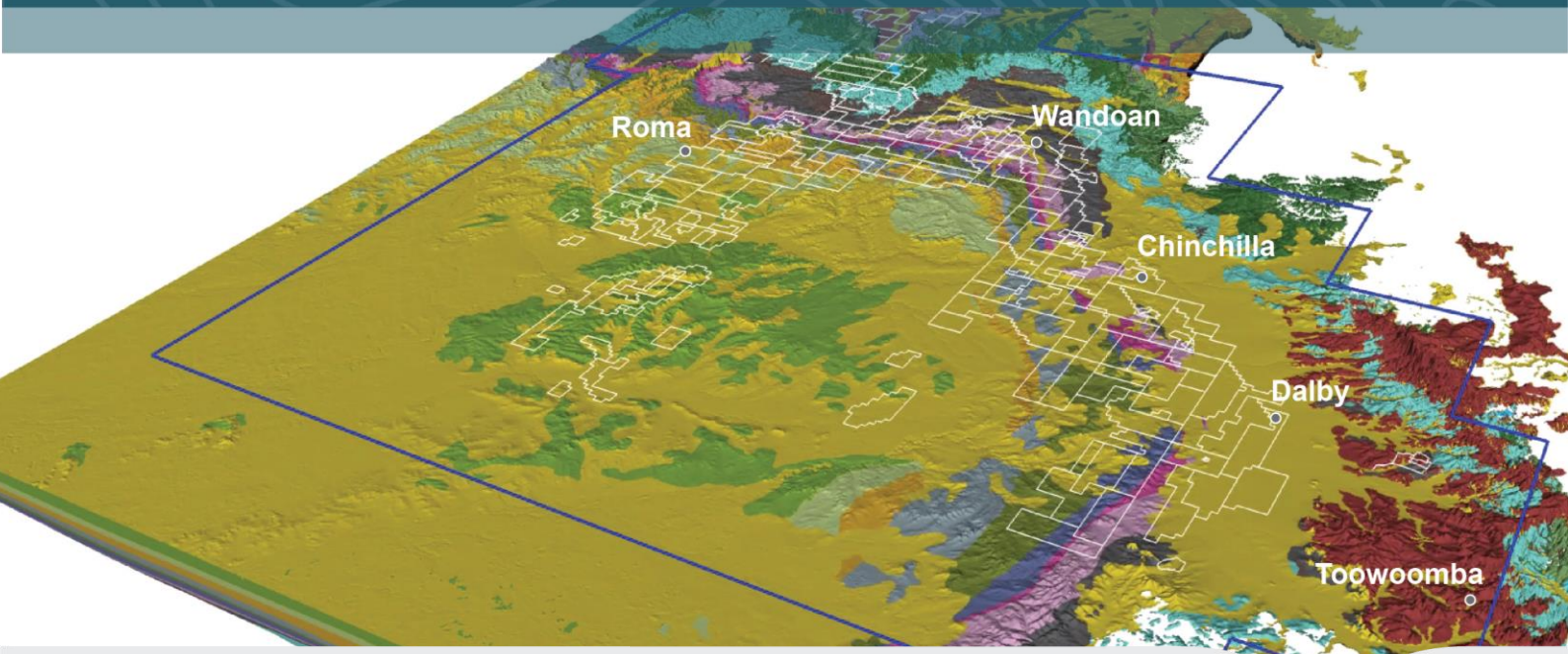
Queensland Government

Office of Groundwater Impact Assessment

Department of Regional Development, Manufacturing and Water



Annual review 2023 for the Surat Underground Water Impact Report

January 2024

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Summary

This document is the second annual review on the implementation of the Underground Water Impact Report (UWIR) 2021 for the Surat Cumulative Management Area (CMA). The review has been prepared by the Office of Groundwater Impact Assessment (OGIA) to provide an update on changes to circumstances that may materially change the predictions of impact reported in the UWIR 2021, and to provide an update on the implementation of management strategies specified in the UWIR 2021. This review should be read in conjunction with the UWIR 2021.

OGIA compiled an updated development profile based on information received from each tenure holder in October 2023. This was then used in determining changes to predictions resulting from changes in the development profile.

A summary of updates is as below:

- Localised changes in existing and proposed production have reduced the overall projected production area by 5%, and coal seam gas (CSG) wells by approximately 10% compared to what was presented in the UWIR 2021.
- Development of planned CSG production areas in the UWIR 2021 has generally also been delayed due to a residual influence of the global pandemic and higher-than-average rainfall in recent years.
- Despite a recent spike, the general declining trend in associated water extraction has continued over the past 24 months to around 48,000 ML/year.
- Due to slight delays in planned production in some areas, 36 of the 108 Immediately Affected Area (IAA) bores identified in the UWIR 2021 are now predicted to be impacted by more than a five-metre threshold at a time beyond the three-year IAA period – the end of 2024.
- Make good agreements for the IAA bores identified so far, including those from the previous UWIRs, are progressing and there are now 153 IAA bores with make good agreements in place, compared to 135 at the time of the UWIR 2021.
- Progress on the installation, repair and replacement of monitoring points required under the UWIR has improved, however there continues to be a residual influence from previous years' logistical issues due to higher-than-average rainfall and supply chain disruptions resulting from the pandemic.
- Interpreted CSG impacts from new monitoring data are progressing as expected. In the Walloon Coal Measures impacts remain largely restricted to the gas fields themselves and the immediately surrounding areas. Declining groundwater pressure trends continue to be observed across the Hutton Sandstone which are interpreted to be due to non-CSG factors at this stage.
- In relation to subsidence, more Light Detection and Ranging (LiDAR) data has been acquired by the tenure holder and provided to OGIA as per the requirement of the UWIR 2021. OGIA developed and released a LiDAR elevation profile tool on its website to display the LiDAR monitoring data.
- Additional ground motion data collected since the UWIR 2021 indicates that the subsidence trend in and around the Condamine Alluvium has also continued as anticipated, with an increase to about 135 mm in some areas.

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1 Introduction

1.1 What is the annual review?

An annual review is prepared to provide an update on changes to circumstances that would materially impact on the predictions reported in the Surat Cumulative Management Area (CMA) Underground Water Impact Report (UWIR) 2021, and to provide updates on the implementation of management strategies specified in the UWIR 2021. This is the second annual review for the current UWIR reporting cycle and should be read in conjunction with the UWIR 2021.

1.2 Background

The UWIR for the Surat CMA is prepared by the independent Office of Groundwater Impact Assessment (OGIA), every three years, on cumulative assessment and management of groundwater impacts from the extractions of associated water by the petroleum and gas, and coal mining development. The Surat CMA was declared in 2010 in response to rapid coal seam gas (CSG) development in the Surat Basin. In January 2020, the Surat CMA was amended to include coal mines in the Surat Basin.

The current Surat UWIR (UWIR 2021) was finalised and approved in March 2022 and took effect on 1 May 2022. It is the fourth UWIR since the establishment of the Surat CMA and was finalised following the release of a consultation draft in October 2021.

1.3 A summary of the Surat UWIR 2021

At the time of the UWIR 2021, the resource industry's existing and planned development plan consisted of approximately 22,000 CSG wells – of which about 8,600 were already in place. The coal mines located in the Surat Basin had a combined footprint less than 2% of the CSG footprint.

Associated water extraction by the CSG operators was around 54,000 megalitres per year, with associated groundwater extraction by the coal mines a fraction of that, at less than 1,000 megalitres per year. At the same time, within 15 km of active resource development, 59,000 megalitres of groundwater per year was extracted for consumptive use.

As anticipated in the previous UWIR assessments, monitoring data available at the time of the UWIR 2021 was showing declines of up to about 400 metres in the target CSG formation in the Surat Basin – the Walloon Coal Measures – and to a lesser extent in the Springbok Sandstone. The data also showed no impacts were occurring at that time in the Hutton Sandstone, Precipice Sandstone or Condamine Alluvium.

The predicted impacts in the UWIR 2021 were broadly similar to the previous UWIR 2019, with minor long-term impacts predicted in areas of the Hutton Sandstone and Precipice Sandstone in later years. Similarly, predictions of impact to the Condamine Alluvium groundwater levels remained less than a metre.

A total of 702 water bores were predicted to be impacted in the long term, spanning across the Springbok Sandstone, Walloon Coal Measures, Hutton Sandstone and Bandanna Formation. Of the 702 water bores, 108 were newly identified as Immediately Affected Area (IAA) bores – i.e. water bores that would be impacted by more than five metres within the next three years, which is the end of 2024 in this instance. This was in addition to 233 IAA bores similarly identified in the previous UWIRs for three-year rolling periods.

The UWIR 2021 also identified seven groups of springs predicted to be impacted by a decline of groundwater level by more than 0.2 metres in their source aquifers. Mitigation strategies were in place for three of these groups.

To strengthen the Water Monitoring Strategy (WMS) monitoring network, OGIA increased the monitoring network from 707 to 824 monitoring points.

Modelling of subsidence was enhanced for the UWIR 2021. The predictions showed that most of the cropping area around the Condamine Alluvium is likely to experience less than 100 mm of subsidence, with a maximum change in slope for most areas of less than 0.001% (10 mm per km). Satellite data available to OGIA at the time of the UWIR suggested that about 100 mm of CSG-induced subsidence had already occurred around CSG fields near the Condamine Alluvium.

2 Update on industry development profile

2.1 Planned development at the time of the UWIR 2021

For the UWIR 2021, OGIA integrated the footprint and timing of the petroleum and gas (P&G) and coal mine industry development plans, to establish a resource industry ***development profile***. A whole-of-life resource industry development profile was prepared and used as the input scenario for the regional groundwater flow model for impact predictions. Output from the model provided, for the given resource industry development profile, predicted short-term (within three years) and long-term (any time in the future) cumulative impacts on groundwater pressures in aquifers.

Many factors can cause changes to the development profile over time. Changes may relate to the timing of development of individual tenure areas, or to the long-term footprint of development. Any such change directly affects the extent and timing of predicted impacts on groundwater pressure.

OGIA requires, and receives annually, information directly from tenure holders about updates to their development plans, to compile a development profile across the whole CMA. The resource industry development profile for the UWIR 2021 was prepared based on information available in late 2020. This includes historical production data and planned development from individual tenure holders as presented in Chapter 2 of the UWIR 2021.

The latest update is from October 2023 which is used for the purpose of this annual review. This chapter presents a summary of changes since late 2020, which then provide context to implications on predictions and management strategies in the UWIR, as detailed in the following chapters.

2.2 Description of changes to planned development

A revised P&G industry development profile as at October 2023 is presented in Figure 1, along with the equivalent presented in the UWIR 2021, to enable comparison in terms of the development footprint (‘production area’) and timing. ***Production area*** is the part of a petroleum lease or petroleum lease under application where production is either occurring (existing production area) or proposed (planned production area). Production area can increase or decrease within the leases without necessarily affecting authorisations associated with the leases – this is often the case within the CMA.

There have been changes to some coal mine development plans, however these changes are unlikely to influence groundwater predictions for the IAA period as presented in the UWIR 2021. Detailed development plans are being acquired from each of the coal mine tenure holders to analyse the implications to the longer-term impacts in the next UWIR.

2.2.1 Overview of the cumulative changes

At the time of the UWIR 2021, the net existing and proposed P&G production area was approximately 15,000 km, with the number of projected CSG wells remaining at around 22,000. There is some retraction in this. The current development profile for the CSG industry now has a net existing and proposed P&G production area of approximately 14,000 km, with the number of projected CSG wells to be just under 20,000.

Most of the retraction to the planned production area is along the fringes – most noticeable are:

- north of Miles and northwest of Dalby, within Arrow tenure
- west of Wandoan, within QGC tenure
- southeast of Roma and north of Injune, within Santos tenure.

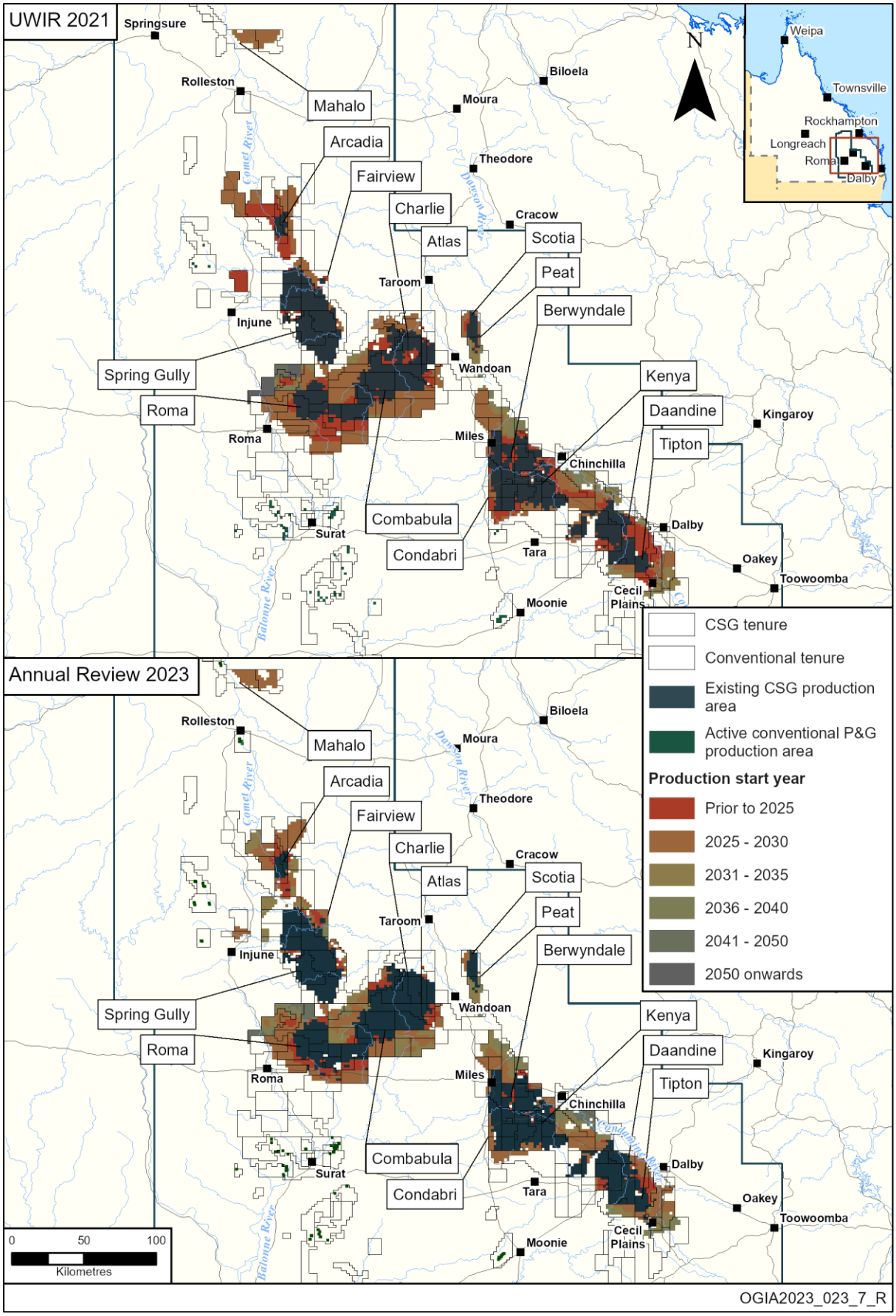

Figure 1: P&G development profiles for the UWIR 2021 and for the annual review 2023

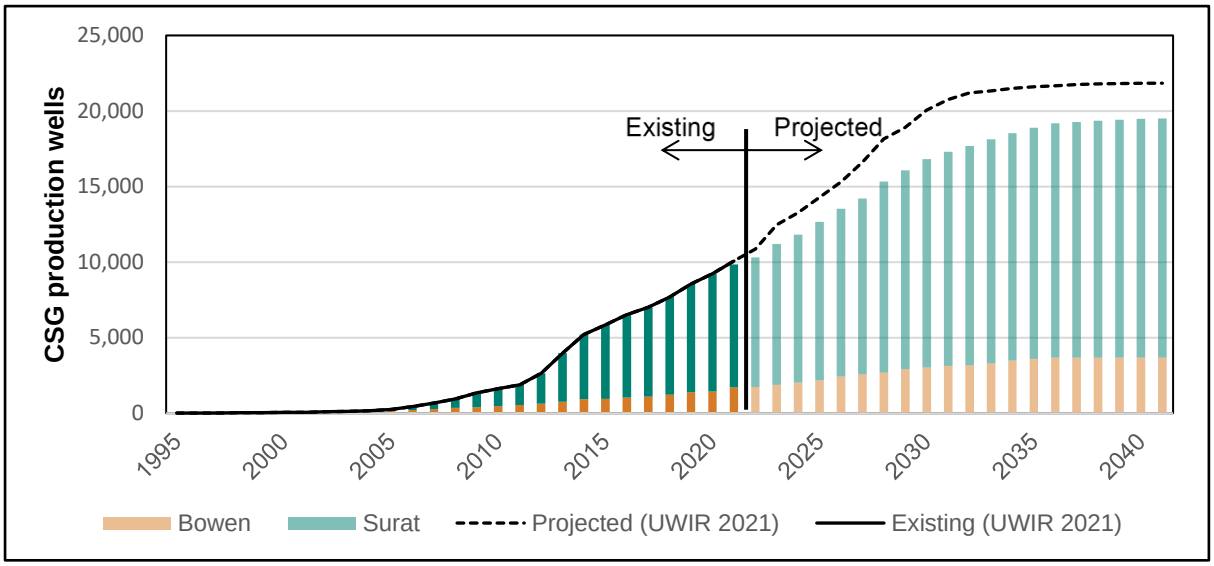

Figure 2: Existing and projected CSG wells in the Surat CMA in current and planned production areas

As anticipated, the existing CSG production area has continued to expand since the UWIR 2021. The CSG production area has increased by approximately 4% since the previous annual review and is now approximately 9% larger than at the time of the UWIR 2021. This is expected as more and more planned production areas progressively come online. Year-to-year localised changes to planned production are often observed, whereby some areas are retracted and others expanded. Additionally, production schedules can fluctuate – for example, starting later and finishing earlier than planned.

Most of the expansion to the existing production area is in three locations:

- the southern portion of Santos's Roma gas field
- the central portion of QGC's northern development area, west of Wandoan
- a corridor of development between Arrow's Daandine and Tipton gas fields.

In terms of changes to the commencement timing, there has been a general delay to the planned production commencement schedules across the CMA, with commencement pushed back for approximately 30% of the planned production area – the average delay being four years.

Small areas of production across the CMA have been brought forward in scheduling, such as some pockets surrounding Cecil Plains, north of Miles, and east of Roma. As noted in the 2022 annual review, Senex has amended its plan from the time of the UWIR 2021, to start earlier for the majority of the Roma North project.

Consideration of changes to timing within the next three years of the UWIR – to the end of 2024 – is important because they can potentially affect IAAs, which may then affect make good obligations. In that context, as noted in the previous annual review, there is some bringing forward of planned commencement with respect to the end of 2024, notably in an area immediately east of Roma within Santos's tenure; however, this has not affected the short-term affected area bores, as detailed in the next chapter. Also as noted in the 2022 review, there are areas of planned development that have been pushed back to commence in years beyond 2024. These include areas adjacent to existing

production areas between Chinchilla and Cecil Plains, an area southeast of Roma, and an area north of Injune, to the northwest of Santos's Arcadia gas field.

Compared to production cessation dates from the UWIR 2021, there has been a general shortening of production periods across the CMA, with some gas fields reducing production periods by up to 16 years.

Associated water extraction by P&G tenure holders in the Surat CMA is presented in Figure 3. There is a general decline in the extraction rate in the last few years from the peak of 67,000 ML/year in 2016. There has been a slight increase in the first six months of 2023, from around 48,000 ML/year to around 56,000 ML/year. This is likely due to tenure holders undertaking final commissioning processes on a number of wells, delayed during the recent pandemic and wet weather period, to bring them online. OGIA will continue to monitor the reported associated water volumes for deviations from the general declining trend.

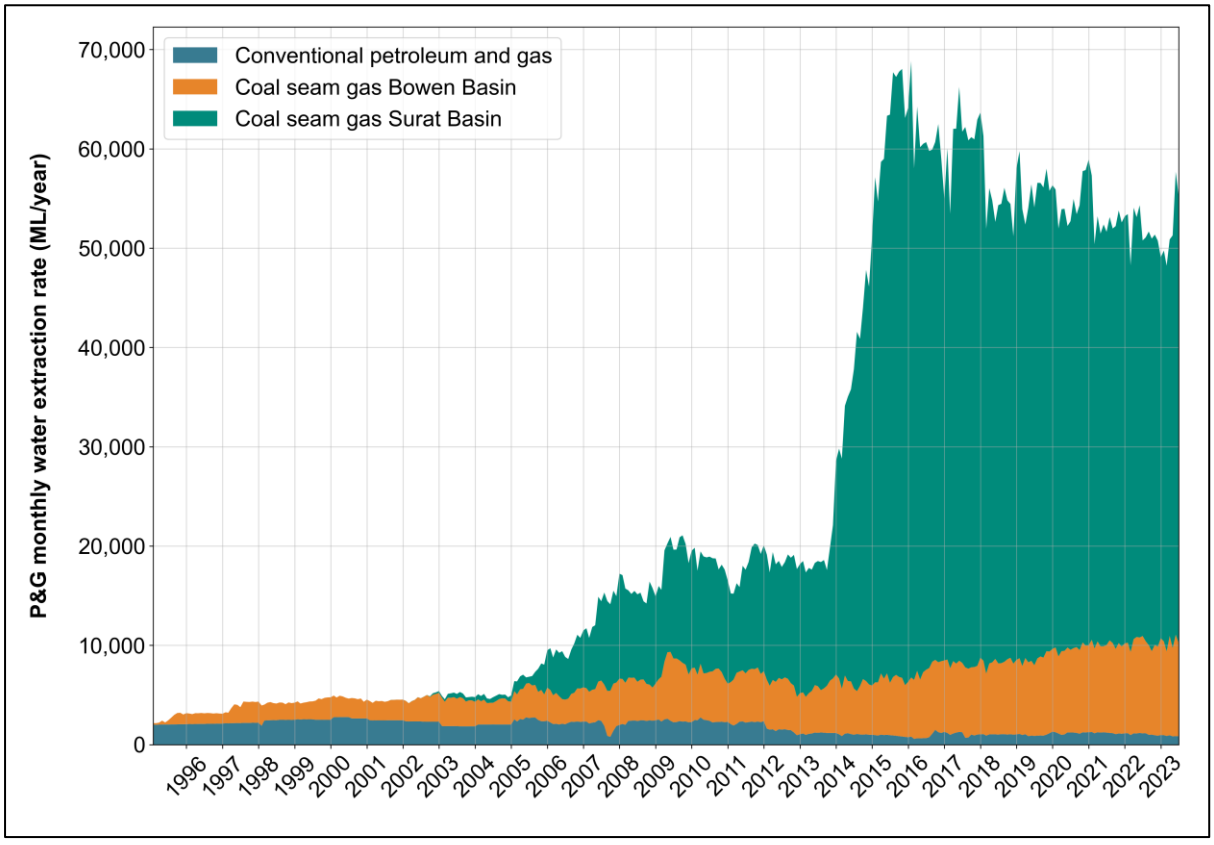

Figure 3: P&G associated water extraction

2.2.2 Santos

As noted in 2022, Santos has taken over the Mahalo project and the planned production area for the Arcadia and Roma gas fields has somewhat retracted. With these changes, Santos's total planned CSG production area is similar to that presented in the UWIR 2021.

Other than general retractions, the Arcadia and Roma gas fields are also where most of the changes to the production commencement timeline are observed, when compared to the UWIR 2021. Most of the Arcadia planned production area has been delayed, with the northwest portion being pushed back by up to 11 years. As noted in the 2022 annual review, some areas of planned development in the

Roma gas field have also been brought forward by a few years, with a portion of the western flank now to be developed prior to the end of 2024.

Despite the overall planned development area being relatively similar to that at the time of the UWIR 2021, Santos's total projected number of wells has reduced by around 15%.

2.2.3 Origin

Origin has divested small tenure areas, which were acquired by other CMA tenure holders. This has slightly reduced Origin's overall planned development area and projected wells correspondingly. When compared to the planned development presented at the time of the UWIR 2021, the timeline for production commencement across Origin's CMA tenures continues to show a general delay. Origin has previously advised this general delay is due to better than expected performance from its in-production gas fields.

2.2.4 QGC

There has been minimal change to QGC's development plans in the past 12 months. There remains a notable retraction in planned CSG production area for its northern development area and only minor changes to the scheduling. QGC now has close to 90% of its overall planned production area in production. All of QGC's planned production area is scheduled to be online by 2027, with approximately 4,000 wells.

2.2.5 Arrow Energy

Despite Arrow's existing production area growing by close to 40% since the time of the UWIR 2021, it makes up only 5% of the total area currently in production across the CMA. Arrow's overall planned production area footprint has reduced by approximately 10% compared to that presented in the UWIR 2021. This is mainly due to retractions noted in 2022 for the northern gas fields, with additional retractions northwest of Dalby and in a pocket of planned production area from PL1039, south of Dalby. Arrow's retractions have generally been due to reservoir assessment and facility and infrastructure rationalisation.

Better than expected gas production performance has contributed to a delay for planned commencement in some areas. Contrary to the general delay to planned production commencement for most areas across Arrow's tenures, the area north of Miles has been brought forward in the production schedule by a few years. Previously planned production commencement between 2030-2039 is now planned for 2027-2037.

2.2.6 Senex

Similar to Arrow, Senex's existing production area has expanded by close to 45% but this is also a small proportion (2%) of the overall current existing production across the CMA. Senex's development schedule has not materially changed in the past 12 months, with key changes compared to the UWIR 2021 as noted in the 2022 annual review:

- The western portion of the Roma North project area, located immediately north of Santos's Roma gas field, has been brought forward and the eastern fields of the project area have been delayed.
- Tenure area adjacent to the Atlas project area, near Wandoan, was acquired from Origin and now forms part of that project.

- The additional tenure area added to the Atlas project is now planned to commence in 2023 – as much as seven years earlier than the plans formerly held by Origin.

Senex has an overall planned production area of approximately 800 km^2 with about 1,000 total projected wells.

3 Update on predicted impacts on groundwater pressures and bores

3.1 Overview of predicted impacts in the UWIR 2021

The UWIR 2021 determined the IAA for each aquifer based on model predictions. For a consolidated aquifer, such as sandstone, the *Water Act 2000* stipulates the IAA is the area where groundwater pressure is predicted to decline by more than five metres within three years as a result of water extraction by the resource industry. Water supply bores accessing water in the affected area of an aquifer become IAA bores. For these bores, various actions and make good arrangements are then triggered as described in section 8.4 of the UWIR 2021.

The UWIR 2021 also determined the Long-term Affected Area (LAA) for each aquifer. The LAA for a consolidated aquifer is the area where groundwater pressure is predicted to decline by more than five metres at any time in the future as a result of water extraction by the resource industry. A total of 702 existing bores were predicted to be impacted in the long term – including the IAA bores.

The UWIR 2021 identified 108 additional water supply bores as IAA bores, a further increase from the 233 IAA bores that were identified in the previous UWIRs. This is because of the rolling three-year basis for IAA – which was the end of 2024 for the UWIR 2021, compared to the end of 2021 for the previous UWIR 2019.

3.2 Assessing changes to predicted impacts

For the purpose of this annual review, the model and the predictive set-up used is the same as that of the UWIR 2021 to simulate the impacts from the current resource industry development profile as described in the previous chapter. Results from the simulations were then compared with UWIR 2021 predictions to assess the implications of changes in the development profile.

3.3 Changes to long-term impacts

There are some minor reductions in predicted impacts in the northern and south-eastern areas of the CMA. Since the 2022 review, there has been further shortening of the period during which the gas fields are planned to be in production, consequently reducing the predicted LAA footprint and the number of LAA bores by about 75 – mainly to the southwest of Cecil Plains. Because of very high bore density in that area, a slight change in LAA boundary results in a comparatively larger change in the number of LAA bores.

3.4 Changes to short-term impacts

Revised predictions based on the current resource industry development profile suggest that for 36 of the 108 IAA bores listed in the UWIR 2021, impacts exceeding the trigger threshold (of five metres) are now predicted to occur after the current UWIR cycle – rather than by the end of 2024, which was the IAA threshold period for the UWIR 2021. Of these 36 bores, impacts in 26 are predicted to reach the trigger threshold during the next UWIR cycle (to the end of 2027). The other 10 are now predicted to be impacted between 2028 and 2046. All of those changes are due to a change in the industry development profile as described in the previous chapter. This is similar to what was reported in the 2022 annual review, with delays extended slightly further due to the increasingly delayed production commencement in some areas. Consistent with the 2022 annual review, most of these 36 bores with

delays to the timing of predicted impacts are within 7 km (north and south) of the Warrego Highway and within 40 km (to the southwest) of Chinchilla.

It is to be noted that while the predicted impacts to some IAA bores are now less than the trigger threshold of five metres by the end of 2024, those bores remain as IAA bores. The status of a bore as an IAA bore is based on the IAA that is established through a current UWIR, based on the development profile at the time. The IAA for an aquifer does not change between UWIRs, but a bore's status as an IAA bore can change based on the new information available about the bore – such as changes in location, authorisation, physical status or aquifer attribution. Changes to IAA bores are detailed further in the next chapter.

4 Changes to bore information

This chapter provides an overview of the status of bores identified as IAA bores in the current and previous UWIRs, in relation to the completion of baseline assessments, bore assessments, their current status, and an update on progress with make good agreements.

4.1 Baseline assessments

Prior to commencing production, resource tenure holders must complete baseline assessments for water bores located on tenure. The schedule for their completion is specified in baseline assessment plans (BAP), which the responsible tenure holders submit to the Department of Environment, Science and Innovation (DESI) for approval.

For water bores that are located off tenure but within an LAA, the UWIR WMS includes a program for the assessment of these bores – for the UWIR 2021 this is based on a prediction of groundwater pressure decline of more than one metre within the next three years (see Figure 9-7, UWIR 2021).

Baseline data is collected by tenure holders, is provided to the landholder and reported to OGIA. The data is available to the interested parties to support the development of future make good agreements between bore owners and resource tenure holders.

During the past 12 months OGIA has received 342 baseline assessment records. Some of these records relate to follow up or secondary visits. OGIA currently holds information from 5,226 baseline assessment records, relating to 4,948 water bores, 732 of which relate to bores located outside the Surat CMA. Information available to OGIA as of October 2023 shows baseline assessments have been conducted for 28 of the 38 bores identified for assessment in the UWIR 2021.

4.2 Bore assessment

Upon approval of a UWIR, responsible tenure holders are required to complete a bore assessment of those bores identified as accessing an aquifer within the aquifer's IAA – referred to as IAA bores. These water supply bores are listed in Table G-1 of the UWIR 2021. Separately, DESI may also direct a tenure holder to undertake a bore assessment.

A bore assessment is undertaken to establish whether a bore has (or is likely to have) an impaired capacity and to assess which make good arrangements may be appropriate. OGIA is not involved with undertaking bore assessments or the negotiations around make good agreements. OGIA only receives and records the outcome of bore assessments. Currently, bore assessment outcomes are held for 254 bores, of which 200 relate to IAA bores.

4.3 Update on IAA bore information

Figure 6-4 of the UWIR 2021 shows the geographical extents of the IAA and LAA. Based on the information available at the time, the UWIR 2021 identified 108 IAA water bores (Table G-1, UWIR 2021). These IAA bores were in addition to the 233 IAA bores listed in previous UWIRs (Table G-2, UWIR 2021). The distribution of all IAA and LAA bores identified in the UWIR 2021 is found in Figure 8-2 of the UWIR.

Bore assessments often provide new or updated information about a bore including location, depth, water chemistry and water level. This information can be used to reassess whether the bore is accessing water from aquifers other than those predicted to be affected. As a result, in the post-UWIR period, some IAA bores may be determined not to be IAA bores. Conversely, bores not previously

identified as IAA bores may be found to be accessing water from affected aquifers. As a result, the number of IAA bores may change during a UWIR cycle without a change being made to the IAA footprint.

The updated post-UWIR 2021 changes to the development profile did not result in any additional bores being identified as impacted by five metres by the end of 2024 – the IAA period. However, due to changes in a bore location, attributed aquifer from which the bore may be taking water from, and updated water licence information, 3 additional bores (RN 24492, RN 17382, and RN 61085) could be identified as IAA bores compared to those listed in the UWIR 2021. OGIA will carry out further validation prior to advising DESI of OGIA's IAA recommendation for their consideration.

Some other changes to listed IAA bore information are as below:

- RN 24497 has been removed from the IAA list because this bore has been replaced by IAA bore RN 172713. A replacement bore is a water bore constructed within 10 metres of the originally authorised water bore and tapping the same aquifer, or where the authorised replacement location was granted through a relevant water licence/development permit. Accordingly, all obligations relating to make good transferred from the original water bore to the replacement water bore.
- DESI issued a Direction Notice to Arrow to undertake a bore assessment on a landholder bore which was potentially being impacted as a result of the resource industry's activities. Through the bore assessment this bore has been clarified as RN 16671 and was already accounted for in the reported UWIR IAA bore numbers.
- The UWIR 2021 also listed RN 87021 as an IAA bore. Subsequent to the UWIR approval, the Department of Regional Development, Manufacturing and Water (DRDMW) updated location details in the State's groundwater database. The updated location places RN 87021 approximately 10km north of the New Acland mine, and beyond all IAAs and LAAs. As such, RN 87021 is no longer an IAA bore.

4.4 Current status of make goods

Information available to OGIA as at October 2023 indicates that of the 341 effective IAA bores (108 newly identified in the UWIR 2021 and 223 from previous UWIRs) listed in the UWIR 2021, there are 153 bores with make good agreements in place and 70 bores with agreements currently in negotiations. Of the 108 IAA bores that were newly identified, 59 still require a bore assessment.

The regulatory framework under the *Water Act 2000* allows for the provision of make good agreements where a bore is determined to be impaired, or likely to be impaired, as a result of resource industry water extraction. Generally, make good negotiations will follow the completion of a bore assessment, which will determine if the bore is, or is likely to be, impaired. In some cases, however, make good agreements are reached in advance of a bore assessment.

An agreement about the make good arrangement between a tenure holder and a bore owner may not necessarily involve decommissioning of the water bore. Such an agreement may provide some form of compensation while the bore continues to supply water, it may also provide for a period of ongoing monitoring and a future date for review of the agreement.

5 Implementation of the Water Monitoring Strategy

5.1 Overview of the UWIR 2021 Water Monitoring Strategy

The UWIR 2021 included a WMS that specified a regional monitoring network comprising groundwater pressure and water chemistry points, as well as the monitoring of water production volumes. The WMS monitoring network is designed for the collection of data to meet multiple objectives related to regional groundwater assessment. The primary objectives are to:

- improve understanding of background trends
- identify pressure changes near resource development
- understand groundwater flow near connectivity features and high-value assets
- improve conceptual understanding and future groundwater modelling
- assess groundwater conditions around coal mining pits.

The UWIR 2021 identified each required monitoring point's location, target formation and responsible tenure holder, as well as a date by which the monitoring point must be installed. As with previous UWIRs, the UWIR 2021 recognises that the locations of the identified sites may need to be altered during implementation due to practical operational issues. To address operational constraints, tenure holders may propose, to OGIA, variations to obligation requirements, while maintaining the overall objectives of the monitoring network.

Any proposed changes to the installation or repair of monitoring points are reported to OGIA through the Network Implementation Report (NIR) every six months. A summary of progress with the implementation of the network since the UWIR 2021 is provided in the following sections.

5.2 Implementation summary

Land access conditions have been more amenable during 2023 for tenure holders to meet their monitoring obligations, with 53 obligations being implemented since October 2022. At the time of the 2022 review, tenure holders had completed approximately 20% of the anticipated implementation obligations. This has now increased to approximately 55% of the anticipated implementation obligations for 2023. Remaining delays are due to logistical reasons.

Tenure holder requests for changes to the monitoring network due to safety considerations, land access and geological interpretation are considered by OGIA on a case-by-case basis in consideration of monitoring objectives associated with each location.

OGIA previously reported Tri-Star's intention to relinquish ATP 663, which would have had implications for determining the responsible tenure holder for the respective monitoring obligations upon that relinquishment. In September 2023, Tri-Star updated OGIA on the matter, advising its intention to withdraw the relinquishment of ATP 663.

5.3 Groundwater pressure network

In the UWIR 2021, the WMS provided that 77 monitoring points were scheduled to be added to the groundwater monitoring network by the end of 2023. Of those 77, as of 1 October 2023:

- 37 have been installed
- 16 have been constructed but are yet to go through final commissioning

- 22 have not been constructed yet
- two are no longer required.

There were 64 existing monitoring points scheduled to be repaired by the end of 2023. As of 1 October 2023:

- 32 have been repaired
- 26 have not been repaired
- six have been removed from the network due to reduction in tenure area and optimisation of surrounding monitoring network points.

There were 14 existing monitoring points scheduled to be replaced by the end of 2023. As of 1 October 2023, six have been replaced and eight are yet to be replaced.

At the time of the UWIR 2021, there were 539 operational groundwater pressure monitoring points; this has now increased to 619, including four monitoring points integrated into the UWIR network for the first time.

5.4 Groundwater chemistry network

At the time of the UWIR 2021, there were 87 operational monitoring points for groundwater chemistry, which has increased to 99 as of 1 October 2023. Of the monitoring points due to be installed by 2023:

- one has been constructed but is yet to go through final commissioning
- one is not yet constructed
- two are due to be replaced.

The UWIR WMS also requires that water chemistry be sampled from production wells. Sampling water from CSG wells can be challenging as CSG wells may be turned off and operational factors may preclude water quality samples from being taken. Where water quality samples are unable to be taken from a production well identified in the UWIR, the tenure holder may take a sample from another well within a three-kilometre radius.

At the time of the UWIR 2021, this groundwater chemistry network included 135 existing production wells, 1 replacement well and 18 wells in areas proposed for development in the future. As of 1 October 2023, 141 wells had been sampled, with 3 more locations due to be sampled by the end of 2023. The remaining 10 locations are proposed and due to be implemented from 2024 onwards.

5.5 Associated water extraction

In addition to the monitoring of groundwater pressure and chemistry, tenure holders are required to report the volumes of associated water produced by CSG wells. For the UWIR 2021, water volumes were available for around 8,600 production wells in 2020. OGIA has since received data for an additional 1,700 wells. Some production wells may not report volume because either they may not be in production at the time or they may be producing negligible amounts. In 2022, a total volume of about 51,200 ML was produced from CSG wells.

5.6 Data availability

Responsible tenure holders provide monitoring data to OGIA every six months, in April and October each year. OGIA reviews each data submission for completeness and technical accuracy. Within

about three months of each submission, data is made publicly available on the Queensland Government's groundwater database and the Queensland Globe.

5.7 Update on trends in groundwater pressure

To support the preparation of the UWIR 2021, OGIA completed a detailed analysis of groundwater pressure trends in aquifers adjacent to the target coal formations – the Walloon Coal Measures and the Bandanna Formation – to identify impacts on groundwater pressure from associated extraction by P&G and coal mining (UWIR 2021, Chapter 5). The key findings presented were as follows:

- There was widespread CSG impact in the target formations, with of up to 400 m drawdown observed at some locations.
- In areas adjacent to operational coal mines, impacts in the Walloon Coal Measures drawdowns of up to 30 m were observed at some locations.
- In the overlying Springbok Sandstone, the trends were mixed, although there was evidence of CSG impact at some sites. There were areas of rising trends around the north-eastern fringe of the development areas, likely to be caused by gas migration.
- In the underlying Hutton Sandstone, there was no evidence of CSG impact at this stage. Declining trends were attributed to groundwater use, although those trends appear to be somewhat stabilising in recent times.
- In the Precipice Sandstone, the basal unit of the Surat Basin, reinjection was the dominant influence on observed groundwater levels, particularly in the north. This increases the complexity of identifying any minor impacts that may have occurred around its contact with the Bandanna Formation in the Bowen Basin.
- No impacts were observed in the overlying Condamine Alluvium at this stage.

Analysis of the monitoring data (primarily from existing monitoring points) collected since the UWIR 2021, suggests the following:

- Consistent with the UWIR 2021 and annual review 2022, CSG impacts in the Walloon Coal Measures are largely restricted to the gas fields and the immediately surrounding areas. The more significant declines are observed in the lower parts of the Walloon Coal Measures. There is little change around reported trends adjacent to operational coal mines.
- Groundwater pressures in the Springbok Sandstone continue to show variable – both rising and declining – trends across the formation. At most locations, the observed trends are consistent with those reported in the UWIR 2021.
- Declining groundwater pressure trends continue to be observed across the Hutton Sandstone. The magnitude and rate of decline varies spatially, however, more significant declines are observed at some locations. For example, at Daandine-121 (RN160350A), 30 km west of Dalby, increased rates of decline transitioned to more stable groundwater levels in 2020 and 2022 respectively. Impacts from CSG are predicted in this area in future, however, the current declining trend at this location is interpreted to be primarily a response to non-CSG groundwater use – around 950 ML/year within 25 km.
- In the Condamine Alluvium, groundwater pressures primarily show stable to minorly increasing trends across the groundwater system during the recent review period. Consistent

with the UWIR 2021, observed trends continue to correlate reasonably well with longer-term dry and wet periods and non-CSG water use from the Condamine Alluvium.

- In the Precipice Sandstone, observed groundwater pressure trends continue to show a consistent response to Origin's reinjection scheme, particular in areas north of Roma and Miles. Since late 2017, reinjection rates reduced from around 550 to 400 ML per month. A short-term reduction in reinjection at the Spring Gully facility in early 2023 resulted in a short period of declining groundwater levels, which rose once reinjection recommenced.

6 Implementation of the Spring Impact Management Strategy

6.1 Overview of the UWIR 2021 Spring Impact Management Strategy

The Spring Impact Management Strategy (SIMS) in the UWIR 2021 identified springs that may be at risk due to underlying aquifers being affected by associated water extraction for P&G or coal mining. The criteria for identifying potentially affected springs is conservative; springs overlying aquifers with predicted long-term pressure impacts of 0.2 metres or more, are identified as potentially affected.

Based on the predictions of impact and a follow-up risk assessment, three groups of springs were identified for mitigation actions. A significant inclusion in the UWIR 2021 is the Spring Impact Mitigation Plan (SIMP), which identifies specific triggers, actions and reporting responsibilities for Santos and OGIA. In addition, the SIMS also identified some reaches of watercourse as potentially receiving groundwater discharge, which require field verification by a responsible tenure holder, as specified in Table H-1 of the UWIR 2021.

Changes to the development plans have resulted in alterations to the magnitude and timing of predicted impacts as described in Chapter 3; however, the changes have not resulted in any material change to predicted impacts at the spring locations.

6.2 Update on spring monitoring

The UWIR 2021 includes a risk assessment for springs and specifies a monitoring program for seven spring complexes and five watercourse springs. Responsibility for implementing the monitoring program is assigned to individual tenure holders.

Spring monitoring is necessary to understand the natural variability in spring discharge. Similar to understanding influences on observed groundwater levels, this information provides the basis for establishing the background conditions, for correlation with seasonal conditions, groundwater use and potential impacts from resource development.

During the previous UWIR cycle, there were extended periods of lower-than-average rainfall and drought across many parts of the Surat CMA. At spring wetlands, this generally resulted in a smaller contribution of rainfall to the wetland water balance, increased grazing pressure on wetland vegetation that resulted in higher disturbance, and a contraction in spring wetland extent and overall condition. In contrast, during this cycle, higher-than-average rainfall throughout 2022 saw many sites stabilise or expand and regain condition in response to the increase in rainfall and reduction in grazing pressure.

The higher-than-average rainfall also meant that in late 2022, access to some sites was not possible or safe, such as watercourse springs along Hutton Creek and the Dawson River, and spring vents at Lucky Last and Abyss. A return to drier conditions in early 2023 allowed field teams to access the sites and complete the required surveys.

6.3 Update on watercourse validation

For the reaches identified for field verification in the UWIR 2021 SIMS, this verification is expected to include a dry-season longitudinal survey of the reaches to determine if groundwater is discharging to surface and to identify source aquifers. The UWIR 2021 suggests field methods including surface

water chemistry analysis, stream gauging, and measurement of water levels and chemistry in nearby water bores.

Field surveys of the Dawson River (W42) and Boyd Creek (W179) watercourse springs occurred during the 2023 dry season. The resulting report was submitted to DESI in November 2023 and is currently being reviewed by OGIA.

Validation of the Wilkie Creek (W278) watercourse spring will likely occur during the 2024 dry season.

6.4 Update on spring impact mitigation

The UWIR is required to include a strategy for preventing or mitigating the predicted impacts on the springs, including the actions to be taken. Based on the predictions of impact and a follow-up risk assessment, three groups of springs were identified for inclusion in a SIMP – Springrock, 311/Yebna 2 and Lucky Last.

As described in the UWIR 2021 (section 10.7.2), the SIMP comprises three parallel streams:

1. **Mitigation actions** to bring the residual risk to low. These actions are described in the UWIR 2021 (section 10.7.3 and Table H-2) and are designed to be implemented within one to two years of being triggered (trigger sites).
2. **Trigger monitoring** and reporting by OGIA of groundwater level trends. This is a biannual assessment of the data to identify the likelihood of CSG impacts at early warning indicator sites (UWIR 2021, Table H-3, Appendix H). OGIA is required to notify Santos and DESI of the outcome of this assessment and if actions are required.
3. **Ongoing investigations** at a number of spring groups to further improve knowledge about impact pathways and spring response to groundwater level impacts.

An update on further assessment and implementation at each mitigation group is provided as below.

Springrock

The Springrock mitigation group of springs is a section of watercourse incised into the Precipice Sandstone, approximately 20 km northeast of Injune. The wetlands are supported by discharge from the Precipice Sandstone, occurring as pools within depressions in exposed sandstone bedding plains and where stream sediment has accumulated. During wet periods, the wetlands are connected by surface water flow. During dry periods, the upper reaches of the tributary become disconnected wetlands.

The two specified early warning indicator sites (RN160653B and RN123531A) are completed in the Precipice Sandstone. Groundwater levels in 2022-2023 show slightly greater variability than in recent years, which correlates with increased rainfall in 2022 and below-average rainfall in 2023. Changes in reinjection rates at Spring Gully during 2023 may also be reflected in the groundwater level responses. CSG impacts are not currently determined for this location.

311/Yebna 2

The 311/Yebna 2 mitigation group is located along the Dawson River near the intersection of Hutton Creek, approximately 30 km east of the Springrock mitigation group. The group has characteristics similar to the Springrock group and is also fed by the Precipice Sandstone. These are permanent to semi-permanent wetlands which occur in the rocky channels of the watercourses within the outcropping Evergreen Formation and Precipice Sandstone.

The two specified early warning indicator sites (RN160661A and RN160650A) are completed in the Precipice Sandstone – one near the contact zone (see UWIR 2021, Figure 4-10) and the second adjacent to the springs. No CSG impacts are currently detected at the trigger sites. Similar to the Springrock mitigation group, the groundwater levels appear to rise and fall with increasing and decreasing rainfall. Additional data is required for the trigger bores to assess the potential contribution of changing reinjection rates on observed water level variations.

Lucky Last

The Lucky Last mitigation group is located approximately 20 km northeast of Injune. This group of springs is adjacent to the Injune Creek and unlike the Springrock and 311/Yebna 2 mitigation groups, these are palustrine rather than riverine wetlands, fed by the Boxvale Sandstone.

The two specified early warning indicator sites (RN13030882A and RN123470A) are completed in the Precipice Sandstone. No CSG impacts are currently detected at the trigger sites. At these locations, the conceptual pathway for impact to the Boxvale Sandstone is via the Precipice Sandstone and early warning monitoring is therefore in this formation. Similar to the other mitigation groups, the groundwater levels continue to show minor variability correlating with climate – rising with higher-rainfall periods, reflecting lower groundwater extraction and increased recharge events.

7 Update on subsidence monitoring

7.1 Overview

The UWIR 2021 included a subsidence monitoring strategy which required: ***baseline monitoring*** to establish background landform using airborne Light Detection and Ranging (LiDAR) data; and ***trend monitoring*** using Interferometric Synthetic Aperture Radar (InSAR) data. This approach enables the identification of CSG-induced subsidence that may have already occurred, continuous improvement of the model for making predictions of CSG-induced subsidence and potential impacts to landform. This chapter provides an update on the implementation of the UWIR 2021 subsidence monitoring strategy.

In parallel with implementation of the subsidence monitoring strategy, OGIA provided technical support to the GasFields Commission Queensland (GFCQ) project to further understand the impacts of CSG-induced subsidence. In May 2023, in response to the GFCQ project, the Queensland Government announced its intention to expand the role of OGIA to provide independent assessment and management of farm scale subsidence, which was one of GFCQ's recommendations.

OGIA established a landholder reference group and identified two pilot farms to test tools and techniques to establish the background landform and to assess CSG-induced subsidence and prepare guidelines for future farm scale assessments. OGIA has undertaken a range of scientific analysis of the available data to determine existing and future subsidence at farm scale, and to assess potential changes in landform due to CSG-induced subsidence. The analysis and findings are shared with pilot study landholders and the landholder reference group on an ongoing basis, to keep them informed and to seek valuable feedback in the process.

7.2 Update on baseline monitoring

In accordance with the UWIR 2021, Arrow Energy is required to undertake an annual airborne LiDAR survey, preferably during the dry season, covering the cropping lands in and around the Condamine Alluvium.

Since the UWIR 2021, OGIA has received two LiDAR surveys:

- 13 June and 7 August 2022 – delivered to OGIA in November 2022
- 30 May and 26 June 2023 – delivered to OGIA in October 2023.

Additional surveys completed in August and November have been acquired and will shortly be provided to OGIA.

The datasets are very large and often require sophisticated hardware and software compared to those available to standard users. Therefore, to enhance stakeholder accessibility, OGIA has developed a LiDAR Elevation Profile Tool, which is published on the OGIA website. This tool displays digital elevations from multiple airborne LiDAR surveys in the western Condamine Alluvium, allowing users to draw section lines and generate land elevation profiles and facilitating the comparison of slope changes between surveys. Future releases of the application will include imagery-matching functionality; however, concurrently collected imagery is currently available through the Queensland Globe.

The datasets are also made available on ELVIS, which is a cloud-based system that enables users to discover and access elevation and bathymetry datasets. ELVIS consolidates data from commonwealth, state and territory governments, providing a convenient central source for this data.

OGIA is actively working on refining workflows for quality assurance and quality control of LiDAR captures and to enhance the functionality of the OGIA online LiDAR tool.

7.3 Update on trend monitoring

For the UWIR 2021, InSAR data was acquired and analysed to understand background natural variability and historical impacts from CSG development around the western Condamine Alluvium. The UWIR 2021 reported that since 2015, the available data indicated about 100 mm of CSG-induced subsidence in mature gas field areas near the Condamine Alluvium, and that natural or 'background' ground movement unaffected by CSG development had been in the order of ±25 mm/year.

OGIA committed to the acquisition of additional InSAR data (within the UWIR cycle), reporting of observed trends in ground motion, making available of data to stakeholders, and ongoing evaluation of best-practice techniques for InSAR processing.

Since the UWIR 2021, OGIA has acquired additional InSAR data for the same area presented in the UWIR 2021 from the same provider, TRE Altamira. To improve confidence and to explore opportunities to expand data coverage, OGIA also acquired the same data from another provider, SkyGeo. Based on a comparison of the data provided, OGIA will continue to acquire InSAR data from SkyGeo. The SkyGeo data held by OGIA extends from April 2015 to September 2023.

Key observations from this updated data suggest that similar to the UWIR 2021, natural or background ground motion unrelated to CSG development is ±25 mm/year with overall trends similar to those reported in the UWIR 2021. The total observed CSG-induced subsidence has increased from 120 mm to about 135 mm, within mature gas fields near the Condamine Alluvium – broadly in line with model predictions in that area.

8 Update on OGIA's research, reporting and engagement activities

OGIA continues to update and build knowledge about the regional groundwater flow system through its ongoing research programs, industry initiatives and research by other organisations.

Since the release of the UWIR 2021, a range of additional datasets have also become available, particularly geological and formation property data from additional CSG wells and groundwater monitoring data, obtained through UWIR obligations as well industry's own monitoring initiatives. OGIA continues to assimilate these additional datasets to improve the hydrogeological conceptualisation, unpack historical impacts from monitoring data and constrain groundwater models used for impact predictions.

8.1 Research

Current and ongoing research activities in each of OGIA's key focus areas are summarised below.

8.1.1 Conceptualisation

There are two primary focus areas where OGIA is improving the conceptual understanding of the groundwater system which may have implications for resource development impacts – the Condamine Alluvium and the Precipice Sandstone.

- To improve the understanding of shallow geology and groundwater systems in the Condamine Alluvium and to further characterise the geometry of the Horrane Fault system, OGIA commissioned an airborne electromagnetic (AEM) survey between Dalby and Cecil Plains in May 2023. Inversions and interpretations of the acquired data with other subsurface information are currently underway. This information will be made available in early 2024.
- In parallel, OGIA is undertaking a comprehensive analysis of the available hydrochemistry data in the Condamine Alluvium to understand potential connectivity with the underlying Walloon Coal Measures. This complements ongoing groundwater level analysis in this area.
- Assessment of lateral and vertical connectivity of the Precipice Sandstone in target areas, to improve understanding of impact pathways for CSG and conventional oil and gas-induced impacts; focusing on areas in and around the Moonie wellfield and contact zones associated with the Peat & Scotia fields in the east and the Fairview & Spring Gully fields in the west. This will incorporate recent investigations by the University of Queensland and 3D seismic data acquired by Origin Energy.
- A field program along reaches of the Hutton Creek and Dawson River watercourse springs to improve the understanding of groundwater contribution to stream flow, a key component of the impact assessment in this area. This was completed through improved geological mapping of formation boundaries and the collection of water samples for analysis, which will assist in identifying source aquifers and major inflow zones.

8.1.2 Groundwater and subsidence modelling

- Development of an integrated framework coupling groundwater flow models and subsidence models to simulate CSG-induced subsidence at local scale.

- Exploring the application of over-land flow models to quantify the farm scale impacts of CSG-induced subsidence, such as changes in inundation periods for areas of interest.
- Development of signal separation models to extract CSG-related signal from InSAR data with a goal to avoid overestimation and underestimation of CSG-induced subsidence.
- Exploring the roles of coal shrinkage and bridging in subsidence evolution during CSG extraction.
- Development of methods to use InSAR data to improve history-matching of the UWIR regional groundwater model.

8.1.3 Geological modelling

- Regional compilation, re-processing, normalisation and interpretation of wireline logs to compile a database of geophysical data to improve the understanding of hydrogeological and geomechanical properties in reservoirs, aquifers and aquitards within the Surat CMA.
- Supporting OGIA's ongoing research on CSG-induced subsidence, a 3D geological model of the western Condamine Alluvium (~5,000km^2) was developed as the structural framework for a coupled groundwater flow - geomechanical model. This geological model has been built using a stair-stepped corner point gridding method, which differs from the previously used method. It can represent complex fault structures such as the Horrane Fault system and ease the integration with flow modelling packages.

9 Conclusions

The development plan provided by the resource industry substantially aligns with the plan provided for the 2022 review. As noted at the time of the 2022 review, there are changes to the planned production footprint and timing of commencement of CSG development within the existing tenures since the UWIR 2021 was prepared. The changes have resulted in a net reduction in the extent of IAAs, along with the overall projected number of production wells.

Despite a recent increase in the rate of associated water extraction from existing wells, the general trend has continued to be a steady decline. OGIA will continue to review the associated water extraction data and report on the observed trends in the forthcoming UWIR.

Given there was little difference between the 2022 and 2023 development plans, the noted delays in planned production resulted in a similar reduction of IAA bores. The development plan for this annual review results in 36 of the 108 bores identified in the UWIR 2021 as IAA bores now predicted to be impacted by more than five metres after the current IAA threshold period – i.e. 2024.

Make good agreements of 341 IAA bores identified so far from all UWIRs are progressing further. There are now 153 IAA bores with make good agreements in place, compared to 135 at the time of the UWIR 2021, with a significant portion of remaining IAA bores in negotiation stages.

Observed trends for the Condamine Alluvium continue to correlate reasonably well with longer-term dry and wet periods and non-CSG groundwater use. In the Walloon Coal Measures, impacts are still largely restricted to the gas fields themselves and the immediately surrounding areas. In recent times the declining groundwater pressure trends in the Hutton Sandstone appear to be stabilising. Groundwater pressure trends in the Precipice Sandstone continue to show a consistent correlation to Origin's reinjection scheme.

In relation to subsidence, capturing of monitoring data is continuing broadly as planned. Additional ground motion data collected since the UWIR 2021 indicates that the subsidence trend in and around the Condamine Alluvium has continued as anticipated, with an increase to about 135 mm.

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