# Executive Summary

## Purpose

The Coal Seam Water Monitoring and Management Annual Report 2016 for the Santos GLNG Project, is required by the Commonwealth Department of the Environment (DOTE). This Annual Report:

- Has been prepared in accordance with Conditions 49 i) and 53 c)ix) of *the Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) (EPBC Act) Approval 2008/4059;
- Reports progress against the Santos GLNG Stage 2 CSG Water Management and Monitoring Plan (Revision 2) (Stage 2 CWMMP Rev 2); and
- Covers the period 1 January 2016 to 31 December 2016.

## Approval Context

In October 2010, the Minister for the former Department of Sustainability, Environment, Water, Population and Communities (now DOTE) granted the EPBC Approval under the EPBC Act, with various conditions. Conditions included the submission of a Stage 1 and Stage 2 Coal Seam Gas Water Monitoring and Management Plan (CWMMP) in which Santos GLNG made commitments for addressing the EPBC Act Approval conditions. The Stage 1 CWMMP and Stage 2 CWMMP Rev 2 were approved by the Minister for the Environment on 29 November 2013.

## Features of this Annual Report

Santos GLNG is progressing as planned against the commitments in the Stage 2 CWMMP Rev 2. The Santos GLNG project continues to be developed and operated in a sustainable manner, with the appropriate mitigation measures implemented. The potential risk of adverse impact to Matters of National Environmental Significance (MNES) remains low.

Table A provides a summary of Santos GLNG's commitments made for the period covered in the Stage 2 CWMMP Rev 2 and provides a status update of progress up to the end of December 2016.

**Table A: Stage 2 CWMMP Rev 2 Commitments & Progress Update**

● **Commitment Complete;** ▶ **Commitment In Progress;** ♦ **Continuous Commitment**

| Condition | Commitment | Target Completion Date Specified in Stage 2 CWMMP Rev 2 | Status | Annual Report Reference |
|---|---|---|---|---|
| **49a, 49d,53c.vi** | **Groundwater Drawdown** | | | |
| | Drawdown limits are now defined for the source aquifer at selected locations. These limits are subject to periodic updates. | Completed. | ● | Section 3 |
| | Installation of Early Warning Spring (EWS) monitoring network. | End 2016. | ▶ | Section 3 |
| | Ground truthing of a selection of springs to assess the presence of EPBC listed species and EPBC communities. | On and off tenure springs baseline initiated as part of the JIP, to be reported April 2015. | ● | Section 3 |
| | Santos GLNG will assume responsibility of mitigation (if required) for on-tenure springs and those off-tenement springs as will be assigned by the Surat Underground Water Impact Report (UWIR)/DOTE. | Ongoing. | ♦ | Section 3 |
| | Comparison of drawdown to UWIR predictions will occur on a quarterly basis. | Quarterly. | ▶ | Section 3 |

● Commitment Complete; ► Commitment In Progress; ♦ Continuous Commitment

| Condition | Commitment | Target Completion Date Specified in Stage 2 CWMMP Rev 2 | Status | Annual Report Reference |
|---|---|---|---|---|
| 49b, 53b, 53d(i)4) | **Aquifer Connectivity** | | | |
| | Santos GLNG commits to provide further characterisation on the level of connectivity between the formations, including undertaking the following upcoming and ongoing hydraulic connectivity programs. Note that the results will be presented in future updates to the CWMMP. | | | |
| | Multi-level monitoring bores. | Ongoing monitoring and data assessment. | ♦ | Section 4 |
| | Contact Zone Program. | Ongoing after installation. | ► | Section 4 |
| | Wallumbilla Fault Program. | Installation planned for 2014. | ● | Section 4 |
| | Aquifer Response. | Ongoing. | ♦ | Section 4 |
| | Isotope and geochemical signature. | Ongoing. | ♦ | Section 4 |
| | Pumping response observations and assessments. | Annually from 2014. | ♦ | Section 4 |
| | The outcomes of the conventional oil and gas well and water bore risk assessment will be presented in an update to the CWMMP. | Updated CWMMP will be submitted for approval in due course. | ► | Section 4 |

● Commitment Complete; ▶ Commitment In Progress; ♦ Continuous Commitment

| Condition | Commitment | Target Completion Date Specified in Stage 2 CWMMP Rev 2 | Status | Annual Report Reference |
|---|---|---|---|---|
| 49c, 53a, 53 d)ii | **Aquifer Re-injection** | | | |
| | Santos GLNG has developed a Managed Aquifer Recharge (MAR) pilot program and schedule for gas field piloting of aquifer reinjection. | | | |
| | Fairview CSG Field Stage 1– Desktop Study. | Completed March 2012. | ● | Section 5 |
| | Roma CSG Field Stage 1– Desktop Study. | Completed January 2011. | ● | Section 5 |
| | Roma CSG Field Stage 2 – Investigations and Assessment. | Completed January 2011. | ● | Section 5 |
| | Roma CSG Field pilot trial (Hermitage) Stage 3 – Construction and Commissioning. | Completed Q1/Q2 2012. | ● | Section 5 |
| | Roma CSG Field pilot trial (Hermitage) Stage 4 – Operation. | Completed Q4 2012. | ● | Section 5 |
| | Roma CSG Field (The Bend) Stage 3 – Construction and Commissioning. | Due for completion Q3 2014. | ▶ | Section 5 |
| | Roma CSG Field (The Bend) Stage 4 – Operation. | Due to commence Q3/Q4 2014. | ▶ | Section 5 |
| | Arcadia Valley CSG Field Stage 1 – Desktop Study. | Completed September 2013. | ● | Section 5 |
| | All approved Injection Management Plans will be provided in an update to the CWMMP. | Ongoing. | ♦ | Section 5 |

● Commitment Complete; ► Commitment In Progress; ♦ Continuous Commitment

| Condition | Commitment | Target Completion Date Specified in Stage 2 CWMMP Rev 2 | Status | Annual Report Reference |
|---|---|---|---|---|
| **49e** | **Hydraulic Fracturing** | | | |
| | Santos GLNG will provide a projection of the anticipated number of wells to be hydraulically stimulated during each year as well as the number of hydraulic stimulations completed in the preceding year. Additional details to be reported will also include location information and the depth of each respective hydraulic stimulation. | Annually. | ♦ | Section 6 |
| **49f** | Santos GLNG has agreed with the DOTE to undertake additional Direct Toxicity Assessment that will include:<br>• an ecotoxicological program, involving, for example, a comparison of (i) coal seam water, (ii) coal seam water with hydraulic fracturing chemicals, and (iii) hydraulic fracturing chemicals in freshwater;<br>• assessing the risk of individual hydraulic fracturing chemicals of concern; and<br>• assessing contribution of hydraulic fracturing chemicals to toxicity of hydraulic fracturing fluids and flowback waters (mixture toxicity).<br>Santos GLNG is committed to undertaking these assessments, as part of the joint industry Ecotoxicity Work Program; the result of which will be provided to the DOTE upon completion. | December 2013 | ● | Section 6 |

● Commitment Complete; ▶ Commitment In Progress; ♦ Continuous Commitment

| Condition | Commitment | Target Completion Date Specified in Stage 2 CWMMP Rev 2 | Status | Annual Report Reference |
|---|---|---|---|---|
| **49.g.iv)** | **Surface Water Baseline** | | | |
| | Ongoing collection of surface water baseline data. | End of 2013. | ♦ | Section 2 |
| | EPBC spring hydrogeological conceptual model. | Initial conceptual models to be provided in November 2013. | ● | Section 3 |
| | Atmospheric pressure monitoring – 1 installation (barrologger or other) at each EPBC spring complex or cluster of spring complexes. | Completed. | ● | Section 3 |
| **49.g.vi)** | **Surface Water Threshold Values** | | | |
| | Collection and reviewing 2 years of baseline data and development of upper and lower confidence levels (Threshold values) for key parameters (relevant to MNES). These threshold values will be provided in an update to the CWMMP. | End of 2014.<br>Completed, data acquisition ongoing. | ▶ | Section 7 |
| **49.g.x)** | **Brine Management Plans** | | | |
| | Provision of Brine Management Plans developed for Arcadia Valley, Roma and Fairview gas fields as a state government requirement within the respective gas field's environmental authorities (EA's). These will be provided in the next update to the CWMMP. | December 2014. | ▶ | Section 8 |

● Commitment Complete; ► Commitment In Progress; ♦ Continuous Commitment

| Condition | Commitment | Target Completion Date Specified in Stage 2 CWMMP Rev 2 | Status | Annual Report Reference |
|---|---|---|---|---|
| **49i, 53c)ix)** | **Reporting** | | | |
| | A Coal Seam Water Monitoring and Management Annual Report will be developed for each calendar year and submitted to the DOTE within the first quarter of the following year. | 31 March 2017 and annually thereafter. | ♦ | Section 10 |
| | Digital data can be provided to the DOTE on request. | Ongoing. | ♦ | Section 10 |
| | Santos GLNG will publish the following reports on the internet (via the Santos Water Portal):<br>▪ Coal Seam Water Monitoring and Management Annual Report; and<br>▪ Link to the latest Surat Cumulative Management Area (CMA) Underground Water Impact Report (UWIR). | Annually | ♦ | Section 10 |
| | Santos GLNG will regularly publish data from the water monitoring network on the Santos Water Portal. | Ongoing | ♦ | Section 10 |
| **55** | The next revision of the CWMMP is currently planned to be submitted to the DOTE 3 months prior to first LNG cargo. | Report to be submitted 3 months prior to first LNG cargo | ► | Section 10 |

● Commitment Complete; ▶ Commitment In Progress; ♦ Continuous Commitment

| Condition | Commitment | Target Completion Date Specified in Stage 2 CWMMP Rev 2 | Status | Annual Report Reference |
|---|---|---|---|---|
| **53.c)iv)** | **Groundwater Baseline** | | | |
| | Groundwater baseline data collection completion. | End of 2014. | ● | Section 2 |
| | Santos GLNG, in collaboration with the other Proponents (APLNG and QGC), will by the end of 2013 develop a statistical methodology to enable definition of significant exceedances from the baseline water pressure and water quality levels. The establishment of this methodology can only reasonably be commenced once the three Projects all have sufficient confirmation of their EPBC conditions being met by the respective CWMMPs. | Completed. | ● | Section 3 |
| **53.d.i.III** | **Subsidence** | | | |
| | The Subsidence Management Plan provides a response plan into exceedance of the defined subsidence trigger. The Subsidence Management Plan describes the monitoring undertaken to establish variation of ground level over time. | Completed. | ● | Section 9 |
| | Subsidence baseline. | Completed. | ● | Section 9 |
| | Monitoring through satellite measurements. | Ongoing. | ♦ | Section 9 |

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# Figures

# 1.0 Introduction

## 1.1 Scope of the Annual Report

The Santos Gladstone Liquefied Natural Gas (GLNG) Coal Seam Water Monitoring and Management Annual Report 2016 (Annual Report) has been prepared in accordance with Condition 49 i) and 53 c)ix) of the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) Approval 2008/4059 (EPBC Approval). This Annual Report provides progress against commitments made in the Santos GLNG Stage 2 Coal Seam Gas Water Management and Monitoring Plan (Revision 2) (Stage 2 CWMMP Rev 2) for the period 1 January 2016 to 31 December 2016.

Annual Reports will be submitted to the Department of the Environment (DOTE) by 31 March of each calendar year. Each Annual Report will cover the progress for the previous calendar year (January to December) against commitments made in the Stage 2 CWMMP Rev 2. The focus of this annual report is to:

- Document the progress against each commitment summarised in Table-A from 1 January 2016 to 31 December 2016; and
- Provide commentary on findings from completed work.

The report has been structured to present progress on commitments under the following subject areas:

- Section 1 Introduction;
- Section 2 Surface Water and Groundwater Baseline Monitoring;
- Section 3 EPBC Springs;
- Section 4 Aquifer Connectivity;
- Section 5 Managed Aquifer Recharge;
- Section 6 Hydraulic Fracturing;
- Section 7 Surface Water Monitoring;
- Section 8 Brine Management;
- Section 9 Subsidence;
- Section 10 Reporting; and
- Section 11 Third Party Audit

## 1.2 Project Context

In May 2010, the Queensland Coordinator-General approved the project under the *State Development and Public Works Organisation Act 1971*. In October 2010, the Minister for the former Department of Sustainability, Environment, Water, Population and Communities (now DOTE) granted approval under the EPBC Act. The GLNG project area location is shown in Figure 1-1.

The EPBC Act provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places — defined in the EPBC Act as Matters of National Environmental Significance (MNES). Accordingly, the CWMMP has been developed to manage the risk of adverse impact to MNES in relation to coal seam water management.

Santos GLNG prepared both Stage 1 and Stage 2 CWMMPs within the specified timeframes to meet the requirements of these conditions. The Stage 1 CWMMP and Stage 2 CWMMP Rev 2 were approved by the Minister for the Environment on 29 November 2013. The Stage 2 CWMMP Rev 2 fulfils the requirements of Conditions 49, 52 and 53 and covers the proposed management activities from 2013 to the first LNG cargo scheduled for 2015.

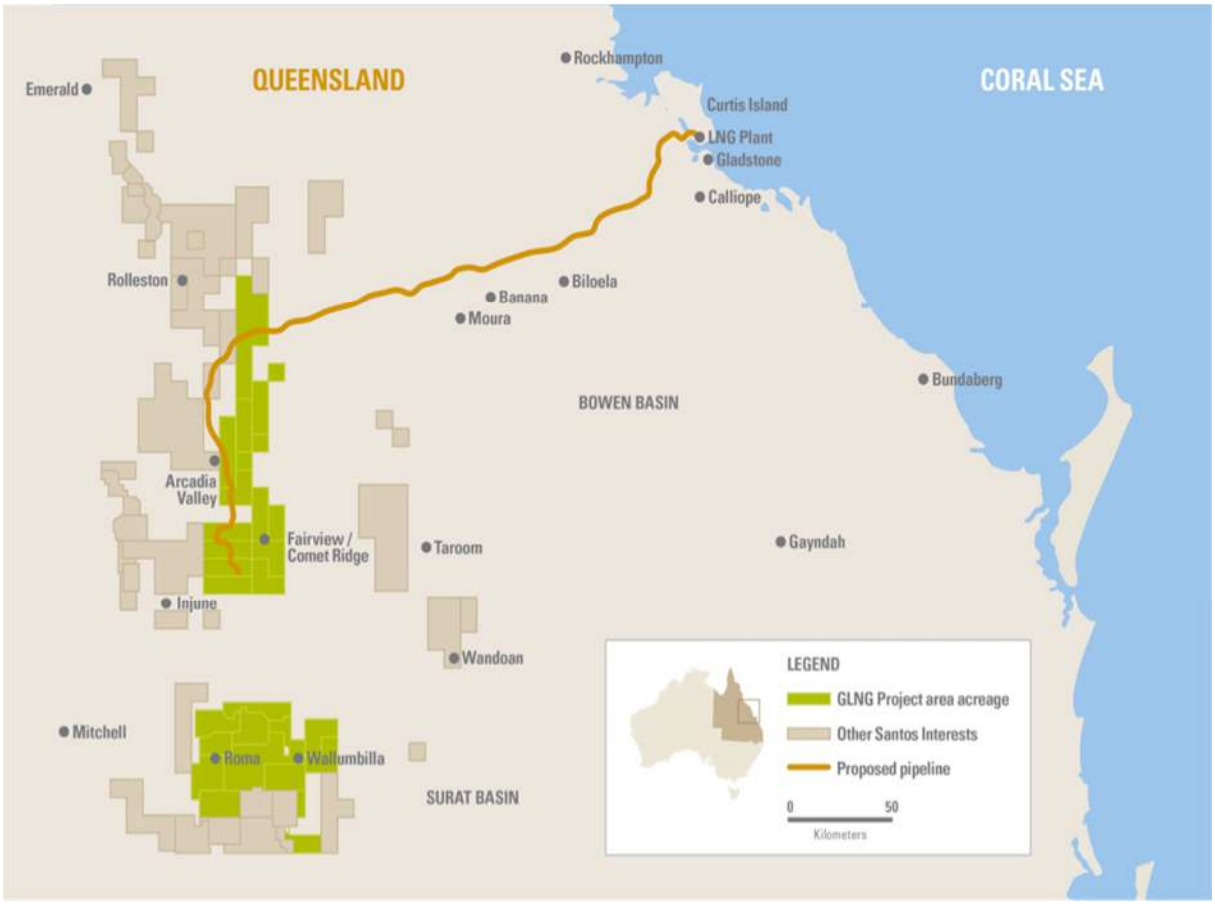


**Figure 1-1: Santos GLNG Project Area**

# 2.0 Surface Water and Groundwater Baseline Monitoring

## 2.1 Overview

Baseline surface water and groundwater data is information which establishes attributes of the water environment prior to the onset of gas field development. This information can be used for comparison in the future to establish if changes have occurred. It may also be possible, dependent upon the nature of the change, to utilise baseline in order to establish a cause, i.e. being potentially related to gas field development activities or not. In relation to MNES, baseline data may also be useful in determining meaningful targets for impact mitigation and management controls.

The water quality baseline data that has been collected over several years, comprises:

- Baseline for surface water quantity and quality;
- Baseline for groundwater pressure and quality; and
- Baseline for springs and wetlands.

The period of data collection that may be required to establish baseline will be location specific, and depend upon the nature of the environment being monitored. This is the case where ambient groundwater conditions are inter- and intra-seasonally dynamic, and affected by a number of interdependent variables such as rainfall, evapotranspiration potential, localised and regional groundwater abstraction activity, land-use changes and more.

Groundwater monitoring may be ongoing throughout the life of Santos GLNG development. It is expected that in most instances, monitoring will continue to gather data many years in advance of potential discernible changes that may be linked to gas field activities, and therefore such data will continue to be considered baseline data. The need for and extent of ongoing monitoring, however, is dictated by the need to monitor and manage specific risks and therefore the potential need for impact mitigation to manage the risk of adverse impact to MNES. Groundwater monitoring proposed in respect of such risks, is described in more detail in the relevant chapters (Chapter 3 – EPBC Springs, Chapter 4 - Aquifer Connectivity and Chapter 5 - Managed Aquifer Recharge).

## 2.2 Coal Seam Water Monitoring and Management Plan Commitments

Table 2-1 provides an outline of the commitments made in the Stage 2 CWMMP Rev 2 specific to surface water and groundwater baseline monitoring and progress against each commitment.

**Table 2-1: Stage 2 CWMMP Rev 2 Commitments – Surface Water and Groundwater Baseline Monitoring**

| Condition | Commitment | Target Completion Date Specified in Stage 2 CWMMP Rev 2 | Status |
|---|---|---|---|
| **53.c)iv)** | **Groundwater Baseline** | | |
| | Groundwater baseline data collection completion. | End of 2014. | Completed. Data acquisition ongoing. |
| **49.g.iv)** | **Surface Water Baseline** | | |
| | Ongoing collection of surface water baseline data. | End of 2013. | Completed. Data acquisition ongoing. |

## 2.3 Surface Water Baseline Monitoring

A surface water monitoring network has been in place since 2003, with the network increasing significantly in 2009-2012 and includes a number of perennial, ephemeral and spring sampling locations across the Roma, Fairview and Arcadia Valley gas fields. A total of 16 grab samples were collected throughout 2016 from perennial sampling points, across Roma and Fairview gas fields.

Surface water baseline monitoring requirements have been met for both Fairview and Roma fields and associated surface water threshold values have been calculated, see Section 7.0 (Surface Water Monitoring) for details. As a result, surface water monitoring stations and/or surface water sample locations are no longer required to be monitored at a pre-determined frequency as seasonal trends have been established. However, as Santos GLNG continues to undertake CSG related activities in each of the gas fields, a surface water monitoring program will be implemented on a regional scale with the objective of identifying potential impacts to surface waters relating to Santos GLNG's activities during long-term operations.

## 2.4 Baseline for Regional Groundwater Pressure and Quality

Santos GLNG has implemented a program for the regional groundwater level monitoring of private bores, dedicated groundwater monitoring bores and multi-level monitoring installations (such as vibrating wire piezometers (VWPs)) since 2008. The groundwater level monitoring network extends across Santos GLNG tenures and across all relevant aquifers. Development of the monitoring network is ongoing based on field development, a summary of the currently active water level monitoring points, and the number of bores that have become active throughout 2016 are summarised in Table 2-2.

**Table 2-2: Summary of Regional Groundwater Level Monitoring Points Active in 2016**

| Formation | Private Water Bores | GLNG Multi-level Monitoring Points | GLNG Dedicated Monitoring Bores | Total |
|---|---|---|---|---|
| Alluvium | 2 | - | - | **2** |
| Volcanics | 1 | - | - | **1** |
| Bungil Formation | 1 | - | - | **1** |
| Mooga Sandstone | 7 | 10 | 3 | **20** |
| Orallo Formation | 8 | 3 | 4 | **15** |
| Gubberamunda Sandstone | 5 | 18 | 13 | **36** |
| Westbourne Formation | - | 10 | - | **10** |
| Springbok Sandstone | - | 6 | 4 | **10** |
| Walloon Coal Measures (WCM, targeting various seams) | - | 52 | 1 | **56** |
| Eurombah Formation | - | 3 | - | **3** |
| Hutton Sandstone | 2 | 6 | 3 | **11** |
| Evergreen Formation | 1 | 2 | - | **3** |
| Boxvale Sandstone | - | 2 | - | **2** |
| Precipice Sandstone | 5 | 12 | 16 | **33** |
| Clematis Sandstone | 2 | - | 2 | **4** |
| Rewan Formation | 1 | - | - | **1** |
| Bandanna Formation | - | | 4 | **4** |
| Unknown* | 3 | | - | **3** |

| Formation | Private Water Bores | GLNG Multi-level Monitoring Points | GLNG Dedicated Monitoring Bores | Total |
|---|---|---|---|---|
| **TOTAL** | **41** | **124** | **50** | **215** |

*Notes: These numbers may differ from those in the 2015 Annual Report due to ongoing refinement of the monitoring network.*
*Number of bores that became operational in 2016 shown in brackets.*
*- no bores present.*
** unknown indicates that the aquifer is to be confirmed through ongoing assessment.*
*Data source: Santos GLNG (as of December 2016).*

Details of the groundwater quality monitoring program undertaken during 2016 are provided below. The summary includes groundwater quality samples taken from dedicated monitoring bores across Roma, Fairview and Arcadia Valley gas fields. Table 2-3 provides a summary of the number of currently active water quality monitoring points.

During January 2016 to December 2016, a total of 43 samples have been collected as part of the groundwater quality monitoring program.

- 26 samples from the Roma field;
- 13 samples from the Fairview field; and
- 4 samples for the Arcadia Valley field.

**Table 2-3: Summary of the Number of Regional Groundwater Quality Monitoring Sampling Points in 2016**

| Formation | Number of sampling events |
|---|---|
| Mooga Sandstone | 2 |
| Orallo Formation | 1 |
| Gubberamunda Sandstone | 4 |
| Springbok Sandstone | 2 |
| Hutton Sandstone | 2 |
| Precipice Sandstone | 4 |
| Clematis Sandstone | 2 |
| Unknown* | 1 |
| **TOTAL** | **18** |

*Notes:*
** unknown indicates that the aquifer is to be confirmed through ongoing assessment.*
*Data source: Santos GLNG (as of December 2016).*

## 2.6 Baseline for Springs and Wetlands

Baseline conditions at EPBC-listed and non EPBC-listed springs have been established by the Office of Groundwater Impact Assessment (OGIA) on behalf of the CSG industry and are presented within reports by KCB (2012) and Queensland Herbarium (2012), outlined in the Surat Cumulative Management Area (CMA) Underground Water Impact Report (UWIR 2012, and UWIR 2016).

In addition to this baseline, Santos GLNG has initiated spring monitoring as required under the Surat UWIR and Santos GLNG approval conditions on Santos GLNG tenures. A joint industry spring baseline program was implemented consisted of quarterly monitoring events and inclusive of ecological and hydrogeological parameters monitoring. The findings of this monitoring is provided by Jacobs (2015) as has not been developed further in 2016.

# 3.0 EPBC Springs

## 3.1 Overview

Groundwater drawdown propagating from production in gas fields has the potential to impact springs hosting ecological communities that are listed as MNES under the EPBC Act, or springs that are sourced from the Great Artesian Basin (GAB). These are known as "EPBC Springs".

Operators in the southern Bowen and Surat Basins (Santos GLNG, Origin Energy and Origin Energy on behalf of APLNG and the Queensland Gas Company (QGC)) have developed a Joint Industry Plan (JIP) for a groundwater monitoring and management system to ensure EPBC Springs are not adversely impacted by groundwater drawdown associated with gas production.

The methodology for monitoring and management of EPBC Springs is defined in the JIP, which was approved by the Minister for the Environment in November 2013 and provided as an appendix to the Santos GLNG Stage 2 CWMMP Rev 2.

## 3.2 Coal Seam Water Monitoring and Management Plan Commitments

Table 3-1 provides an outline of Santos GLNG's commitments presented in the Stage 2 CWMMP Rev 2, specific to EBPC Springs and progress against each commitment.

**Table 3-1: Stage 2 CWMMP Rev 2 Commitments – EPBC Springs**

| Condition | Commitment | Target Completion Date Specified in the Stage 2 CWMMP Rev 2 | Status |
|---|---|---|---|
| **49a, 49d,53c.vi** | Drawdown limits are now defined for the source aquifer at selected locations. These limits are subject to periodic updates. | Completed. | Completed (2013). |
| | Installation of Early Warning Spring (EWS) monitoring network. | End 2016. | Ongoing (see Table 3-2). |
| | Ground truthing of a selection of springs to assess the presence of EPBC listed species and EPBC communities. | On and off tenure springs baseline initiated as part of the (JIP), to be reported in April 2015. | Completed (2015). |
| | Santos GLNG will assume responsibility of mitigation (if required) for on-tenure springs and those off-tenement springs as will be assigned by the Surat Underground Water Impact Report (UWIR)/DOTE. | Ongoing. | Ongoing. |

| Condition | Commitment | Target Completion Date Specified in the Stage 2 CWMMP Rev 2 | Status |
|---|---|---|---|
| | Comparison of drawdown to UWIR predictions will occur on a quarterly basis - Graphic comparisons will be provided in the Santos GLNG Annual Report for Early Warning System bores that Santos GLNG is responsible for. | Quarterly. | The methodology has evolved – once groundwater level reference values are defined, Santos GLNG is assessing the feasibility of programing a system of alerts in the database. Until then, three monthly data checks will be completed. |
| **49.g.iv)** | EPBC spring hydrogeological conceptual model. | Initial conceptual models to be provided in November 2013.<br><br>Additional conceptual models will be provided at completion of spring baseline assessment (April 2015). | Completed April 2015. |
| | Atmospheric pressure monitoring – 1 installation (barrologger or other) at each EPBC Spring complex or cluster of spring complexes. | Completed. | Completed for on-tenement springs 2013. |
| **53.c)iv)** | Santos GLNG, in collaboration with the other Proponents (APLNG and QGC), will by the end of 2013 develop a statistical methodology to enable definition of significant exceedences from the baseline water pressure and water quality levels. The establishment of this methodology can only reasonably be commenced once the three Projects all have sufficient confirmation of their EPBC conditions being met by the respective CWMMPs. | Completed. | Ongoing. The JIP provided a statistical methodology for groundwater level trend analysis that has not yet been implemented in practice. |

## 3.3 EPBC Springs Monitoring Progress

Details of activities undertaken during 2016 are summarised in the following subsections.

### 3.3.1 Progress on the EPBC Springs Early Warning System Implementation

Potential impacts on EPBC Springs continue to be monitored through a network of groundwater monitoring bores, providing early warning of potential impact propagating from the production gas fields towards the EPBC Spring in the source aquifer. The JIP defines the responsibilities for the implementation and monitoring of the groundwater monitoring bores.

There are 12 groundwater level monitoring installations which fall under Santos GLNG responsibility within the JIP, of which ten are operational and the remaining one is scheduled for completion in 2017. A summary status is provided in Table 3-2.

**Table 3-2: Progress on EPBC Springs Early Warning System Monitoring Implementation**

| Bore | Lat. (WGS84) | Long. (WGS84) | Aquifer | EPBC Spring | Date Water Level Monitoring Commenced | Status |
|---|---|---|---|---|---|---|
| OKSGWP01 | -25.8098 | 148.8276 | Precipice Sandstone | Abyss, Lucky Last | December 2016 | Active |
| MHTGWH01 | -25.8250 | 148.7916 | Hutton Sandstone | Abyss | Nov 2014 | Active |
| MHTGWP01 | -25.8250 | 148.7916 | Precipice Sandstone | Lucky Last | Dec 2013 | Active |
| MNHGWP02* | -25.7881 | 148.9233 | Precipice Sandstone | Abyss, Lucky Last | Aug 2015 | Active |
| AVLOP01 | -25.9419 | 150.0742 | Precipice Sandstone | Cockatoo Creek | Dec 2015 | Active |
| AVLGWH | -25.9141 | 150.0736 | Hutton Sandstone | Cockatoo Creek | Dec 2013 | Active |
| AVLVWH1 AVLVWH2 | -25.9379 | 150.0739 | Hutton Sandstone | Cockatoo Creek | Dec 2012 | Active |
| AVLVWP1 AVLVWP2 | -25.9379 | 150.0739 | Precipice Sandstone | Cockatoo Creek | Dec 2012 | Active |
| EWMI7 | -24.6074 | 149.0761 | Clematis Sandstone | Elgin 2 | - | To be equipped in 2017 |
| SBNGWH01 | -25.8263 | 149.0370 | Hutton Sandstone | Yebna 2 | - | No groundwater present |
| SBNGWP01 | -25.8263 | 149.0370 | Precipice Sandstone | Yebna 2 | Nov 2014 | Active |
| MW0902 | -25.7347 | 149.0829 | Precipice Sandstone | Yebna 2 | Jan 2011 | Active |

Notes: * MNHGWP02 replaces MW0905 as originally specified in the JIP.

### 3.3.2 Spring Baseline Acquisition

The Industry has delivered quarterly spring baseline surveys throughout 2015. Surveys were conducted in 2016 in accordance with the requirements of the Spring Impact Monitoring Strategy outlined in the UWIR for the Surat CMA.

## 3.4 EPBC Spring Hydrogeological Conceptual Models

Using information collected during the baseline monitoring and additional research conducted both by the OGIA and by GLNG, the OGIA prepared conceptualisation reports for the EPBC listed spring sites. These conceptualisation reports were submitted to the DOTE in a letter from the OGIA dated 30th April 2015.

No further re-conceptualisation of spring hydrogeology has occurred since that time.

## 3.5 Assessment of Trends for Analysis of Groundwater Data

The definition of reference values is ongoing based on the period that the equipped monitoring bores have been able to gather data. Of the bores that have been equipped with monitoring, there are monitoring locations that have data over a period of more than a year. Whilst assessment of the groundwater level trends in these bores is ongoing, a summary of the assessment to date is summarised for each of these bores.

To date apparent generalised upward or downward trends that seem or are conclusively typical across the periods in which monitoring data has been collected have not been identified. Most trends appear to be seasonal, with seasonal (i.e. intra-annual) groundwater pressure variations being less than inter-annual variations.

A statistical methodology is being defined which can objectively define the meaningful threshold values against which the significance of groundwater pressure variations can be assessed against baseline water pressures. It is predicted that several years of data collection before baseline values and threshold trigger values for a change to groundwater pressures at an Early Warning Spring (EWS) can be objectively determined.

The following sections present a summary of the observed groundwater level trends data collected to date.

### 3.5.1 Yebna 2 Spring Complex

MW0902 and SBNGWP01 are EWS bores for the Yebna 2 EPBC spring complex. Groundwater pressure data for these bores is displayed graphically in **Error! Reference source not found.**.

MW0902 has been monitoring the Precipice Sandstone since January 2011 and has shown a general upward trend in groundwater level since Q4 in 2012. The groundwater level has increased by approximately 1 metre (m) through 2015, therefore at a rate of approximately 1 m increase per year. The short-term variation of the longer term groundwater level trend (i.e. the short-term ‘noise’) has range of up to around 0.5 m.

SBNGWP01 has been monitoring the Precipice Sandstone since December 2014 and has shown a general upward trend in groundwater level since that time. The groundwater level has increased by approximately 1 metre (m) through 2015, therefore at a rate of approximately 1 m increase per year. In 2016 the groundwater level increased by approximately 0.5m. The short-term variation of the longer term groundwater level trend (i.e. the short-term ‘noise’) has range of up to around 0.5 m.

### 3.5.2 Abyss / Lucky Last Spring Complexes

MHTGWP01, MHTGWH01 , MNHGWP02 and OKSGWP01 are EWS bores for the Abyss and Lucky Last EPBC spring complexes. Groundwater pressure data for these bores is displayed graphically in Figure 3-2, Figure 3-4 and Figure 3-4.

MHTGWP01 has been monitoring the Precipice Sandstone since December 2013, and is located more than 10 km west of any active gas field development. It generally shows a downward trend since April

2014, and a stable trend since August 2014. From 2014, groundwater pressures vary by up to around 0.1 m approximately monthly, and up to around 0.5 m over an approximately annual cycle.

MHTGWH01 has been monitoring the Hutton Sandstone since November 2014, and is located more than 10 km west of any active gas field development. It generally shows a stable trend since monitoring commenced. Throughout this period, groundwater pressures vary up to around 0.2m in approximately fortnightly cycles.

MNHGWP02 has been monitoring the Precipice Sandstone since August 2015, and is also located more than 10 km west of any active gas field development. It generally shows a stable trend since monitoring commenced. Throughout 2016, groundwater pressures vary by up to around 0.3 m.

OKSGWP01 has been monitoring the Precipice Sandstone since mid-December 2016. Only around two weeks of monitoring data is available to review. The bore is located approximately 3km west of active CSG wells. It is located on the unconformable contact zone between the Precipice Sandstone and the underlying Bandanna Formation. The monitoring data suggest a steep 10m groundwater level decline since monitoring began. However, very little data is available for 2016 to corroborate longer term trend.

The reliability of the data for OKSGWP01 is currently being investigated. It is likely the pressure decline is related to the fact the well was over-pressurised as it was drilled, and so the early monitoring data shows that the water level in the well is still equilibrating with the monitored formation.

### 3.5.3 Cockatoo Creek Spring Complexes

AVLGWH01, AVLVWH1, AVLVWH2, AVLVWP1 and AVLVWP2 are EWS bores for the Cockatoo Creek Spring Complex. Groundwater pressure data for these bores is displayed graphically in Figure 3-5.

#### *3.5.3.1 AVLGWH01*

AVLGWH01 has been monitoring the Hutton Sandstone since January 2013, and is located more than 30 km north of Santos GLNG gas field development areas. AVLGWH01 is a landholder bore that is understood to remain in operation as an active extraction bore.

The observed groundwater pressures in the bore generally show a downward trend since the record began in January 2013. Throughout 2013 the rate of decline was approximately 0.2 m/year, in 2014 the rate of decline was approximately 0.7 m/year.

It is not possible to know if the decrease in groundwater level represents seasonal variation, or longer term decline. Throughout 2015 the water level varied by more than 20 m which most likely comprises the water pressure response to pumping of the bore. The increased rate of decline of the bore water level throughout 2014 most likely corresponds to a period of increased abstraction intensity, rather than gas field development activities. In 2015 it appears that abstraction abated and the water pressures appear more stable, varying around 3 m for the latter half of 2015. In 2016 the groundwater pressure increased by around a metre.

#### *3.5.3.2 AVLVWH1/ AVLVWH2*

AVLVWH1 and AVLVWH2 are monitoring points located within the same Vibrating Wire Piezometer (VWP) monitoring location. There is no Santos GLNG gas field development area in close proximity to this location. The two monitoring points are monitoring different depths in the Hutton Sandstone, with H1 being at 155 mbgl and H2 at 250 mbgl.

The VWP has been monitoring the Hutton Sandstone since December 2012. The two monitoring depths show different groundwater level trends.

- H1 (the shallowest) shows a general downward trend in groundwater level since records began. The groundwater level has decreased by approximately 5 m from December 2012 to May 2014. Since May 2014, water levels appeared to have stabilised at approximately 247 mAHD, and increased from around May 2015. Throughout 2016, groundwater pressures decline by around a metre. Groundwater levels vary around the longer term average water level by up to 4 m seasonally.
- H2 (the deeper) shows a period of increasing groundwater levels from December 2012 to June 2013 (13 m increase), prior to demonstrating a period of decline from June 2013 to April 2015, and appear stable throughout the remainder of 2015. 2016 shows a general decline of around 3 m that appears to stabilise in the final quarter. Groundwater levels vary around the longer term average water level by up to 4 m seasonally.

#### *3.5.3.3 AVLVWP1/AVLVWP2*

AVLVWP1 and AVLVWP2 are monitoring points located within the same VWP monitoring location. The two monitoring points are monitoring different depths in the Precipice Sandstone, with P1 being at 490 mbgl and P2 at 528 mbgl.

The VWP has been monitoring the Precipice Sandstone since December 2012. The two monitoring depths show different groundwater level trends.

- P1 (the shallowest) shows a general upward trend in groundwater levels, with a decline in 2015, and general increase throughout 2016. The groundwater level has increased by approximately 12 m from December 2012 to December 2014, approximately 6 m/year. In August 2015, groundwater levels dropped rapidly by around 15 m and appear broadly stable throughout the rest of 2015. In 2016 groundwater levels increased by around 5 m. Within any single year, the groundwater level may vary by up to around 10 m around longer term trends.
- P2 (the deeper) shows a period of decreasing but stabilising groundwater levels from December 2012 to December 2016. Over this period the water level decreased by approximately 3.5 m/year. Throughout 2016 groundwater pressures increased by around a metre. Within any single year, the groundwater level may vary by up to around 1 m around longer term trends.

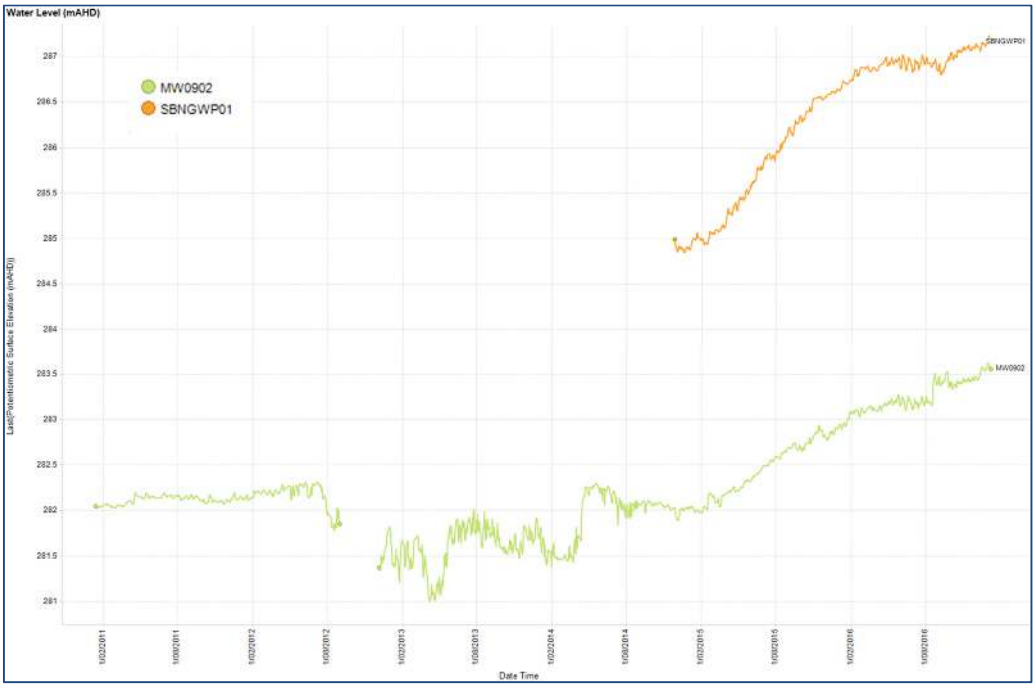


**Figure 3-1: Yebna 2 EWS Groundwater Pressure Data**

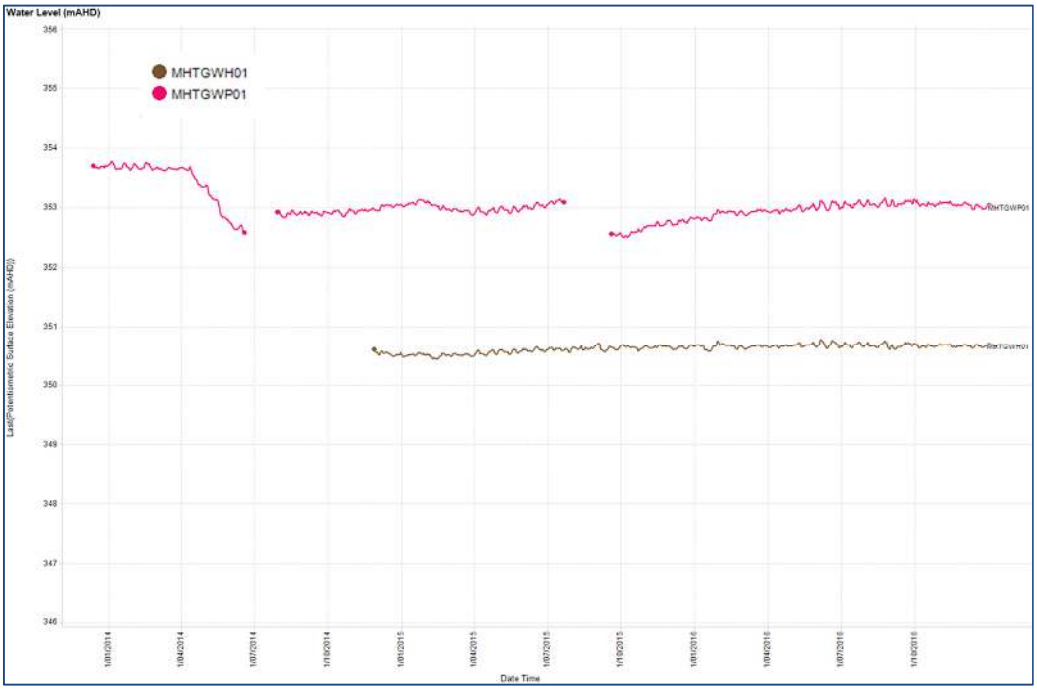


Figure 3-2: Abyss and Lucky Last EWS Groundwater Pressure Data at MHTGWP01 and MHTGWH01

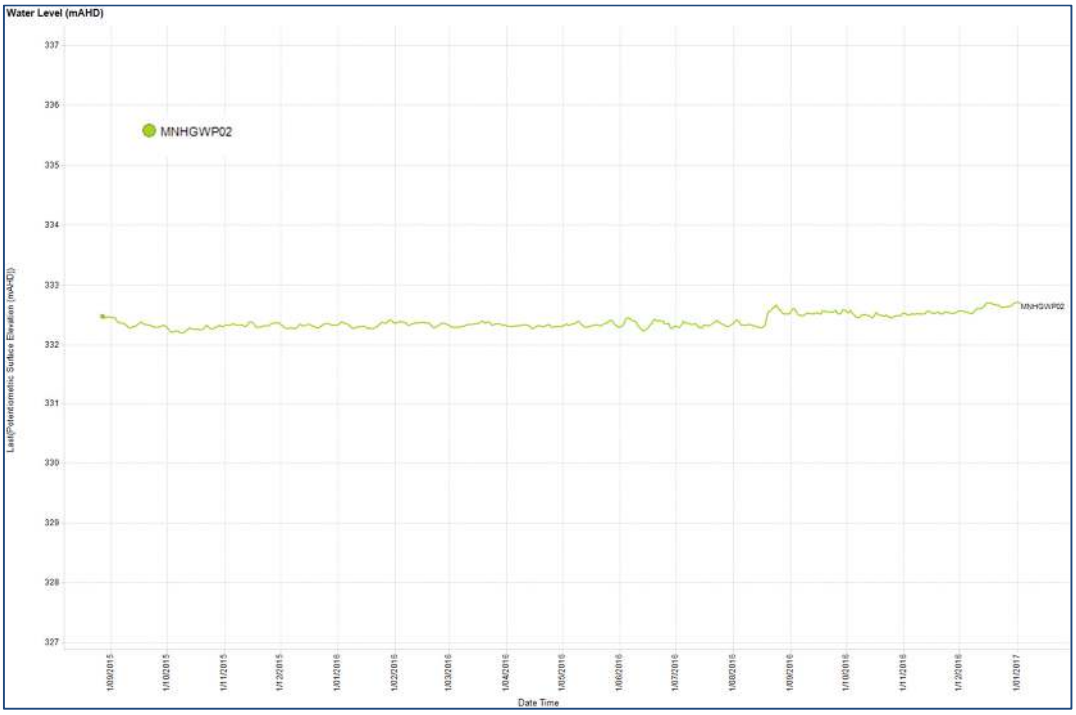


**Figure 3-3: Abyss and Lucky Last EWS Groundwater Pressure Data at MNHGWP02**

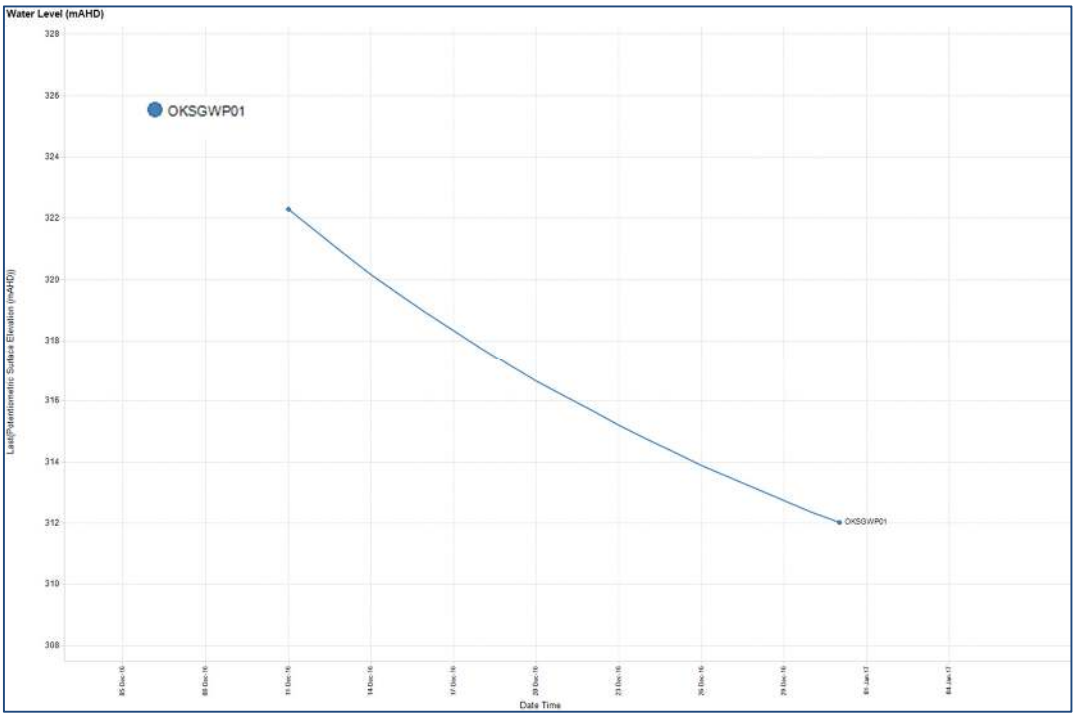


**Figure 3-4: Abyss and Lucky Last EWS Groundwater Pressure Data at OKSGWP01**

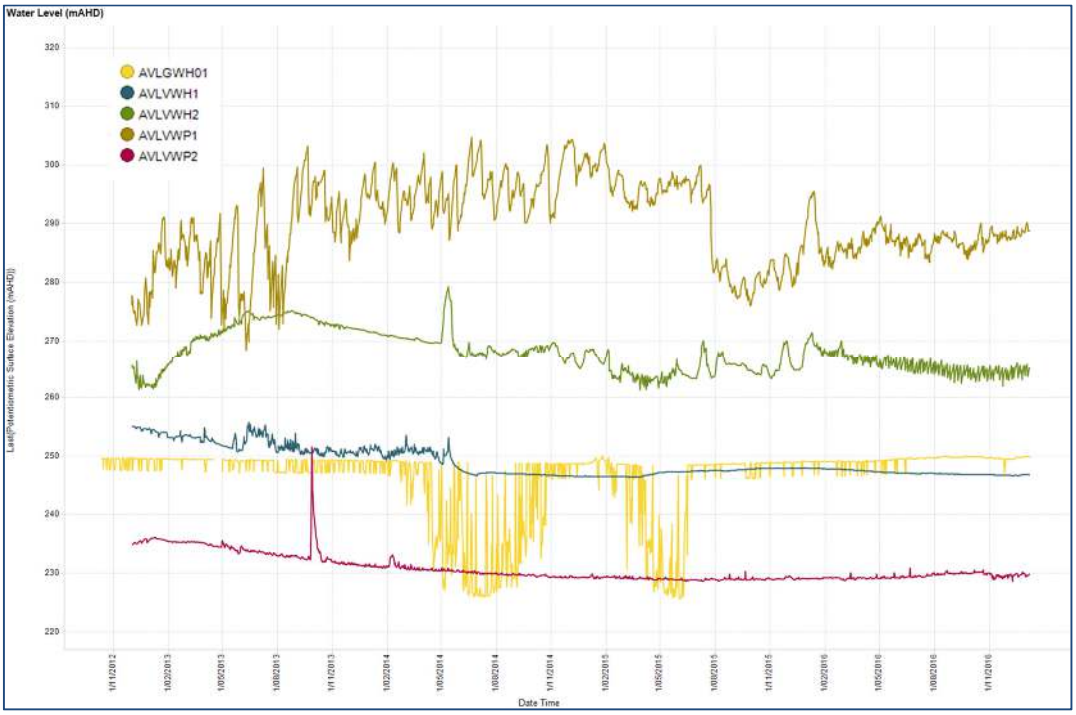


**Figure 3-5: Cockatoo Creek Spring Complex EWS Groundwater Pressure Data**

# 4.0 Aquifer Connectivity

## 4.1 Overview

In accordance with approval conditions Santos GLNG has undertaken its own primary data collection and interpretation related to aquifer connectivity. Santos GLNG has also provided data to various work programs being undertaken by State and Federal Government departments, including the OGIA, Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Office of Water Science.

Santos GLNG activities and results to October 2013 were reported in the Stage 2 CWMMP Rev 2. No major additional results have been collected since the submission of the Stage 2 CWMMP Rev 2, however the forward work program is outlined in the following sections.

## 4.2 Coal Seam Water Monitoring and Management Plan Commitments

Table 4-1 provides an outline of Santos GLNG's commitments presented in the Stage 2 CWMMP Rev 2, specific to aquifer connectivity and progress against each commitment.

**Table 4-1: Stage 2 CWMMP Rev 2 Commitments – Aquifer Connectivity**

| Condition | Commitment | Target Completion Date Specified in the Stage 2 CWMMP Rev 2 | Status |
|---|---|---|---|
| **49b, 53b, 53d(i)4)** | Santos GLNG committed to provide further characterisation on the level of connectivity between the formations. Most of the studies, at this stage, are ongoing and not yet conclusive. Note that the results, where available, will be presented in future updates to the CWMMP. | | |
| | Multi-level monitoring bores. | Ongoing monitoring and data assessment. | Completion of monitoring bores in 2016, ongoing data collection took place in 2016. |
| | Contact Zone Program. | Ongoing after installation. | Contact zone monitoring well installed in 2016, data review will be possible in 2017. |
| | Wallumbilla Fault Program. | Installation planned for 2014, scope currently under development. | Complete. Additional monitoring data not feasible. |
| | Aquifer response to CSG depressurisation. | Ongoing. | Ongoing. |
| | Isotope and geochemical signature. | Ongoing. | Ongoing. |
| | Pumping response observations and assessments. | Annually from 2014. | Ongoing. |
| | The outcomes of the conventional oil and gas well and water bore risk assessment will be presented in an update to the CWMMP. | 2014. | Ongoing. Updated CWMMP is due in 2017. |

## 4.3 Multi-level monitoring

The Santos GLNG monitoring network includes multi-level piezometers and nested single-zone groundwater level monitoring bores. These piezometers target aquifers and specific monitoring zone depths to pre-defined data acquisition objectives. The number of multi-level monitoring locations is summarised in the Table 4-2.

**Table 4-2: Number of Active Multi-level Groundwater Level Monitoring Installations**

| Gas Field | Number of Active, Multi-level Installations or Nested Bore Sites |
|---|---|
| Roma | 23 |
| Fairview | 4 |

Multi-level monitoring data will continue to be collected, such data are provided to the OGIA.

## 4.4 Contact Zone near the Fairview Field

Erosion of the Rewan Formation in the south western corner of Fairview prior to deposition of the Precipice Sandstone has resulted in an unconformity where the Precipice Sandstone directly overlies the Bandanna Formation. This area is referred to as a contact zone. The contact zone does not underlie an area that is proposed to be an operational gas field for the Bandanna Formation. The nearest potentially producing gas well in the Bandanna Formation is located approximately 3 km from the contact zone.

Since the initial definition of this study program, the location and extent of the contact zone in Fairview has been reviewed using more recently acquired geological data. This has reduced the size of the contact zone.

The project plan was to investigate the geological stratigraphy and monitor the contact zone through the construction of a number of groundwater monitoring bores as defined in Table 4-3. Two vibrating wire piezometers were installed in 2009 (VWP0902 and VWP0903), and one monitoring bore was installed in 2013 (QWC129, also referred to as MTGWP01 or the Mount Hutton bore). Given the revised location of the contact zone, the Mount Hutton bore, VW0902 and VW0903 are no longer interpreted to be in the contact zone. The closest monitoring point is VW0902 which is expected to be less than 400 m from the contact zone.

Santos GLNG drilled the bore labelled “Contact Zone” in 2016. It was equipped with monitoring equipment very late in 2016. This bore is referred to as OKSGWP01 in Section 3. There is not currently sufficient monitoring data to allow interpretation of long term groundwater level pressure trends related to the proximately of the contact zone.

**Table 4-3: Status of Groundwater Level Monitoring Installations Investigating the Contact Zone in Fairview**

| Bore name | Monitored Formation | Status |
|---|---|---|
| VW0902 | Precipice Sandstone | Completed |
| VW0903 | Precipice Sandstone | Completed |
| Contact Zone (Ok Station) | Precipice Sandstone | Completed |
| | Hutton Sandstone | - |
| QWC 129 – Mount Hutton | Precipice Sandstone | Completed |
| | Hutton Sandstone | Completed |
| Spring Gully – PB1 | Precipice Sandstone | Completed |
| | Hutton Sandstone | Not completed* |

*Proposed bore location is to be delivered by APLNG, drilling and completion schedule not known.

## 4.5 Hutton-Wallumbilla Fault

The Hutton-Wallumbilla Fault (also called the Wallumbilla Fault) is defined as a complex faulting system. The fault system consists of a main fault to which are associated a number of secondary significant faults. The fault system spreads in width of approximately two kilometres. The main fault is not a straight box offset fault type and its characteristics vary along the fault profile. The main fault offset can be made of a number of offsets with varying displacements. The amplitude of the displacement varies from a few metres to the south to about 50 m to the north of the Roma field.

The fracturing and the displacement do not affect the full stratigraphic profile. The main faulting occurred during a compressive phase of mid-Triassic. The faults were reactivated during the mid-cretaceous causing minor faulting throughout the Secondary sequences or causing folding. Fractures affecting the Secondary could also result from differential sediments compaction and as such be tension fractures.

Using the Boxgrove Ironstone Member (a reliable geophysical/seismic marker) at the top of the Boxvale Sandstone, seismic sections show that the formations above the Evergreen Formation are continuous across the fault. Therefore it is now interpreted that the coal beds of the Walloon Coal Measures and all the aquifers above them are continuous across the fault zone.

Beneath the Walloon Coal Measure, the Precipice Sandstone would have been deposited, over the structure prior to the significant displacement and therefore is hydrogeologically a non-continuous structure across the Roma Shelf. The displacement of the Precipice Sandstone appears to be over 50 m, whereas the Precipice Sandstone at this location is not more than 25 m thick. Besides discontinuity, lateral permeability is limited by lithology with the Precipice Sandstone comprising well cemented fine-grained sands, less typical of the highly permeable, coarse sandstone depositions of Precipice Sandstone observed in other areas of the Surat Basin, away from the Roma Shelf.

In terms of its hydraulic properties, the Hutton-Wallumbilla Fault is not necessarily considered to be a barrier to horizontal flow through aquifers that are younger than the Evergreen Formation. Conversely, lateral extent and integrity of lower permeability aquitards layers above the Evergreen Formation are also considered to be continuous, and as such provide a continuous throttle to vertical pressure prorogation and fluid flow. As such, the fault is not expected to play a major role in controlling drawdown resulting from coal seam depressurisation neither vertically (i.e. between formations) and horizontally (i.e. across formations).

A hydrogeochemistry review was undertaken of bore water chemistries around the Hutton-Wallumbilla Fault in the Roma field to understand whether this data might elude to the presence of vertical flow and connectivity pathways between the shallow (above coal) water bearing formations of the Bungil, Mooga, Orallo and Gubberamunda sandstones. The review concluded that the water chemistry data that had

been obtained as part of the regional bore inventory and baseline assessment program did not provide a clear indication of the impact that the Hutton-Wallumbilla Fault may have on vertical and lateral connectivity of shallow aquifers.

## 4.6 Aquifer Response to Depressurisation

The intention of this program is to continue to monitor aquifer groundwater levels, to periodically review the measured values and to share the data with regulating authorities as they request it.

To date there has been no discernible response to aquifer groundwater levels in aquifers in response to CSG development.

## 4.7 Isotope and Geochemical Signature

Baseline isotope and geochemistry data will continue to be collected from regional groundwater monitoring bores, as required and stipulated by various regulatory drivers which require it. All data is supplied to the regulating authorities as required.

## 4.8 Pumping Response to Depressurisation

Measurement of groundwater pressures throughout the life of the project will provide evidence of drawdown effects that may be due to depressurisation of gas bearing formations. The ongoing groundwater pressure monitoring program will include the regional groundwater pressure monitoring as stipulated by the UWIR, as in compliance with the *Water Act 2000* (Qld), and as required by other impact assessments such as spring impact monitoring in accordance with the JIP.

## 4.9 Support of OGIA Research

Future programs of work will focus on supporting the hydraulic connectivity work programs that are identified and implemented by the OGIA. The findings of these research programs are reported by the OGIA annually and are being carried out in collaboration with CSIRO, Geoscience Australia, universities, other research institutions and petroleum tenure holders.

The OGIA manages and interprets a number of hydraulic connectivity investigations across the Surat CMA. The OGIA directly manages some investigations directly, but is also the principal stakeholder of research being undertaken by others parties such as the Queensland Herbarium, University of Queensland Centre for Coal Seam Gas, Geoscience Australia, the Geological Survey of Queensland, Gas Industry Social and Economic Research Alliance (GISERA), and Queensland University of Technology.

Current research themes that are being considered for inclusion in the next UWIR include geology, hydrogeology, groundwater flow modelling and springs. Specific research topics under each of these themes are developed or advocated by OGIA where they are deemed to improve certainty of model prediction and management outcome. More detail about specific research topic under each of the major themes is usually provided on OGIA's website, which may be periodically updated as research themes develop.

In addition to specific studies, the OGIA use monitoring data to verify conceptual understanding of hydraulic connectivity. The OGIA reviews the adequacy of the groundwater model at least every years (annual review) for example. Such reviews compare monitoring data with predicted changes to the groundwater regime that have been modelled. This is a statutory roles of the OGIA that is required to prepare and maintain a UWIR.

As an example, monitoring data may provide evidence that the location of connecting geological structures such as faults and unconformities that connect two or more hydrogeological units needs to be re-assessed. In this way, the OGIA's evaluation of the monitoring data forms a fundamental process

for verifying the degree of hydraulic connectivity that is assumed by the groundwater model now and into the future.

# 5.0 Managed Aquifer Recharge

## 5.1 Overview

Managed aquifer recharge (MAR) is the purposeful recharge (or injection) of water to aquifers for subsequent recovery. In the case of the proposed Santos GLNG MAR trial in Roma, the injected water comprises treated coal seam water.

This section provides an update on the water monitoring and management strategies that Santos GLNG proposes to implement for MAR. This reiterates the work that has been completed to date, and provides an update to the development schedule that was outlined in the Stage 2 CWMMP Rev 2.

## 5.2 Coal Seam Water Monitoring and Management Plan Commitments

Table 5-1 provides an outline of Santos GLNG's commitments presented in the Stage 2 CWMMP Rev 2, specific to MAR and progress against each commitment.

**Table 5-1: Stage 2 CWMMP Rev 2 Commitments – MAR**

| Condition | Commitment | Target Completion Date Specified in the Stage 2 CWMMP Rev 2 | Status |
|---|---|---|---|
| **49c, 53a, 53d)ii** | Santos GLNG has developed a MAR pilot program and schedule for gas field piloting of aquifer reinjection: | | |
| | Fairview CSG Field Stage 1– Desktop Study. | Completed March 2012. | Completed March 2012. |
| | Roma CSG Field Stage 1– Desktop Study. | Completed January 2011. | Completed January 2011. |
| | Roma CSG Field Stage 2 – Investigations and Assessment. | Completed January 2011. | Completed January 2011. |
| | Roma CSG Field pilot trial (Hermitage) Stage 3 – Construction and Commissioning. | Completed in Q1/Q2 2012. | Completed Q1/Q2 2012. |
| | Roma CSG Field pilot trial (Hermitage) Stage 4 – Operation. | Completed Q4 2012. | Completed Q4 2012. |
| | Roma CSG Field (The Bend) Stage 3 – Construction and Commissioning. | Due for completion Q3 2014. | Not 100% completed as not required by Operations. |
| | Roma CSG Field (The Bend) Stage 4 – Operation. | Due to commence Q3/Q4 2014. | Not in operation as not required for normal Operations. |
| | Arcadia CSG Field Stage 1 – Desktop Study. | Completed September 2013. | Completed September 2013. |
| | All approved Injection Management Plans will be provided in an update to the CWMMP. | Ongoing. | Ongoing. |

## 5.3 Status of Feasibility and Regulatory Approval

Santos GLNG is assessing the feasibility of implementation of MAR within the Roma field at the location of water treatment and gas compressor station Roma Hub Compressor Station 2 (HCS-02).

MAR in Roma would comprise injection of treated water into a number of injection wells, as few as four and as many as 12 injection wells may be used. The number of wells will depend upon the total volume of water produced by Santos GLNG activities; less the demands for coal seam water from the portfolio of alternative beneficial re-use strategies such as construction, dust suppression and irrigation.

An application to the Queensland Government was sought to amend Environmental Authority (EA) conditions to permit the operation of MAR in the Roma field. This amendment was approved in 2014 following the submission including an Injection Management Plan (IMP) in support of the amendment application.

The IMP adopts a risk management framework consistent with the "National Water Quality Management Strategy, Australian Guidelines for Water Recycling Managing Health and Environmental Risks (Phase 2), Managed Aquifer Recharge". The finalised IMP that was submitted to DEHP on 15 January 2014 was provided in the 2013 CWMMP Annual Report (Santos GLNG, 2014).

There are no new findings regarding MAR feasibility to those presented in the Stage 2 CWMMP Rev 2.

# 6.0 Hydraulic Fracturing

## 6.1 Overview

Hydraulic fracturing is employed in the petroleum industry to improve the production efficiency of appraisal and production wells (i.e. more efficient and more economical extraction of gas from the coal seams). Hydraulic fracturing is not carried out on all wells as the process is only necessary at locations with low permeability.

Hydraulic fracturing is carried out as one of the last activities in the construction of an appraisal and/or production well and prior to bringing the well into service. It is typically performed on newly drilled and constructed appraisal and production wells after the final well casing pipe has been inserted and the bore annulus cemented and after the casing has been perforated (i.e. the well is opened to access specific coal seams).

Hydraulic fracturing uses a mix of water, sand and minor concentrations of other fluids mixed on the surface and then injected down into the well and then through the perforations into the coal seam. The water and sand are typically up to around 99% of the volumes of the hydraulic fracturing fluids, the remainder being the added chemical used to enhance the process.

The hydraulic fracturing process occurs under varying positive high hydraulic pressures (ranging from approximately 7,000 to 34,500 KPa) in order to open existing fractures in the coal matrix. The hydraulic fracturing fluids are injected through the perforations in the steel well casing pipe via wellhead works on the surface and coil-tube pipe down to a device which isolates the coal seam to be fractured.

After completion of the stimulation, the well is put into production. The initial produced fluids (often referred to "flow-back") largely comprises the water used in the hydraulic fracturing fluid mixture, degraded additives as well as coal seam water and other geo-genic constituents sourced from the target formation.

## 6.2 Coal Seam Water Monitoring and Management Plan Commitments

Table 6-1 provides an outline of Santos GLNG's commitments presented in the Stage 2 CWMMP Rev 2, specific to hydraulic fracturing and progress against conditions.

**Table 6-1: Stage 2 CWMMP Rev 2 Commitments – Hydraulic Fracturing**

| Condition | Commitment | Target Completion Date Specified in Stage 2 CWMMP Rev 2 | Status |
|---|---|---|---|
| **49e** | Santos GLNG will provide a projection of the anticipated number of wells to be hydraulically stimulated during each year (up to and including 2016) as well as the number of hydraulic stimulations completed in the preceding year. Additional details to be reported will also include location information and the depth of each respective hydraulic stimulation. | Annually. | Complete<br>Provided in Table 6.2 of this Annual Report. |
| **49f** | Santos GLNG has agreed with the Department of the Environment to undertake additional Direct Toxicity Assessment that will include: | December 2013. | Completed Q4 2016. |

| Condition | Commitment | Target Completion Date Specified in Stage 2 CWMMP Rev 2 | Status |
|---|---|---|---|
| | • an ecotoxicological program, involving, for example, a comparison of (i) coal seam water, (ii) coal seam water with fraccing chemicals, and (iii) fraccing chemicals in freshwater;<br>• assessing the risk of individual fraccing chemicals of concern; and<br>• assessing contribution of fraccing chemicals to toxicity of fraccing fluids and flow-back waters (mixture toxicity).<br>Santos GLNG is committed to undertaking these assessments, as part of the joint industry Ecotoxicity Work Program; the result of which will be provided to the Department of the Environment upon completion. | | |

## 6.3 Hydraulic Fracturing in 2016

As of December 2016, 85 wells within the Santos GLNG gas fields had been hydraulically fractured. A total of 512 hydraulic fracturing events/stages were completed within these wells. The location and depth of the hydraulic fracturing stages are presented in Table 6-2.

**Table 6-2: Hydraulic Fracturing Locations and Perforation Details Completed in 2016**

| Well Name and Stage | Top of Perforation (mbgl) | Bottom of Perforation (mbgl) | Latitude [WGS84] | Longitude [WGS84] |
|---|---|---|---|---|
| RM02-05-1 | 208.85 | 396.6 | -26.336 | 149.065 |
| RM02-06-1 | 209 | 397.99 | -26.337 | 149.075 |
| RM02-10-1 | 189.1 | 400.96 | -26.342 | 149.07 |
| RM02-11-1 | 183.2 | 393.18 | -26.347 | 149.076 |
| RM02-12-1 | 202.45 | 397.01 | -26.341 | 149.082 |
| RM02-18-1 | 227.3 | 362.08 | -26.353 | 149.073 |
| RM02-19-1 | 206.9 | 410.6 | -26.354 | 149.081 |
| RM02-25-1 | 243.1 | 409.47 | -26.359 | 149.076 |
| RM02-26-1 | 220 | 377.46 | -26.376 | 149.083 |
| RM02-31-1 | 211.1 | 414.26 | -26.37 | 149.076 |
| RM02-32-1 | 209.05 | 412.51 | -26.376 | 149.083 |
| RM02-38-2 | 706.05 | 1124.35 | -26.404 | 149.07 |
| RM02-38-3 | 628.95 | 1052.85 | -26.404 | 149.07 |
| RM02-38-4 | 629.55 | 1062.45 | -26.404 | 149.07 |
| RM03-01-1 | 199.2 | 386.46 | -26.337 | 149.088 |
| RM03-02-1 | 181.7 | 354.03 | -26.337 | 149.099 |
| RM03-08-1 | 205.6 | 393.82 | -26.342 | 149.094 |
| RM03-09-1 | 193 | 391.18 | -26.342 | 149.107 |
| RM03-42-1 | 271.8 | 467.99 | -26.371 | 149.15 |
| RM03-44-1 | 207.45 | 419 | -26.377 | 149.096 |
| RM03-48-1 | 208.6 | 416.55 | -26.381 | 149.09 |
| RM03-49-1 | 213.6 | 440.4 | -26.381 | 149.102 |
| RM03-52-1 | 290.6 | 499.42 | -26.376 | 149.144 |
| RM03-55-1 | 211.6 | 225.2 | -26.387 | 149.095 |
| RM03-56-1 | 386 | 450.85 | -26.387 | 149.108 |
| RM03-58-1 | 261.1 | 675.5 | -26.396 | 149.087 |
| RM03-61-1 | 278.5 | 482.2 | -26.387 | 149.13 |
| RM03-62-1 | 268.7 | 486.88 | -26.393 | 149.127 |
| RM03-66-1 | 276.7 | 328.1 | -26.398 | 149.108 |
| RM03-68-1 | 290.25 | 481.95 | -26.398 | 149.134 |
| RM03-76-1 | 310.3 | 476.5 | -26.382 | 149.138 |
| RM03-80-1 | 356.5 | 537.1 | -26.392 | 149.151 |
| RM07-13-1 | 420.9 | 916.46 | -26.391 | 149.011 |
| RM07-13-2 | 415.7 | 782.66 | -26.391 | 149.011 |
| RM09-01-1 | 302.3 | 499.9 | -26.397 | 149.145 |
| RM09-02-1 | 356.5 | 509.45 | -26.404 | 149.139 |
| RM09-03-1 | 346.8 | 570.8 | -26.403 | 149.163 |
| RM09-09-1 | 689.95 | 1009.85 | -26.426 | 149.071 |
| RM09-09-2 | 602.8 | 1069 | -26.427 | 149.071 |
| RM09-09-3 | 587.5 | 1093.1 | -26.427 | 149.071 |

| Well Name and Stage | Top of Perforation (mbgl) | Bottom of Perforation (mbgl) | Latitude [WGS84] | Longitude [WGS84] |
|---|---|---|---|---|
| RM09-09-4 | 636.3 | 1171.9 | -26.427 | 149.071 |
| RM09-11-1 | 306.6 | 498.25 | -26.421 | 149.121 |
| RM09-12-1 | 311.8 | 480.7 | -26.427 | 149.114 |
| RM09-15-1 | 361.3 | 498.1 | -26.432 | 149.108 |
| RM09-16-1 | 626.7 | 1159.7 | -26.426 | 149.127 |
| RM09-18-1 | 324.8 | 494.4 | -26.432 | 149.119 |
| RM09-20-1 | 628.17 | 897.04 | -26.441 | 149.116 |
| RM09-20-2 | 633.04 | 986.74 | -26.441 | 149.116 |
| RM09-21-1 | 569.9 | 951.5 | -26.443 | 149.129 |
| RM09-21-2 | 542.7 | 949.5 | -26.443 | 149.129 |
| RM09-26-1 | 760.14 | 1071.24 | -26.449 | 149.096 |
| RM09-26-2 | 785.17 | 1113.57 | -26.449 | 149.096 |
| RM09-26-3 | 722.84 | 1074.94 | -26.449 | 149.096 |
| RM09-26-4 | 843.74 | 1082.44 | -26.449 | 149.096 |
| RM09-27-1 | 834.8 | 1114.1 | -26.451 | 149.127 |
| RM09-27-2 | 472 | 680.5 | -26.451 | 149.127 |
| RM09-30-1 | 617.8 | 1034 | -26.447 | 149.132 |
| RM09-31-1 | 560.2 | 798.3 | -26.456 | 149.11 |
| RM09-31-2 | 940.7 | 1296.1 | -26.456 | 149.11 |
| RM09-31-3 | 1054.1 | 1481.6 | -26.456 | 149.11 |
| RM09-31-4 | 787.5 | 1178.8 | -26.456 | 149.11 |
| RM09-34-1 | 334.9 | 35890.7 | -26.397 | 149.158 |
| RM09-35-1 | 320.5 | 531.95 | -26.403 | 149.152 |
| RM09-36-1 | 309.4 | 518.9 | -26.409 | 149.145 |
| RM09-37-1 | 362.9 | 763.3 | -26.419 | 149.129 |
| RM09-38-1 | 351.7 | 543.1 | -26.409 | 149.158 |
| RM09-39-1 | 355.3 | 544.05 | -26.415 | 149.152 |
| RM09-40-1 | 412.4 | 666.5 | -26.418 | 149.146 |
| RM09-41-1 | 395.6 | 588.1 | -26.413 | 149.163 |
| RM09-49-1 | 608.9 | 1165.15 | -26.461 | 149.12 |
| RM13-01-1 | 792.35 | 1109.7 | -26.465 | 149.078 |
| RM13-01-2 | 773.5 | 1055.3 | -26.465 | 149.078 |
| RM13-01-3 | 688.7 | 970.9 | -26.465 | 149.079 |
| RM13-01-4 | 792 | 1112.2 | -26.465 | 149.079 |
| RM13-15-1 | 854.1 | 1179.4 | -26.472 | 149.097 |
| RM13-15-2 | 832.9 | 1149.1 | -26.472 | 149.097 |
| RM13-15-3 | 818.2 | 1157.4 | -26.472 | 149.097 |
| RM13-15-4 | 824.6 | 1185.5 | -26.472 | 149.097 |
| RM14-01-1 | 430.5 | 735.1 | -26.464 | 149.137 |
| RM14-01-2 | 509.7 | 897.8 | -26.464 | 149.137 |
| RM14-02-1 | 562.4 | 901.75 | -26.468 | 149.143 |
| RM14-02-2 | 466.6 | 784.05 | -26.468 | 149.143 |
| RM14-02-3 | 659.6 | 1043.25 | -26.468 | 149.143 |

*mbgl – metres below ground level*

## 6.4 Direct Toxicity Assessment

As detailed in the Stage 2 CWMMP Rev 2, Santos GLNG committed to undertake additional Direct Toxicity Assessments as part of the joint Industry Working Group (IWG) CSG Fracturing Fluid Ecotoxicology Work Plan (Hydrobiology, June 2013). The Ecotoxicology Work Plan, prepared by Hydrobiology and approved by the former Department of Sustainability, Environment, Water, Population and Communities (now DOTE) and the Expert Panel for major coal seam gas projects, was developed to assess the incremental toxicity of fracturing fluids in the context of the natural ecotoxicity of coal seam gas water to surface water organisms.

The direct toxicity assessment for various waters and fluids commenced in December 2015, this involves testing representative coal seam waters from wells to be fractured and testing the hydraulic fracturing fluid and coal seam water as formulated for injection. The assessment was completed in December 2016.

**Table 3**: Hydraulic Fracturing Locations – Scheduled 2017

| Asset | Well ID | Status | Start | Finish |
|---|---|---|---|---|
| Roma.West | RM03-45-1 | Completed | 15-Jan-17 | 16-Jan-17 |
| Roma.West | RM03-10-1 | Completed | 17-Jan-17 | 18-Jan-17 |
| Roma.West | RM03-04-1 | Completed | 19-Jan-17 | 19-Jan-17 |
| Roma.West | RM03-11-1 | Completed | 20-Jan-17 | 22-Jan-17 |
| Roma.West | RM03-05-1 | Completed | 23-Jan-17 | 23-Jan-17 |
| Roma.West | RM03-03-1 | Completed | 24-Jan-17 | 25-Jan-17 |
| Roma.West | RM03-15-1 | Completed | 26-Jan-17 | 26-Jan-17 |
| Roma.West | RM03-22-1 | Completed | 27-Jan-17 | 28-Jan-17 |
| Roma.West | RM03-17-1 | Completed | 15-Feb-17 | 16-Feb-17 |
| Roma.West | RM09-07-1 | Completed | 17-Feb-17 | 18-Feb-17 |
| Roma.West | RM07-03-1 | Completed | 19-Feb-17 | 21-Feb-17 |
| Roma.West | RM07-03-3 | Completed | 21-Feb-17 | 22-Feb-17 |
| Roma.West | RM07-03-2 | Completed | 22-Feb-17 | 23-Feb-17 |
| Roma.West | RM07-04-4 | Completed | 24-Feb-17 | 25-Feb-17 |
| Roma.West | RM07-04-1 | Completed | 25-Feb-17 | 28-Feb-17 |
| Roma.West | RM07-04-3 | Completed | 28-Feb-17 | 02-Mar-17 |
| Roma.West | RM07-04-2 | Completed | 02-Mar-17 | 03-Mar-17 |
| Roma.West | RM07-01-2 | Completed | 04-Mar-17 | 05-Mar-17 |
| Roma.West | RM07-01-1 | Completed | 05-Mar-17 | 07-Mar-17 |
| Roma.West | RM01-05-2 | Completed | 08-Mar-17 | 08-Mar-17 |
| Roma.West | RM01-05-4 | Completed | 08-Mar-17 | 10-Mar-17 |
| Roma.West | RM01-05-3 | Completed | 10-Mar-17 | 11-Mar-17 |
| Roma.West | RM01-05-1 | Completed | 11-Mar-17 | 12-Mar-17 |
| Roma.West | RM01-01-1 | Not Started | 01-Apr-17 | 01-Apr-17 |
| Roma.West | RM01-01-2 | Not Started | 02-Apr-17 | 02-Apr-17 |
| Roma.West | RM01-02-1 | Not Started | 03-Apr-17 | 04-Apr-17 |
| Roma.West | RM01-02-2 | Not Started | 04-Apr-17 | 05-Apr-17 |
| Roma.West | RM01-02-3 | Not Started | 05-Apr-17 | 06-Apr-17 |
| Roma.West | RM01-02-4 | Not Started | 06-Apr-17 | 07-Apr-17 |
| Roma.West | RM08-18-1 | Not Started | 08-Apr-17 | 08-Apr-17 |
| Roma.West | RM08-18-2 | Not Started | 09-Apr-17 | 09-Apr-17 |
| Roma.West | RM08-18-3 | Not Started | 10-Apr-17 | 10-Apr-17 |
| Roma.West | RM08-18-4 | Not Started | 11-Apr-17 | 11-Apr-17 |
| Roma.West | RM08-20-1 | Not Started | 12-Apr-17 | 13-Apr-17 |
| Roma.West | RM12-04-1 | Not Started | 14-Apr-17 | 14-Apr-17 |
| Roma.West | RM12-04-2 | Not Started | 15-Apr-17 | 15-Apr-17 |
| Roma.West | RM12-13-1 | Not Started | 16-Apr-17 | 17-Apr-17 |
| Roma.West | RM12-13-2 | Not Started | 17-Apr-17 | 18-Apr-17 |
| Roma.West | RM12-13-3 | Not Started | 18-Apr-17 | 19-Apr-17 |
| Roma.West | RM12-13-4 | Not Started | 19-Apr-17 | 20-Apr-17 |
| Roma.West | RM12-15-1 | Not Started | 21-Apr-17 | 21-Apr-17 |
| Roma.West | RM03-63-1 | Not Started | 13-May-17 | 13-May-17 |
| Roma.West | RM03-77-1 | Not Started | 15-May-17 | 15-May-17 |
| Roma.West | RM03-79-1 | Not Started | 16-May-17 | 17-May-17 |
| Roma.West | RM03-64-1 | Not Started | 18-May-17 | 18-May-17 |
| Roma.West | RM03-54-1 | Not Started | 19-May-17 | 20-May-17 |
| Roma.West | RM03-53-1 | Not Started | 21-May-17 | 21-May-17 |

| Asset | Well ID | Status | Start | Finish |
|---|---|---|---|---|
| Roma.West | RM03-43-1 | Not Started | 22-May-17 | 23-May-17 |
| Roma.West | RM03-36-1 | Not Started | 24-May-17 | 24-May-17 |
| Roma.West | RM03-78-1 | Not Started | 25-May-17 | 26-May-17 |
| Roma.West | RM03-98-1 | Not Started | 27-May-17 | 27-May-17 |
| Roma.West | RM03-25-1 | Not Started | 28-May-17 | 29-May-17 |
| Roma.West | RM03-32-1 | Not Started | 30-May-17 | 30-May-17 |
| Roma.West | RM03-19-1 | Not Started | 31-May-17 | 01-Jun-17 |
| Roma.West | RM03-18-1 | Not Started | 02-Jun-17 | 02-Jun-17 |
| Roma.West | Hermitage 13 | Not Started | 24-Jun-17 | 25-Jun-17 |
| Roma.West | Hermitage 14 | Not Started | 26-Jun-17 | 27-Jun-17 |
| Roma.West | Pleasant Hills 34 | Not Started | 28-Jun-17 | 29-Jun-17 |
| Fairview.Bandanna | FV17-31-1 | Not Started | 30-Jun-17 | 01-Jul-17 |
| Fairview.Bandanna | FV12-27-1 | Not Started | 02-Jul-17 | 04-Jul-17 |
| Fairview.Early Permian | Dawson Bend 3 | Not Started | 05-Jul-17 | 06-Jul-17 |
| Fairview.Bandanna | Fairview 534 | Not Started | 07-Jul-17 | 09-Jul-17 |
| Fairview.Bandanna | Fairview 537 | Not Started | 10-Jul-17 | 11-Jul-17 |
| Fairview.Bandanna | Fairview 529 | Not Started | 13-Jul-17 | 14-Jul-17 |
| Fairview.Bandanna | Yebna South 1 | Not Started | 04-Oct-17 | 05-Oct-17 |
| Fairview.Bandanna | Springwater 2 | Not Started | 06-Oct-17 | 08-Oct-17 |
| Fairview.Early Permian | FV12-22-4 | Not Started | 09-Oct-17 | 10-Oct-17 |
| Fairview.Early Permian | FV13-28-1 | Not Started | 11-Oct-17 | 13-Oct-17 |
| Fairview.Early Permian | FV13-29-1 | Not Started | 14-Oct-17 | 15-Oct-17 |
| Fairview.Early Permian | FV12-37-1 | Not Started | 16-Oct-17 | 18-Oct-17 |
| Fairview.Early Permian | FV12-37-2 | Not Started | 18-Oct-17 | 20-Oct-17 |
| Fairview.Early Permian | FV12-38-1 | Not Started | 21-Oct-17 | 22-Oct-17 |
| Fairview.Early Permian | FV12-41-1 | Not Started | 23-Oct-17 | 25-Oct-17 |
| Arcadia | Mount Kingsley 14 | Not Started | 15-Nov-17 | 17-Nov-17 |
| Arcadia | Mount Kingsley 15 | Not Started | 18-Nov-17 | 19-Nov-17 |
| Arcadia | Mount Kingsley 16 | Not Started | 20-Nov-17 | 22-Nov-17 |
| Arcadia | Mount Kingsley 17 | Not Started | 23-Nov-17 | 24-Nov-17 |
| Arcadia | Mount Kingsley 18 | Not Started | 25-Nov-17 | 27-Nov-17 |
| Arcadia | Mount Kingsley 19 | Not Started | 28-Nov-17 | 29-Nov-17 |
| Fairview.Early Permian | FV12-39-1 | Not Started | 01-Dec-17 | 02-Dec-17 |
| Fairview.Early Permian | FV12-40-1 | Not Started | 03-Dec-17 | 05-Dec-17 |
| Fairview.Early Permian | FV12-42-1 | Not Started | 06-Dec-17 | 07-Dec-17 |
| Fairview.Early Permian | FV12-43-1 | Not Started | 08-Dec-17 | 10-Dec-17 |

# 7.0 Surface Water Monitoring

## 7.1 Overview

The Fairview and Arcadia Valley fields are located within the Fitzroy Basin, whilst the Roma field is located in the upper catchment area of the Murray Darling Basin (MDB). The main water systems within the Fairview field are the Dawson River and its tributaries Baffle Creek and Hutton Creek. There are five creeks running through the Roma field which drain south to the Balonne River (Condamine-Balonne River system), including Dargal Creek, Bungil Creek, Blyth Creek, Wallumbilla Creek, and Yuleba Creek and from there into the MDB. The Arcadia Valley field lies within both the Comet River and Dawson River catchments, where the surface water network is largely limited to ephemeral streams.

Santos GLNG has established surface water monitoring programs for springs, treated coal seam water discharge points, ephemeral streams and permanent watercourses within these catchment systems.

## 7.2 Coal Seam Water Monitoring and Management Plan Commitments

Table 7-1 provides an outline of the commitments made in the Stage 2 CWMMP Rev 2, specific to surface water monitoring and progress against each commitment.

**Table 7-1: Stage 2 CWMMP Rev 2 Commitments – Surface Water Monitoring**

| Condition | Commitment | Target Completion Date Specified in Stage 2 CWMMP Rev 2 | Status |
|---|---|---|---|
| **49.g.vi)** | **Surface Water Threshold Values** | | |
| | Collection and reviewing 2 years of baseline data and development of upper and lower confidence levels (Threshold values) for key parameters (relevant to MNES). | End of 2014. | Completed. Data acquisition ongoing. |

### 7.2.1 Surface Water Threshold Values

As summarised is Section 2, baseline threshold values for surface water have been established.

# 8.0 Brine Management

## 8.1 Overview

Brine is defined as the concentrated reverse osmosis waste stream (RO concentrate). Once RO concentrate reaches above 40,000 mg/L total dissolved solids (TDS), it is then defined by DEHP as 'brine'. Santos GLNG has the following mechanisms currently in place for RO concentrate management:

- **Fairview field:** Santos GLNG stores and manages RO concentrate production in brine containment ponds.
- **Roma field:** Santos GLNG stores and manages RO concentrate production in brine containment ponds.
- **Arcadia Valley field:** No RO concentrate will be produced in Arcadia Valley field within the scope of the Santos GLNG Stage 2 CWMMP Rev 2.

Further brine management options or expansion of current options may be required as gas fields develop, Santos GLNG is currently assessing options for the long-term management of RO concentrate and/or brine.

## 8.2 Coal Seam Water Monitoring and Management Plan Commitments

Table 8-1 provides an outline of Santos GLNG's commitments presented in the Stage 2 CWMMP Rev 2, specific to brine management and progress against each commitment.

**Table 8-1: Stage 2 CWMMP Rev 2 Commitments – Brine Management**

| Condition | Commitment | Target Completion Date Specified in Stage 2 CWMMP Rev 2 | Status |
|---|---|---|---|
| **49.g.x)** | **Brine Management Plans** | | |
| | Provision of Brine Management Plans developed for Arcadia Valley, Roma and Fairview gas fields as a state government requirement within the respective gas field's EA's. These will be provided in an update to the CWMMP. | December 2014. | March 2020<br>Due to an extension granted by the state government (DEHP) for provision of Brine Management Plans to December 2019. |

## 8.3 Brine Management Progress

As stated in the 2014 CWMMP Annual Report there has been a significant reduction in water volumes (approximately 30%-50%) then originally predicted in the CWMMP Rev 2, for the Roma and Fairview gas fields. This has therefore significantly reduced estimated brine production volumes.

During 2016, the focus on brine management studies included maximising beneficial use options for coal seam water, that meets relevant standards, understanding and capitalising on these opportunities as priority will minimise brine and solid salt production.

The outcomes of brine and salt management feasibility assessments are ongoing; however, based on current sanctioned Development Projects, Santos GLNG has constructed sufficient storage capacity in the Fairview field for brine management beyond 2020. The Arcadia Valley field is not estimated to start production until mid 2018 and therefore there will be no brine to manage during the scope of the Stage 2 CWMMP Rev 2.

Extension was previously granted by the state government (DEHP) for provision of Brine Management Plans for Roma field and Fairview and Arcadia Valley fields by December 2019.

# 9.0 Subsidence

## 9.1 Overview

Pressure reductions in the subsurface due to coal seam water production have the potential to cause subsidence within the coal seam and a risk of deformation at the ground surface. Santos GLNG is required by EPBC Act Approval Condition 65 to undertake:

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 as well as to any relevant regional program of monitoring;

b) modelling to estimate the potential hydrological implications of the predicted surface and subsurface deformation; and

c) methods for linking surface and sub-surface deformation arising from CSG activities.

Santos GLNG has developed a Subsidence Management Plan which defines the process for identifying a reportable subsidence occurrence. The Subsidence Management Plan was provided as an appendix to the Santos GLNG Stage 2 CWMMP Rev 2.

Santos GLNG is using InSAR (interferometric synthetic aperture radar) technology to detect ground movement and deformation across the entire extent of its fields.

## 9.2 Coal Seam Water Monitoring and Management Plan Commitments

Table 9-1 provides an outline of Santos GLNG's commitments presented in the Stage 2 CWMMP Rev 2, specific to subsidence monitoring and progress against each commitment.

**Table 9-1: Stage 2 CWMMP Rev 2 Commitments – Subsidence**

| Condition | Commitment | Target Completion Date Specified in the Stage 2 CWMMP Rev 2 | Status |
|---|---|---|---|
| **53.d.i.III** | **Subsidence** | | |
| | The Subsidence Management Plan provides a response plan into any exceedance of the defined subsidence trigger. The Subsidence Management Plan describes the monitoring undertaken to establish variation of ground level over time. | Completed. | Completed. |
| | Subsidence baseline. | Completed. | Completed. |
| | Monitoring through satellite measurements. | Ongoing. | Ongoing. |

## 9.3 Findings to Date

Stage 1 of the monitoring program comprised collection and interpretation of baseline ground motion conditions across the Surat and Bowen basins where gas field development activity is expected to occur at some point in the future. The findings were used to inform the Subsidence Management Plan.

Stage 2 of the InSAR monitoring program commenced in July 2012. An Interim report on the Stage 2 InSAR monitoring program was submitted to the DOTE in November 2013 as per the commitment made in the Stage 2 CWMMP Rev 2 and described the interim findings of Stage 2 of the monitoring program. Stage 2 was completed in April 2015.

Stage 3 of the current InSAR monitoring program commenced in April 2015. The first interim report for Stage 3 was provided to Santos in April 2016. Stage 3 is projected to run until February 2018. The next stage of monitoring will be commissioned to ensure it is provides continuous ground motion monitoring beyond February 2018.

To date, the results show a stability pattern over time for the whole Santos GLNG tenures. No direct correlation between ground deformation and exact locations of the gas activities is evident. The localised displacements measured over the Santos GLNG fields (accumulated values of up to 20 mm) are likely due to superficial processes. Such processes might include natural processes such as erosion, sediment deposition, and soil wetting/drying, as well as anthropogenic activity such as large civil construction projects and agricultural activities.

## 9.4 Ongoing Studies and Monitoring

InSAR image data acquisition for Stage 2 commenced in April 2015 and will run for 3 years. The data acquisition rate is every 48 days with periodic reporting scheduled for April 2016, March 2017 and February 2018 when Stage 3 of the data acquisition is programmed to stop.

Quarterly Reports have been delivered since the start of data acquisition in April 2015, up to December 2016. The next quarterly report is due in Q1 2017.

# 10.0 Reporting

## 10.1 Overview

This section will outline the reporting commitments made in the Stage 2 CWMMP Rev 2 and report on progress against each item.

## 10.2 Coal Seam Water Monitoring and Management Plan Commitments

Table 10-1 provides an outline of Santos GLNG's commitments presented in the Stage 2 CWMMP Rev 2, specific to reporting and progress against each commitment.

**Table 10-1: Stage 2 CWMMP Rev 2 Commitments – Reporting**

| Condition | Commitment | Target Completion Date Specified in Stage 2 CWMMP Rev 2 | Status |
|---|---|---|---|
| **49i, 53c)ix)** | **Reporting** | | |
| | A Coal Seam Water Monitoring and Management Annual Report will be developed for each calendar year and submitted to DOTE within the first quarter of the following year. | Annually. | Complete. |
| | Digital data can be provided to DOTE on request. | Ongoing. | Ongoing. |
| | Santos GLNG will publish the following reports on the internet (via the Santos Water Portal):<br>▪ Coal Seam Water Monitoring and Management Annual Report;<br>▪ Link to the latest Surat Cumulative Management Area (CMA); and Underground Water Impact Report (UWIR). | Annually | Complete. |
| | Santos GLNG will regularly publish data from the water monitoring network on the Santos Water Portal. | Ongoing. | Ongoing (last updated December 2016). |
| **55** | The next revision of the CWMMP is currently planned to be submitted to the DOTE 3 months prior to the first LNG cargo. | Report to be submitted 3 months prior to first LNG cargo | In progress. |

## 10.3 2016 Reporting

### 10.3.1 CWMMP Annual Report

The first Annual Report was submitted to the DOTE on 31 March 2014. The 2013 Annual Report included progress updates from October 2013 to December 2013 which incorporated the 2013 period since submission of Stage 2 CWMMP Rev 2. The 2014 and 2015 Annual Reports were previously submitted and reported on progress during 2014 and 2015, respectively.

This 2016 Annual Report has been developed to provide progress against commitments from 1 January 2016 to 31 December 2016 and will be made available on the Santos Water Portal as required by Conditions 49 and 53 of the EPBC approval by the 31 March 2017.

### 10.3.2 Digital Data Requests

No digital data was requested by the DOTE during this reporting period.

### 10.3.3 Santos Water Portal

Updates to the water monitoring network were published on the Santos Water Portal, this included updated water level and water quality results for a range of groundwater bores and surface water monitoring locations. These were most recently updated in December 2016.

The Santos Water Portal can be accessed via http://www.santoswaterportal.com.au/.

### 10.3.4 Future Reporting

The forward work plan to meet reporting commitments is outlined below:

- Provision of digital data to the DOTE upon request;
- Updates to water monitoring network and data on the Santos Water Portal on a quarterly basis with Q1 2017 data being uploaded in April 2017;
- Submission of the update to the CWMMP will be submitted to DotE for approval; and
- Commencement of the Annual Report 2017 covering January 2017 to December 2017.

# 11.0 Third Party Audit

On 4 December 2015 Santos Ltd was directed to undertake a second independent compliance audit of the EPBC Act approval granted to develop, construct, operate and decommission the coal seam gas resources in the Surat and Bowen Basins between Roma and Emerald in Queensland to supply gas for a related proposal for a natural gas liquefaction and export facility near Gladstone as described in EPBC 2008/4059. This was undertaken in accordance with condition 100 of the approval and as part of the strategic audit component of the Department of the Environment's annual compliance audit program.

The project has 114 conditions of approval. The second directed audit focused on the implementation of the Stage 1 and 2 of Coal Seam Gas (CSG) Water Monitoring and Management Plan (WMMP) requirements, and the effectiveness of the conditions in protecting MNES.

The independent audit has addressed the criteria to the satisfaction of the Minister's delegate.

The audit found that overall Santos Ltd has demonstrated reasonable measures have been undertaken to achieve compliance with the WMMP.

The audit found that Santos Ltd had met the majority of activities to satisfy the conditions of the EPBC Act approval that were within the scope of the audit, however four non-compliances were identified. These included:

- delays to agreed delivery dates to finalise commitments (77.1 and 78.1);
- not meeting all monitoring requirements (50.1.2(i) and 50.1.9)
- failure to communicate and seek approval for changes to aspects of the Plan implementation (77.1 and 78.1).

All non-compliances are considered to be low level and not to have resulted in impacts to MNES.

The Department of the Environment is engaging with Santos Ltd to ensure the non-compliances identified above are addressed to the satisfaction of the Department and in accordance with the EPBC Act Compliance and Enforcement Policy.

## 12.0 References

Department of the Environment, 2013, *Letter of Approval of Stage 2 CSG Water Management and Monitoring Plan - Reference: MS13-000959*

Hydrobiology Pty Ltd, 2013, *CSG Fraccing Fluid Ecotoxicology Work Plan June 2013*

Jacobs Engineering Group Inc. (Jacobs) 2015, *Surat Basin Quarterly Spring Baseline Monitoring Program: Springs Baseline Summary Report*, Report no. IH037400.

Klohn Crippen Berger (KCB) 2012, *Desktop Assessment of the Source Aquifer for Springs in the Surat Cumulative Management Area*, Brisbane.

Natural Resource Management Ministerial Council, Environment Protection and Heritage Council, National Health and Medical Research Council, 2009, National Water Quality Management Strategy, *Australian Guidelines for Water Recycling Managing Health and Environmental Risks (Phase 2), Managed Aquifer Recharge.*

Queensland Herbarium 2012, *Ecological and Botanical Survey of Springs in the Surat Cumulative Management Area,* Brisbane.

Queensland Water Commission, 2012, *Underground Water Impact Report for the Surat Cumulative Management Area.*

Santos GLNG, 2013, *Joint Industry Plan for an Early Warning System for the Monitoring and Protection of EPBC Springs.*

Santos GLNG, 2013, *Stage 2 Revision 2 CSG Water Management and Monitoring Plan.*

Santos GLNG, 2014, *Santos GLNG Coal Seam Water Monitoring and Management Annual Report.*

URS 2015, *Baseline Threshold Values for Surface Water Quality in Fairview and Roma Project Areas,* Report no. 42627494/R001/0.