

Advice to decision maker on coal seam gas project

IESC 2014-061: Santos GLNG Gas Fields Development Project (EPBC 2012/6615) – Expansion

Requesting agency	The Australian Government Department of the Environment The Queensland Office of the Coordinator-General
Date of request	04 November 2014
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Advice stage	Assessment

Context

The Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (the IESC) was requested by the Australian Government Department of the Environment and the Queensland Office of the Coordinator-General to provide advice on the proposed Gas Fields Development Project (GFD Project) by Santos in Queensland.

This advice draws upon aspects of information in the draft Environmental Impact Statement (EIS), together with the expert deliberations of the IESC. The project assessment documentation and information accessed by the IESC are listed in the source documentation at the end of this advice.

The GFD Project is a large extension of the approved Gladstone Liquefied Natural Gas Project (GLNG Project), located in the Surat and Bowen Basins, and within the Fitzroy River Basin and the Condamine-Balonne River Basin catchments. The proposed project covers an area of 10,676 km² and has an expected operational life of 30 years. The GFD Project includes 35 tenements in four gasfields: Roma, Arcadia, Fairview and Scotia, which are located near the towns of Injune, Miles, Rolleston, Roma, Surat, Taroom and Wandoan. Up to 6,100 new coal seam gas production wells (beyond the currently approved 2,650 wells for the GLNG Project) are proposed to be installed into the targeted coal resources of the Walloon Coal Measures of the Surat Basin, and the Bandanna Formation (including the equivalent Baralaba Formation) of the partially underlying Bowen Basin. Major project activities include: drilling; aquifer depressurisation; hydraulic stimulation; co-produced water management (storage, treatment, re-use, and discharge/disposal); infrastructure construction; and operation and decommissioning phases. Associated infrastructure in the region includes production and injection wells, bores, gas and water pipelines, gas compression and treatment facilities, and water treatment and management facilities.

There are three other major coal seam gas operations within the region: the Australia Pacific LNG Project; the Queensland Curtis LNG Project; and the Arrow Energy Gas Project. The region was declared a Cumulative Management Area (Surat CMA), which gave the then Queensland Water Commission (QWC) responsibility for preparing an Underground Water Impact Report (UWIR). The

QWC - now known as the Office of Groundwater Impact Assessment (OGIA) - is responsible for assessing cumulative impacts and establishing integrated management arrangements that include the development of a groundwater model (the Surat CMA groundwater model) to predict the impacts of water extraction by petroleum and gas operators on groundwater within this region.

The IESC acknowledges that conditions have been placed on the GLNG project (and other approved coal seam gas projects in the region) by the Australian and State Governments. However the requirements under these conditions have not been included in the proponent's project assessment documentation and have therefore not been considered as part of this advice.

Key potential impacts

The scale, the early stage and the geographic extent of the proposed project development, together with other significant coal seam gas projects in the region, creates considerable scientific uncertainty about potential impacts on surface water and groundwater and associated ecosystems. These include:

- Reduced water supply to Groundwater Dependent Ecosystems (GDEs), including *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) listed Great Artesian Basin (GAB) discharge and watercourse springs and endangered ecological communities, and groundwater users.
- Cumulative impacts of Surat and Bowen basin activities, particularly coal seam gas and coal mining, on groundwater pressures and lag-time effects on water resources.
- Hydrological and ecological consequences of surface water discharge into the tributary gully, waterhole and Dawson River potentially impacting the surface water flow regime, geomorphology, water quality and instream biota.
- Changes to groundwater and surface water quality due to direct project activities and management of co-produced water.

Assessment against Information Guidelines

The IESC, in line with its Information Guidelines (IESC, 2014), has considered whether the proposed project assessment has used the following:

Relevant data and information: key conclusions

Recognising the considerable information provided in the project assessment documentation, the IESC is concerned that relevant data and information from investigations and monitoring from the GLNG Project and Joint Industry Programmes have not been incorporated into the project assessment documentation for the GFD Project. The hydroecological information, including ecological water requirements of systems, provided is inadequate for understanding potential ecological impacts at the local scale. Groundwater baseline information in some areas is limited for example in the northern portion of the GFD Project.

Application of appropriate methodologies: key conclusions

Methods applied are appropriate to understand regional impacts, particularly cumulative groundwater drawdown, however the methods used are not sufficient for understanding local-scale impacts, particularly to ecological assets. This results in a high level of scientific uncertainty associated with the local scale impacts and the mitigation of those impacts, particularly with respect to springs. Predicted groundwater impacts associated with the GFD Project have not been differentiated from those of another (unnamed) proponent that has been simultaneously represented in Surat CMA groundwater

model runs. Assessment of impacts to groundwater and surface water as a result of the GFD Project are difficult to determine as they have not been differentiated from the GLNG Project.

There is limited assessment of ecological risk. The proponent has instead undertaken a significance assessment of sensitive habitats and magnitude of impacts, with no consideration of the likelihood of the hazard occurring. Use of an ecological risk assessment framework would also allow conceptual models of surface water and groundwater components and impacts to be developed.

The proponent has presented local and regional water balances in a format consistent with IESC Information Guidelines (IESC, 2014), however there is no linkage between modelling of surface water and groundwater elements. The Surat CMA groundwater model was not designed to predict surface water impacts, so potential reduction in baseflow to surface waters and springs due to groundwater drawdown is not estimated.

Local scale conceptual models for surface water resources and ecological values, including relationships between baseflow, groundwater drawdown, faults and springs should be provided within the project assessment documentation for each gasfield. Predicted water quality and flow (discharge rate, frequency and duration) of potential co-produced water discharges are needed to enable a quantitative assessment of the approved Dawson River discharge scheme on the environment separate from the GLNG Project.

Reasonable values and parameters in calculation: key conclusions

The proponent has presented hydrogeological data that supports values and parameters used in the Surat CMA groundwater model.

Advice

The IESC's advice in response to the requesting agencies' specific questions is provided below.

Question 1: Does the Committee agree with the proponent's interpretation of the GFD Project's impact to groundwater that was predicted by the Surat Cumulative Management Area (CMA) groundwater model?

Response

1. The modelling approach used is appropriate for predicting regional scale cumulative groundwater impacts, but does not enable assessment of local scale impacts by the GFD Project. The Surat CMA groundwater model was not designed to investigate groundwater-surface water interactions, which restricts the assessment of groundwater-surface water connectivity and limits the interpretation of potential impacts to surface water resources, particularly watercourse and GAB discharge springs.

Explanation

2. The Surat CMA groundwater model predicts regional groundwater depressurisation, however groundwater depressurisation associated with the GFD Project is not differentiated from that of another unnamed proponent operating in the region. Under the 2013 EIS Scenario, the maximum level of depressurisation in three formations is predicted to increase: these are the Bungil Formation (0.3 m reduction in pressure head), the Springbok Sandstone (1 m reduction) and the Bandanna Formation (1 m reduction). Areas of impact will increase due to expansion of the project area including the Walloon Coal Measures, the Bandanna Formation, the overlying Springbok Sandstone, the Hutton/Marburg Sandstone and the Gubberamunda Sandstone. As a result of the EIS scenario, there are potential impacts to additional water users, springs

complexes and watercourse springs, although there appears to be uncertainty about the number impacted.

3. The Surat CMA groundwater model is not designed to predict impacts to shallow unconfined aquifers within the project area particularly those associated with alluvium. Finer scale conceptualisation and monitoring of groundwater and surface water connectivity is needed in sensitive areas such as watercourse springs to provide a benchmark against which changes in baseflow associated with proposed project operations can be assessed.
4. There is a lack of evidence to support the conclusions that the impact of groundwater drawdown at the surface is not significant (EIS, App. U2, p. 161).

Question 2: Does the draft EIS adequately identify impacts to matters of national environmental significance, including surface and groundwater dependent species and communities, springs and water resources, and has the mitigation and management of these impacts been adequately addressed?

Response

5. The EIS identifies the potential for and assesses the significance of impacts to water-related Matters of National Environmental Significance (MNES) although a quantitative risk assessment considering likelihood and consequence has not been, but should be, undertaken. The assessment is high-level and inappropriately relies upon monitoring in order to reduce the magnitude of impact to springs. A quantitative assessment of impacts of the GFD Project separate to both the approved GLNG Project and an unspecified proposal from another proponent has not been provided. Assessment of the impacts of the proposed project on water-related MNES should include the provision of technical assessments addressing deficiencies highlighted under the 'Explanation' section below, in relation to: groundwater impacts; groundwater monitoring; surface water characterisation; water balance and co-produced water management; hydraulic stimulation and chemical use; cumulative impacts; and mitigation and management.
6. The proponent relies on existing GLNG Project monitoring and management plans for the mitigation and management of identified impacts from the GFD Project. The existing plans focus primarily on monitoring as a management and mitigation option. Information should be provided to demonstrate the efficacy of proposed recovery methods or offset opportunities to mitigate the impacts to springs. As the plans were developed for impacts associated with the approved GLNG Project, their adequacy to address impacts associated with the increased scale of the combined GLNG and GFD projects needs to be justified.

Explanation

Groundwater impacts

7. The regional scale groundwater model with a grid size of 1.5 km does not allow for the adequate representation for impacts to MNES. More detailed modelling and monitoring are needed including how the proposed project contributes to changes in flux in the local water balance for each gasfield.
8. The proponent's assessment of impacts to groundwater other than depressurisation is based on qualitative significance assessments. Whilst the significance of depressurisation itself has not been assessed, the proponent considers that the magnitude of potential impacts is reduced by the application of controls such as water monitoring and management plans. Monitoring alone will not reduce the significance of potential impacts.

9. It is unclear why depressurisation and drawdown impacts are not indicated in any layers near tenements ATP 803P (Scotia) and ATP 665P near Roma (EIS, App. O, p. 86).
10. Adequate identification of impacts of the GFD Project on MNES would need groundwater modelling to:
 - a. Represent the GFD Project alone.
 - b. Include the Quaternary alluvium associated with rivers and major creeks.
 - c. Represent groundwater-surface water fluxes especially near and downstream of the watercourse springs.
 - d. Reflect changes in groundwater pressure/level at a more detailed scale than the currently employed grid size, which would allow for improved assessment of drawdown in the alluvium and identification of potential impacts on GDEs.

Groundwater monitoring

11. A comprehensive assessment of baseline groundwater quality and physical characteristics should be provided to enable the assessment of potential impacts attributable to the GFD Project. Currently:
 - a. Baseline groundwater quality data only includes pH, electrical conductivity, iron and manganese. A full suite of water quality parameters including metals and major ions should be measured at relevant locations.
 - b. Bore hydrographs are presented for deep strata only (EIS, App. O, App. B). Bore hydrographs should be presented for shallower strata especially near watercourse springs.
 - c. There is a lack of groundwater monitoring and early warning bores in proximity to the EPBC Act listed spring complex 594. A large number of spring vents adjacent to the northern tip of the Arcadia gasfield fall within the groundwater drawdown extent that has been modelled under the EIS Scenario. The source aquifer for spring complex 594 is interpreted to be the Clematis Sandstone (EIS, App. AE-B, p. 38). Although no drawdown is predicted within the sandstone aquifers in this area, potential drawdown of spring complex 594 will be dependent on the integrity of the Rewan Formation. Baseline monitoring and the installation of additional monitoring bores in the north-eastern portion of the Arcadia gasfield should be undertaken to assess potential impacts to springs in this area.
 - d. There is little long-term monitoring proposed to assist in understanding potential impacts due to the time lag in depressurisation. Although maximum depressurisation will occur towards the end of the proposed project's life between 2020 and 2030, there will be a time lag to maximum depressurisation in overlying and underlying formations depending on the hydraulic conductivity and degree of connectivity between formations. A monitoring regime should be in place to determine potential impacts due to the lag-time in depressurisation and to inform appropriate action.

Surface water characterisation

12. Conceptual and numerical models linking surface water, groundwater and ecological components and processes are needed to inform assessment of potential impacts to surface water resources. Potential impacts to geomorphology, water quality, water quantity and flow regime, as well as the amalgamated footprints of infrastructure components and consequent catchment loss, should be estimated.

13. The proponent states that specific details such as regular and event-based monitoring will be undertaken in accordance with the relevant regulatory criteria for the GFD Project, but may be expected to vary during different phases of the proposed project (EIS, App. AE, p. 66). Surface water monitoring locations, frequency and scope (range of parameters tested and methodology used, along with estimates of statistical power and uncertainty) need to be provided.
14. Sampling record and frequency are generally sufficient to characterise the existing surface water quality condition within the sub-catchment scale. However, additional surface water sampling and assessment is needed to:
 - a. Increase the understanding of spatial (at a level finer than the sub-catchment scale) and temporal variability in water quality and to establish site-specific water quality objectives once the infrastructure layout and water management options are confirmed.
 - b. Characterise surface water hydrology, geomorphology, aquatic ecology and water quality in locations proposed for water treatment facilities and coal seam co-produced water discharge.
 - c. Evaluate the range of potential environmental impacts when determining potential re-use/disposal options for coal seam co-produced water.
 - d. Account for impacts of groundwater drawdown on baseflow in all relevant watercourses in the Surat CMA groundwater model. Where potential impacts are identified, field based investigations and monitoring are needed to assess impacts to water-related assets within the region.
 - e. Develop conceptual models for surface water dynamics, particularly those associated with GDEs including springs.

Water balance and co-produced water management

15. Based on the maximum development scenario, estimated co-produced water extraction over the operational life of the GFD Project is 219 GL (EIS, App. Z, p. 10). However, the amount of coal seam water produced in the EIS Scenario water balance totals 708 GL over 100 years (EIS, App. U2, p. 163, 165, 169 and 171). The contribution of the GFD Project to the total estimated water production under the EIS Scenario should be clarified and the local water balance updated accordingly.
16. The proponent's water balance models (EIS, App. U2, Chap. 6) do not quantify groundwater-surface water interactions or system flows to individual beneficial use or disposal options following co-produced water treatment. The water balances presented do not address: potential reductions in surface water flow due to groundwater drawdown; treated surface water re-entering the shallow groundwater system through seepage or dust suppression; managed aquifer recharge and brine reinjection to deeper aquifers; or water demand for hydraulic stimulation.
17. The placement of brine and salt management infrastructure should be more specific with regard to potential flooding. A salt balance is needed to inform the appropriateness of salt disposal options and beneficial uses of untreated co-produced water. Consideration should be given to the potential cumulative effects of salt disposal from the other coal seam gas operators in the area.
18. The proponent proposes to discharge a maximum of 18 ML per day of treated co-produced water to the Dawson River in the approved GLNG Project (EIS, App. U2, pp. 159–161). It is not clear whether the frequency and duration of discharge will change as a result of the GFD Project. A quantitative assessment should be undertaken on the potential impact of proposed discharges compared to existing/approved releases under the GLNG Project, including the potential impacts

to water and sediment quality, flow, geomorphology and ecology in the tributary gully, the waterhole and the Dawson River. This assessment should be informed by:

- f. A minimum twenty-four months of data collection to establish existing baseline conditions.
- g. Contextual information (location and timing of sampling) on surface water quality dataset.
- h. Modelling of discharge scenarios specifying the timing, quality and volumes.
- i. Water quality sampling for the tributary gully, the waterhole, and upstream and downstream in the Dawson River.
- j. Installation of gauge stations upstream and immediately downstream of the confluence of the tributary gully and the Dawson River to determine the existing flow regime and model changes due to the proposed discharge.
- k. Monitoring and assessment of the effects of increased sedimentation and cumulative impacts on the geomorphology of potential refuge pools, especially in areas downstream of the discharge locations and in areas of intermittent flow.
- l. Surveys consistent with the Survey Guidelines for Australia's Threatened Reptiles (DSEWPAC, 2011) to establish whether the Fitzroy River Turtle *Rheodytes leukops* is likely to be present at the proposed discharge site. If so, then the likely impacts of the proposed discharge on habitat, such as the above-mentioned interconnected pools for different life cycle stages need to be identified.
- m. Assessment of the impacts of treated water quality parameters found to exceed water quality guidelines including site-specific ecotoxicological testing.
- n. Consideration of the construction and use of appropriate management facilities and treatment processes for co-produced water.

Hydraulic stimulation and chemical use

- 19. Conditions as part of the approval process of the GLNG Project required the proponent to identify the number and spatial distribution of boreholes where hydraulic stimulation may be necessary. The proponent states in the EIS (App. AE-F, App. A) that this condition has been addressed in the risk assessment, however; this document only lists wells that have already been hydraulically stimulated up to December 2012.
- 20. Information should be provided on the number and locations of inclined wells and multi-branch wells (if they will be used) along with corresponding information on the amount of hydraulic stimulation that may be undertaken. This should include water supply requirements, extent of fracture propagation (both horizontal and vertical), the type and amount of chemicals to be used for each well and the plan for the handling of flowback fracturing fluids.
- 21. The proponent states that the likelihood of impacts is low due to bore construction controls. Provided strict controls, such as bore integrity and monitoring/investigations are being carried out as part of the GFD Project in accordance with industry standards and conditions, it is likely impacts would be low. Data and information on well integrity failure rates that could cause water related impacts such as interconnection between formations and predicted failure rates should be provided based on industry experience and/or analogous operations.
- 22. The following chemicals were not able to be identified on the Australian Inventory of Chemical Substances for import or use in Australia as an industrial chemical. The proponent should obtain written advice from the National Industrial Chemicals Notification and Assessment Scheme that

chemicals used in the hydraulic stimulation process are for import, manufacture or use in Australia. Specific chemicals include:

- o. Erucic amidopropyl dimethyl betaine (CAS no. 149879-98-1)
 - p. Polyvinyl acetate, partially hydrolysed (CAS no. 304443-60-5)
 - q. Bentonite (CAS no. 121888-68-4)
 - r. Coffee beans (CAS no. 327-97-7).
23. The proponent should check the CAS numbers for the following (EIS, App AE-F, App. C4, p. 3):
- s. Hydrochloric acid (assigned 7647-01-1, the correct CAS no. is 7647-01-0)
 - t. Magnesium nitrate (assigned 13077-60-3, the correct CAS no. is 10377-60-3).
24. The following chemicals cannot be identified or assessed by the IESC because no CAS numbers were provided (EIS, App. AE-F, pp. 3–4). The majority of these chemicals are trademarked and categorised as confidential business information and include:
- u. Ester salt
 - v. Non-ionic surfactant mix™
 - w. Surfactant mix™
 - x. Fatty acid ester™
 - y. Ethoxylated fatty acid ester™
 - z. Enzyme™.
25. Chemicals used in coal seam gas extraction are considered to be industrial chemicals and should have their hazards and risks rigorously and transparently assessed. Where required, appropriate risk mitigation processes should be implemented. Chemical risk assessments should be informed by appropriate physico-chemical, ecotoxicological, and site-specific monitoring data. The use of any chemicals that have not had their risks rigorously assessed should be avoided until an assessment has been undertaken.
26. The Santos GLNG Water Monitoring and Management Plan (stage 2-revision 2) for the approved GLNG Project includes a Persistence, Bioaccumulation and Toxicity assessment of the hydraulic fracturing chemicals, however, it does not assess interaction between chemicals in mixtures or potential degradation products. A direct toxicity assessment programme would assist in assessing the toxicity of fracturing fluid mixtures. Site-specific direct toxicity assessment is being undertaken as part of the Joint Industry Work Program for CSG Fraccing Fluid Ecotoxicology and the results should be used to better inform and assess the risk of the potential impacts of chemicals.
27. Further information should be provided on the potential use and general suitability of acid injection prior to hydraulic stimulation, including the chemicals and volumes used, and disposal of the injected liquids.

Subsidence

28. Whilst the predicted risk due to subsidence as a result of the GFD Project is assessed as low, the proponent has committed to carrying out ground deformation and supporting water level monitoring to verify assumptions and assessed risk. Verification of remote satellite data by

comparison to conventional or GPS levelling should be considered (Commonwealth of Australia, 2014).

29. Ground deformation estimates for the Scotia gasfield and examples of potential subsidence mitigation options for the GFD Project should be provided.

Ecological values and water-related assets

30. The EIS identified impacts to some MNES including surface water - and groundwater - dependent species and communities. However, it is difficult to distinguish between the potential regional impacts from the approved GLNG Project and the proposed GFD Project. Local scale impacts on GDEs including impacts to baseflow ecosystems and vegetation accessing the unconfined water table have not been identified.
31. The potential impacts to springs as a result of the proposed GFD Project are poorly described and particular springs that are likely to be impacted are not clearly identified. Many spring vents appear to overlie the extent of impact modelled under the EIS Scenario and have not been included in the proponent's impact assessment, most notably those in proximity to the north-eastern border of the Arcadia gasfield. As there are no proven recovery methods or offset opportunities to mitigate the impacts to springs, ongoing monitoring of these springs should be undertaken to ensure geological structures do not support a hydrogeological connection between the springs and any potentially impacted hydrogeological units.
32. All springs likely to be impacted by the GFD Project should be clearly identified in the project assessment documentation regardless of the assigned responsible tenure holder. Similar reports to the Evaluation of Prevention or Mitigation Options for Fairview Springs report should be prepared for any other springs, including the assessments of cumulative effects along watercourse springs, in and surrounding the GFD Project area.
33. The EIS references the Joint Industry Plan for an EPBC Springs Early Warning System, 2013, which states "The Clematis Sandstone is no longer classified under the GAP(sic) ROP—Great Artesian Basin Resource Operations Plan—as a GAB aquifer. SEWPaC has yet to advise if the approval conditions apply to springs sourced from the Clematis Sandstone and meeting the criteria of community of native species dependent on GAB" (EIS, App. U2, App. J, App. B, p. 5). Consistent with the state water resource plan the Clematis Sandstone should be considered as part of the GAB (*Queensland Water Resource Plan (Great Artesian Basin), 2006*).
34. There is a lack of monitoring bores in proximity to EPBC listed spring complex 594 (Elgin 2), at Dawson 8, and a large number of spring vents located north and east of the Arcadia gasfield (EIS, App. O, p. 97, Table 7.5 and EIS, App. AE-B, p. 28). The proponent holds the closest petroleum tenures and may be responsible for monitoring springs in this region. Additional monitoring locations and bores installed as part of an early warning system should be placed close to or within the source aquifer of these springs.
35. The proponent states that the Robinson and Palm Tree Creeks Wetland is not identified as a GDE in the Queensland GDE mapping (EIS, App. U-2, p. 181) but the Queensland GDE mapping has not been completed for the Fitzroy catchment. The contribution of groundwater to the wetland needs to be investigated and assessed to determine the wetland's reliance on groundwater input.
36. There is no interpretation made of the impact of predicted drawdowns on watercourse springs associated with outcrops of GAB stratigraphic units, for example those assessed with Gubberamunda Sandstone. Further consideration of drawdown in aquifers that may contribute to flows within the Murray-Darling Basin, such as the Gubberamunda Sandstone, is needed so as to assess all potential impacts on water resources.

37. The impact of groundwater drawdown at the surface is reported not to be significant with no expected increase in recharge from the surface water systems to underlying aquifers (EIS, App. U2, p. 161). There is a lack of evidence to support this conclusion. Finer scale groundwater and surface water modelling and monitoring may be needed, especially during the dry season, in sensitive areas such as watercourse springs to assess changes in flow regimes in intermittent rivers and changes in baseflow and groundwater-surface water interactions associated with project operations.
38. Surveys of suitable microhabitat for the EPBC-listed Boggomoss snail *Adclarkia dawsonensis* should be undertaken to ensure potential impacts on this species can be adequately assessed.

Cumulative Impacts

39. The Surat CMA groundwater model developed by the OGIA is an appropriate regional-scale tool for assessing cumulative impacts to groundwater from the coal seam gas proponents. To assess more broadly the potential cumulative impacts on water resources in the future, the model would need to consider other groundwater impacts within the region. Even if groundwater drawdown from the GFD Project is not predicted to intersect with drawdown from mining operations, the cumulative impact of all water-intercepting and water-discharging operations on the regional water balance needs to be identified. This would enable planning and management of proposed surface water discharge under the GFD Project to take discharges from nearby mines into account.

Mitigation and management

40. The UWIR is due to be updated in 2015 which may include a new groundwater model re-calibrated with new monitoring data and/or incorporating changes to planned petroleum and gas development. If required, the OGIA will revise the assignment of responsible tenure holder obligations in the UWIR to reflect changes in tenure ownership and the new assessment of potential impacts to bores and springs. Spring surveys and reports conducted and prepared by coal seam gas proponents in the area are scheduled to be completed in early 2015. This information should be incorporated in the groundwater model revision to provide a more robust assessment of the potential cumulative impacts in the surrounding area.
41. GLNG Project monitoring and management plans are yet to be proven effective for the larger GFD Project. Management and mitigation plans designed to address the potential impacts of the GLNG Project should be updated to incorporate the results of the revised UWIR assessment and include the potential impacts of the GFD Project.
42. Commitments for surface water and groundwater monitoring should be presented as part of a water monitoring plan and should be consistent with the National Water Quality Management Strategy.

Question 3: Is the geological conceptualisation of faults adequate for the groundwater impact assessment?

Response

43. The geological conceptualisation of faults is based on detailed surface geological mapping, and in the case of the Hutton-Wallumbilla fault, targeted drilling operations. This is adequate for regional groundwater impact assessment and for the purpose of predicting drawdown impacts at the regional scale but is not adequate to assess potential impacts on individual springs. The local scale hydrogeological conceptualisation of the relationship between, or dependence on, smaller scale faults identified in geological mapping and springs should be determined. This information should be presented in the project assessment documentation and used to assess potential impacts to groundwater.

Explanation

44. The Surat CMA is not located within a known complex tectonic or structurally deformed area. Some geological structures have been identified within the proposed GFD Project area however they are considered by the proponent to be at low risk of being critical to groundwater flow at the regional scale. While the Surat CMA groundwater model is not of a scale appropriate to specifically model groundwater-fault interactions, the proponent does not expect this to affect the modelled drawdown predictions. In the absence of modelling at a finer resolution it is uncertain what scale of impact the adequate representation of geological structures would have on model predictions.
45. Cross-sections provided do not intersect with fault planes and therefore fault properties and their effect on groundwater flow are not shown. A conceptual model and cross-section depicting the interpreted nature of faulting and effect of faults on groundwater flow would be useful aids to justify the proponent's fault-groundwater conceptualisation.
46. Preliminary assessment of the hydrogeological characteristics of the Hutton-Wallumbilla fault is presented in the Hydraulic Connectivity Characterisation report (EIS, App. AE-A). A discussion on the fault acting as a groundwater flow conduit has not been provided.
47. For springs that overlie faults (i.e. springs that are proximal to the Hutton-Wallumbilla fault, south of Fairview, and north and east of the Arcadia gasfield tenements) source aquifers and spring conceptual typology should be determined to establish the dependence of the overlying spring on the structural feature.

Question 4: Has the risk of hydraulic stimulation resulting in aquifer connection been adequately assessed?

Response

48. The risk of hydraulic stimulation resulting in aquifer connection has not been assessed and is only considered in the EIS based on the conceptualisation of interconnectivity in the Surat CMA groundwater model. The Surat CMA groundwater model assumes limited potential for vertical interconnectivity between hydrogeological units. The proponent indicates the likelihood that stimulated fractures would extend into the overlying and underlying sedimentary rock layers is remote but this statement needs to be supported with further evidence on fracture propagation length, vertical and horizontal fracture propagation ratio, and geophysical and hydrochemical properties of the target formation and surrounding hydrological units.
49. There is little existing monitoring data or ongoing monitoring proposed to assess connectivity. The proponent states that the industry code of practice for constructing and abandoning wells will be followed. Monitoring regimes should include the use of other measures of fracture propagation and occur in association with each hydraulic stimulation event.

Explanation

50. There are no planned activities to specifically investigate connectivity that might be induced by hydraulic stimulation of coal seam gas wells (WMMP, p. 208).
51. Given the uncertainty in the location of where hydraulic stimulation would be undertaken, it was conservatively assumed in the assessment that all gas well locations have the potential to be hydraulically stimulated. The number and spatial distribution of boreholes where hydraulic stimulation may be necessary needs to be clarified (see paragraphs 19–21).

52. The proponent states that the likelihood of stimulated fractures extending into the overlying and underlying sedimentary rock layers is considered remote (EIS, App. AE-F, p. 91) and the potential to induce inter-aquifer connectivity is low. The assessment of fracture propagation could be strengthened by:
- a. Elucidating the presence of significant natural features including faults and fractures, and presenting information on properties of the rock, bore integrity (specifically the integrity of the annulus), and variability in thickness of the overlying confining layers.
 - b. Analysis and discussion of how far fractures propagate, the ratio between horizontal and vertical fracture propagation, and how fracture propagation will be monitored.
 - c. The use of an integrated approach using a combination of multiple diagnostics, such as tiltmeters, radioactive tracers, sonic anisotropy logging, geochemical modelling and treatment pressure history-matching data to more accurately interpret fracture propagation and geometry (Johnson *et al.*, 2010).
53. Monitoring and managing potential impacts and risks of production wells needs to be considered over the different phases of the life of a well including: drilling phase; pressurisation phase (well perforation and hydraulic stimulation), depressurisation and the production phase; and the decommissioning and return to equilibrium phase.

Other considerations

54. The Northern Inland Catchments, which includes the Maranoa-Balonne-Condamine subregion, has been identified as a Bioregional Assessment priority region. Data and relevant information from the proposed GFD Project should be made accessible to this Bioregional Assessment and other research to assist the knowledge base for regional scale assessments.

Date of advice	18 December 2014
Source documentation available to the IESC in the formulation of this advice	EIS, 2014. Santos Gas Fields Development Project draft Environmental Impact Statement. WMMP, 2013. Santos GLNG Project Water Monitoring and Management Plan, stage 2—revision 2.
References cited within the IESC's advice	Commonwealth of Australia, 2014. Monitoring and management of subsidence induced by coal seam gas extraction, Knowledge report, prepared by Coffey Geotechnics for the Department of the Environment, Commonwealth of Australia, Canberra. DSEWPAC, 2011. Survey Guidelines for Australia's Threatened Reptiles' Australian Government Department of the Sustainability, Environment, Water, Population and Communities, Canberra. IESC, 2014. Information Guidelines for Independent Expert Scientific Committee advice on coal seam gas and large coal mining development proposals available at: http://iesc.environment.gov.au/pubs/iesc-information-guidelines.pdf Johnson <i>et al.</i> 2010. Evaluating hydraulic fracture effectiveness in a coal seam gas reservoir from surface tiltmeters and microseismic monitoring, Society of

Petroleum Engineers, Conference paper.

UWIR, 2012. Underground Water Impact Report for the Surat Cumulative Management Area, Queensland Water Commission (now OGIA); and the 2013 Annual Report.
