all hazardous or regulated dams and storages on site;*

Regulated dams are not designed to leak or seep, this is an unnecessary condition. C8-C12 requires that regulated dams be designed with a floor and sides of material that contains the wetting front otherwise the dam must be repaired or rehabilitated. This is an unnecessary condition.

37.4.18 *(g) manage stormwater and on site water flows;*

The analysis of mapping data available for this on a wide scale across the whole area of the environmental authority for site water flows is onerous. QGC is not able to influence the use of land by others. This condition is unnecessary and unreasonable, considering the extensive requirements of condition (B2 and B3) which requires the implementation of an erosion and sediment control plan which includes the management of stormwater and site water flows and B31 to prevent contaminants being released to waters.

37.4.19 *(h) develop and implement a system for emergency spills or discharges;*

This is an unnecessary condition as conditions A17 to A18 already require the development and implementation of a contingency plan for emergency events and environmental incidents.

37.4.20 *(i) manage off site water releases and minimise sediments and salinity releases;*

This is an unnecessary condition as it is already covered by conditions B2 and B3; D45 to D48 which relate to developing and implementing a land release management plan and G10-G12 relating to CSG water use and release.

37.4.21 *(j) ensure protection of the environmental values of the receiving waters downstream as it relates to the activity;*

This condition is unnecessary as it is already covered by condition G10-G12.

38 Condition G20 and G21

Issue

38.1 These conditions will need to be deleted if condition G18 and condition G19 are deleted.

39 Condition I10(b)

Issue

39.1 The condition identifies all active land holders, ground water bores, by reference to a two kilometre horizontal radius (condition I10(a)). Condition I10(b) appears intended to apply to those bores referred to in I10(a). Consequentially it should be amended to read:

"(b) All active land holders' ground water bores identified pursuant to (a), and within 200 metres vertically, of the stimulation initiation point; and"

Reasons

39.2 The condition as presently drafted is not necessary or desirable because:

(i) it appears to be incorrect and incomplete;

(ii) in its present form it is likely to mislead and cause confusion;

(iii) in its present form it would lead to unintended consequences in terms of the interpretation to be given to I10(b) which would be left without any limiting parameters at all.

40 Condition I11

Issue

40.1 Condition I11 requires that QGC have sufficient water quality data to accurately represent stimulation well water quality prior to undertaking stimulation.

40.2 In the circumstance of the initial exploration wells being drilled in a particular area, it will not be possible to accurately represent the water quality parameters in (I12). This is because:

(i) there are no other nearby wells with water quality monitoring data in the CSG formation to "accurately represent " the initial well; and

(ii) water may not be flowing freely at the initial well as the purpose of well stimulation is to induce water flow. In addition any water that is obtained from, for example, drill stem tests, may be contaminated by drilling muds.

40.3 QGC propose that the word "accurately" is replaced with "reasonably" in condition (I11).

41 Condition I12

Issue

41.1 There are a number of difficulties with condition I12 as follows.

41.2 Condition I12(d) should be amended to read:

"Evolved (produced) gas (i.e. methane, carbon dioxide, hydrogen sulphide) mg/L".

41.3 Evolved gases are those that come to the surface. It is far more valid to measure evolved gases or produced gases for purposes of baseline bore and

well assessment. It is proposed to delete chlorine because chlorine has been shown not to be present in these gases. It is not necessary to measure for it for baseline purposes. It is not able to be produced by QGC processes so its inclusion is not necessary.

41.4 Condition I12(g) is a duplication of (e) and should be deleted.

41.5 With respect to condition I12(l) the xylene speciation is a theoretical possibility but is not able to be differentiated by Gas Chromatography mass spectrometry methods to the speciation listed in the condition. A total xylene is all that should be required. Ortho-xylene, para-xylene, meta-xylene can be reported on as total xylene but not individually.

41.6 Conditions I12(n) and (o) refer to sodium hypochlorite and sodium hydroxide. Both are reactive chemicals that disassociate in water. Their concentrations will be undetectable. Hydroxide (not sodium hydroxide) will be included in the anion suite in (e).

41.7 Condition I12(n) and (o) should be deleted.

41.8 Condition I12(q) refers to ethanol. This would only be introduced into a well through the use of one of the "restricted stimulation fluids". It is prohibited under Condition B18. QGC will not use a "restricted stimulation fluid". The condition is not necessary or desirable.

41.9 Condition I12(r) requires measuring gross alpha radiation. QGC processes do not result in gross alpha radiation. The measure should be for gross beta radiation. This being the case, the monitoring regime for groundwater should also be for gross beta radiation (Schedule 1 Table 1).

41.10 The radio active materials used are beta emitters with half-lives less than 85 days. Gross alpha radiation is irrelevant unless radioactive elements are naturally produced and detected at a field wide level. Testing for gross alpha radiation is also costly and unnecessary from a well stimulation perspective.

To summarise:

- condition I12(d) should be amended as noted above;
- condition I12(g) should be deleted for the reasons noted above;
- condition I12(l) should be amended so only total xylene is assessed;
- condition I12(n) and (o) should be deleted for the reasons noted above;
- condition I12(q) should be deleted;
- condition 112(o) should be amended as noted above.

Reasons

41.11 The condition as presently formulated is not necessary or desirable because:

(i) it is in some respects seeking to undertake assessments of contaminants that cannot be measured or are not present. It cannot be fully implemented;

(ii) the condition does not seek an assessment, e.g., in relation to (gases) in the most effective way for baseline assessment;

(iii) the condition internally duplicates some requirements e.g., (g) and (e).

42 Condition I14-18

Issue

42.1 Condition (I15) requires the Stimulation Impact Monitoring Program must provide for the analysis of stimulation fluids to sufficiently demonstrate quality and quantity to be used in stimulation activities.

42.2 For health and safety reasons it is not possible to sample the mixed stimulation fluids as they are injected into the well. An analysis of the components of the stimulation fluids can be provided but this is a duplication of the risk assessment.

42.3 The risk assessment provides a full list of stimulation fluids for the event and the return water monitoring verifies this.

42.4 Condition (I16) requires monitoring of quantity and quality of coal seam gas water produced from every stimulated well after stimulation at certain minimum frequencies. This condition is extremely onerous, prescriptive and unreasonable. It is not based on any proper risk assessment or scientific evidence.

42.5 QGC therefore submits that condition (I14) – (I18) be replaced by the following conditions:

(I14) The Stimulation Impact Monitoring Program must be able to detect adverse impacts to water quality from stimulation activities and must consider the findings of the risk assessment required by conditions (B23) and (B24) that relate to stimulation activities and must include, as a minimum, monitoring of:

(a) the stimulation fluids to be used in stimulation activities at sufficient frequency and which sufficiently represents the quantity and quality of the fluids used; and

(b) flow back waters from stimulation activities at sufficient frequency and which sufficiently represents the quality of that flow back water; and

(c) flow back waters from stimulation activities at sufficient frequency and accuracy to demonstrate that 150 % of the volume used in stimulation activities has been extracted from the stimulated well;

(d) all active landholders' groundwater bores (subject to access being permitted by the landholder) that are:

(i) within a two (2) kilometre horizontal radius from the location of the stimulation initiation point; and

(ii) that draw water from the target coal seam gas producing formation; or

(iii) within 200 vertical meters of the stimulation initiation point; and

(e) any other bore that could potentially be adversely impacted by the stimulation activities in accordance with the findings risk assessment required by conditions (B23) and (B24); and

(I15) The Stimulation Impact Monitoring Program must provide for monitoring of:

(a) analytes and physico-chemical parameters relevant to baseline bore and well assessments to enable data referencing and comparison including, but not necessarily being limited to the analytes and physico-chemical parameters in condition (I12); and

(b) any other analyte or physico-chemical parameters that will enable detection of adverse water quality impacts and the inter-connection with a non-target aquifer as a result of stimulation activities including chemical compounds that are actually or potentially formed by chemical reactions with each other or coal seam materials during stimulation activities.

(I16) The Stimulation Impact Monitoring Program must provide for monitoring of the bores in condition (I14)(d) at the following minimum frequency:

(a) monthly for the first six (6) months subsequent to the stimulation activities being undertaken; then

(b) annually for the first five (5) years subsequent to the stimulation activities being undertaken or until analytes and physico-chemical parameters listed in condition (I12)(x),– (I2)(x) are not detected in concentrations above baseline bore monitoring data on two (2) consecutive monitoring occasions.

Reasons

42.6 As currently drafted conditions I14-I18 is not necessary or desirable because they:

(i) ignore health and safety issues and are therefore unreasonable ;

(ii) are too prescriptive, onerous and are therefore unreasonable;

(iii) are not based on any risk assessment and are not proportional to any risk of environmental harm;

(iv) duplicate the risk assessment required by other conditions; and

(v) are not based on any proper scientific evidence.

42.7 Further, the proposed conditions are consistent with the corresponding conditions imposed on the Woleebee Creek EA.

43 Condition I21

Issue

43.1 The condition requires a Ground Water Monitoring Program to be developed and implemented which is able to detect any changes to ground water quality as a result of storing contaminants in containment facilities (e.g. surface dams, monocells).

43.2 The condition as drafted contains uncertainty particularly around the idea of "surface dams". Because the term is not defined, its scope is uncertain and potentially too broad having the potential to capture all dams of whatever type and purpose. Regulated dams and monocells are the only type of containment facility which present a risk of environmental harm commensurate with the level of monitoring required by this condition. QGC therefore proposes the following amendments to I21:

> *"I21 A Ground Water Monitoring Program must be developed and implemented which is able to detect changes in ground water quality as a result of storing contaminants in regulated dams and monocells*

Reasons

43.3 This condition, in the form proposed by the DERM, would seem to require that monitoring be carried out at all dams. Dams other than regulated dams simply do not contain concentrations of contaminants which warrant the cost, disturbance or work associated with the installation of monitoring bores.

43.4 QGC's proposed amendments simply clarify that the monitoring required under this condition is limited to regulated dams, which may contain concentrations of contaminants which justify the type of monitoring proposed.

43.5 As currently drafted the condition is not necessary or desirable because:

(i) it is too uncertain;

(ii) it may result in unintended consequences;

(iii) it requires greater precision to identify the types of dams actually intended to be captured;

(iv) it lacks proportionality to risk and is unreasonable.

44 Condition I23(d)

Issue

44.1 This condition duplicates the requirements of conditions I10 – I18 and is therefore unnecessary.

44.2 Duplication such as this should be avoided and is unreasonable.

44.3 QGC seeks its deletion.

Reasons

44.4 The condition is not necessary or desirable because:

(i) it duplicates an existing requirement and is unnecessary;

(ii) it is unreasonable.

45 Condition I23(g)

Issue

45.1 This condition is a word for word duplication of (f). This appears to be a typographical error.

Reasons

(i) As above.

46 Condition (I27)

Issue

46.1 QGC proposes the following amendments to condition (I27):

(I27) The monitoring program of regulated dam water must include sufficient analytes and physio-chemical parameters to characterise the water quality in the dam and must include, but not necessarily be limited to:

Third last line: delete "ortho-, para-, meta-xylene" and retain "total xylene"

Last line: add "or gross beta radiation".

Reason

46.2 With respect to the xylene, speciation is a theoretical possibility but is not able to be differentiated by Gas Chromatography mass spectrometry methods to the speciation listed in the condition. A total xylene is all that should be required. Ortho-xylene, para-xylene, meta-xylene can be reported on as total xylene but not individually.

46.3 The table requires measurement of gross alpha radiation. QGC processes do not result in gross alpha radiation. The measure should be for gross beta radiation. This being the case, the monitoring regime for groundwater should be for gross beta radiation (Schedule 1 Table 1).

46.4 The radio active materials used are beta emitters with half-lives less than 85 days. Gross alpha radiation is irrelevant unless radioactive elements are naturally produced and detected at a field wide level. Testing for gross alpha radiation is also costly and unnecessary.

46.5 This is consistent with the corresponding condition in the Woleebee Creek EA.

47 Condition K1

Issue

47.1 QGC requests that condition (K1) be replaced with the following condition:

(K1) The holder of the environmental authority must telephone the Department of Environment and Resource Management's Pollution Hotline (telephone: 1300 130 372) and any affected landholder, occupier or their nominated representative as soon as reasonably practicable, but within 24 hours after becoming aware of:

(a) any release of contaminants not in accordance with the conditions of this environmental authority; or

(b) any event where unlawful environmental harm has been caused or may be caused; or

(c) any detection of restricted stimulation fluids from stimulation fluid monitoring; or

(d) any result from baseline bore, well or stimulation water impact monitoring that exceeds a water quality objective for the protection of any environmental value of that water resource.

47.2 The condition (K1)(d) currently requires the holder to telephone the DERM Pollution Hotline and any affected landholder within 24 hours of becoming aware of:

> *"Any result from baseline bore, well or stimulation water impact monitoring that exceeds 10% of the baseline bore assessment water quality and/or any water quality objective for the ground water environmental values."*

47.3 Ten per cent is an arbitrary trigger value for notification to the Pollution Hotline. It is not reflective of ANZECC Guidelines (Water Quality Guideline 2000) for trigger value setting, where ten per cent variation is not necessarily an indicator of harm or required protection. For example, pH measured at 7 in a bore on original assessment would trigger a notification under this requirement when a later reading (up to five years later) is analysed at 7.8. This change in pH is insignificant with regard to risk of causing environmental harm, hence reporting this has no relevance with relation to environmental protection or action required. Reporting matters that have no requirement for action or concern within 24hrs to a pollution hotline is not necessary. Reporting to a pollution hotline should be for incidents and emergencies that have the potential to cause serious or material environmental harm. Reporting natural variability in monitoring results puts an unnecessary administrative burden on government and QGC resources.

47.4 A nominal value of ten per cent variation as a trigger for reporting is not based on a reasonable metric for a natural system which has variability for a number of natural and induced reasons. This is particularly relevant considering the comparison is going to be made to one baseline sample which is unlikely to be

representative of the average natural condition. Without knowing natural variability of groundwater systems, there is no scientific way to choose a correct level of variability which would be of significant concern. In addition, a 10% change in one parameter (such as EC) may have no environmental significance or threat.

47.5 This would also be consistent with the corresponding condition in the Woleebee Creek EA.

48 Definitions

48.1 Consistent with the definition relied on in the Woleebee Creek environmental authority, the definition of "Category C Environmentally Sensitive Area" should be amended to provide as follows:

"**Category C Environmentally Sensitive Area**" means any of the following areas:

- Nature Refuges as defined under the *Nature Conservation Act 1992*;
- Koala Habitat Areas as defined under the Nature Conservation (Koala) Conservation Plan 2006;
- State Forests or Timber Reserves as defined under the *Forestry Act 1959*;
- Declared catchment areas under the *Water Act 2000*;
- Resources reserves under the *Nature Conservation Act 1992*
- An area identified as "Essential Habitat" under the *Vegetation Management Act 1999* for a species of wildlife listed as endangered, vulnerable, rare or near threatened under the *Nature Conservation Act 1992*;
- Of Concern Regional Ecosystems identified in the database maintained by the Department of Environment and Resource Management called 'RE description database' containing Regional Ecosystem numbers and descriptions."

48.2 Definition of "Stimulation Impact Zone": for the reasons set out in relation to conditions B24 and B26, and consistent with the conditions imposed on the Woleebee Creek Environmental Authority, QGC seeks to delete this definition.

48.3 Definition of "limited petroleum activities": consistent with the definition in the Woleebee Creek Environmental Authority QGC seeks the amendment of this term as follows -

"limited petroleum activities" means activities undertaken for the purpose of extraction of coal seam gas. Limited petroleum activities may include:

- single well sites not exceeding 1 hectare of disturbance, and multi-well sites not exceeding 1.5 hectares of disturbance. Well sites may include:
  (a) well pads;

(b) water pumps and generators associated with well operations;

(c) sumps for storing drilling muds;

(d) flare pits;

(e) ponds used to contain and/or store stimulation fluid;

(f) mobile camp sites associated with well sites for the purpose of establishing the limited petroleum activity, so long as the mobile camp site is established in previously disturbed areas.

- geophysical surveys (including seismic petroleum activities);
- ecological, geological, topographic and cadastral surveys, etc.;
- gas gathering lines;
- water gathering lines;
- supporting access tracks; and
- communication and power lines that are necessary for the undertaking of petroleum activities and can be located within well sites, well pads and pipeline right of ways without increasing the disturbance area of petroleum activities.

For clarity, limited petroleum activities exclude and are not necessarily limited to:

- single well sites of disturbance greater than 1 hectare or multi-well sites of disturbance greater than 1.5 hectares;
- the construction of infrastructure for processing or storing petroleum or by-products;
- regulated dams;
- low hazard dams (excluding ponds used to contain and/or store stimulation fluid, and sumps for storing drilling muds if located within a well site, or immediately adjacent to a well site);
- borrow pits;
- compressor stations;
- campsites / workforce accommodation other than mobile campsites;
- power supplies;
- pipelines which are used to transport gas after the Field Compressor Stations (e.g. trunk pipelines, transmission pipelines or pipelines that require a pipeline licence)
- waste disposal; or
- other supporting infrastructure for the project (e.g. sewage treatment plants)"

48.4 Consistent with the Woleebee Creek EA, the definition of "Wetland" should be changed to provide as follows -

"wetland" means a wetland as defined under the Queensland Wetlands Program and are areas of permanent or periodic / intermittent inundation, with water that is static or flowing fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six (6) metres. To be classified as a wetland, the area must have one or more of the following attributes:

- at least periodically, the land supports plants or animals that are adapted to and dependent on living in wet conditions for at least part of their life cycle, or
- the substratum is predominantly undrained soils that are saturated, flooded or ponded long enough to develop anaerobic conditions in the upper layers, or
- the substratum is not soil and is saturated with water, or covered by water at some time.

For the purposes of Chapter 5A activities, wetlands do not include springs and watercourses and those wetlands that are defined in the document entitled *"Wetland Mapping and Classification Methodology"* (Department of Environment and Resource Management, 2005) as:

- H2M1 Riverine or ex-riverine (lacustrine) water bodies associated with dams and weirs located in a channel;
- H2M3p Ponded pastures;
- H2M5 Palustrine / lacustrine water bodies where ecological character has changed due to gross mechanical disturbance (e.g. cropping);
- H2M6 Palustrine / lacustrine water bodies that have been converted, completely or mostly, to a ring tank or other controlled storage;
- H2M7 Riverine water bodies that have been converted mostly to canals or irrigation channels;
- H3C1 Artificial stand-alone water storages not within a natural water body or channel; or
- H3C2 Artificial Channel drain / canal –bore drains, swales, bores and irrigation channel overflows / ponding."