Status of coal seam gas and conventional petroleum and gas development in the Surat Cumulative Management Area

(OGIA/21/CD01/V1)

A snapshot supporting the Surat Underground Water Impact Report 2021

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1.0	4 November 2021	Sanjeev Pandey

Overall guidance and direction: Sanjeev Pandey

Prepared by: Sanjeev Pandey, Sean Lowry

Contributors: Sean Lowry, Sanjeev Pandey, Steven Flook, Ben Cairns

Review: Gerhard Schöning

Acknowledgement: Ben Ross and Jeremy Wolff (mapping); Hugh Marshall (document editing)

**Currently not with OGIA*

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1 Preamble

This section provides contextual information about petroleum and gas (P&G) development activities in the Surat Cumulative Management Area (CMA), production methods, as well as current and proposed production footprints – as these development activities are stressors to groundwater systems. This information is then used in developing the conceptual understanding of groundwater impact pathways (OGIA, 2021a) and trends (OGIA, 2021b) and to prepare an industry development scenario for input to the regional groundwater flow model (OGIA, 2021c) for making predictions of impacts.

2 Petroleum and gas production methods

P&G is extracted from geological formations using conventional and unconventional methods. Conventional methods involve the direct extraction of P&G residing in porous rock formations, such as sandstone (**conventional petroleum and gas**). In recent decades, unconventional methods have been developed to extract gas from other formations (**unconventional gas**) including coal formations (coal seam gas (CSG)), low-porosity rock formations such as shale (shale gas) and low-permeability sandstone/siltstone (tight gas). CSG is typically extracted from relatively shallower depths of 200 to 1000 m, while shale gas and tight gas are extracted from depths of 1,000 to 5,000 m (Figure 2-1).

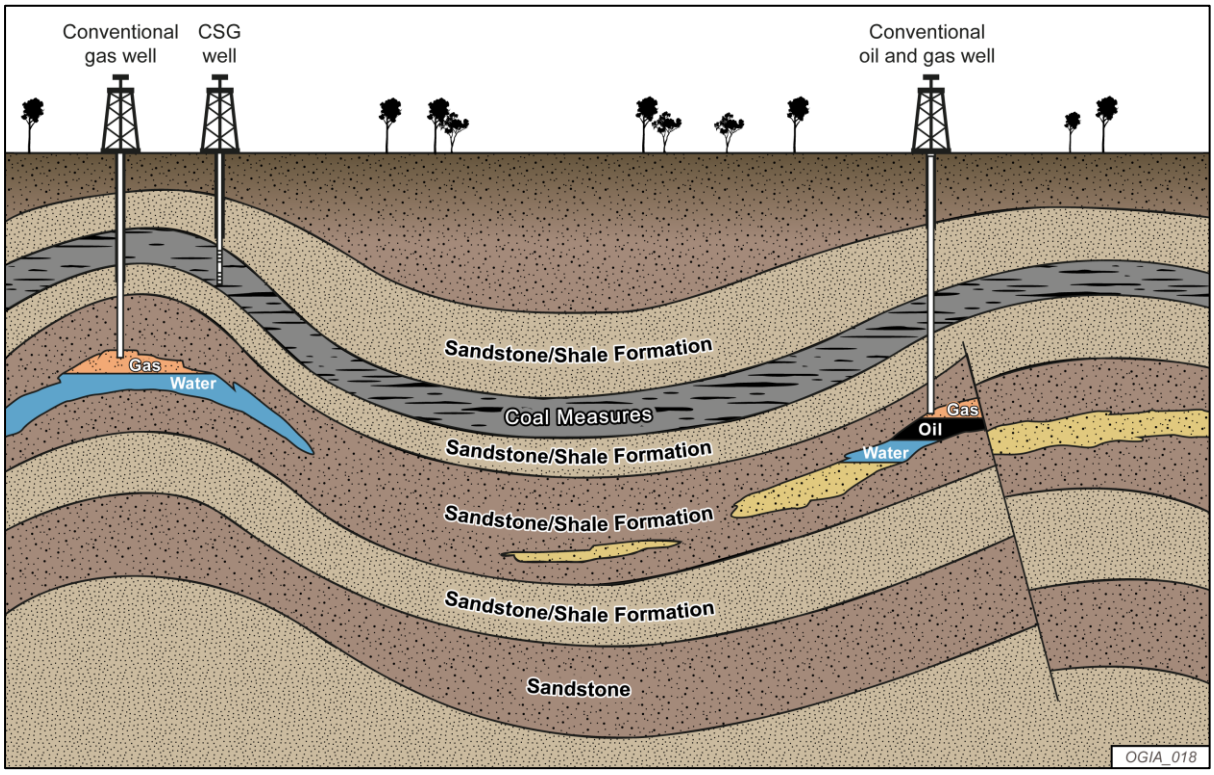

Figure 2-1: Schematic of oil and gas accumulation types

Geologically, the main target for CSG is from the Walloon Coal Measures in the Surat Basin and shallower parts of the Bowen Basin, while conventional oil and gas targets have been the deeper Bowen Basin formations (Figure 2-2).

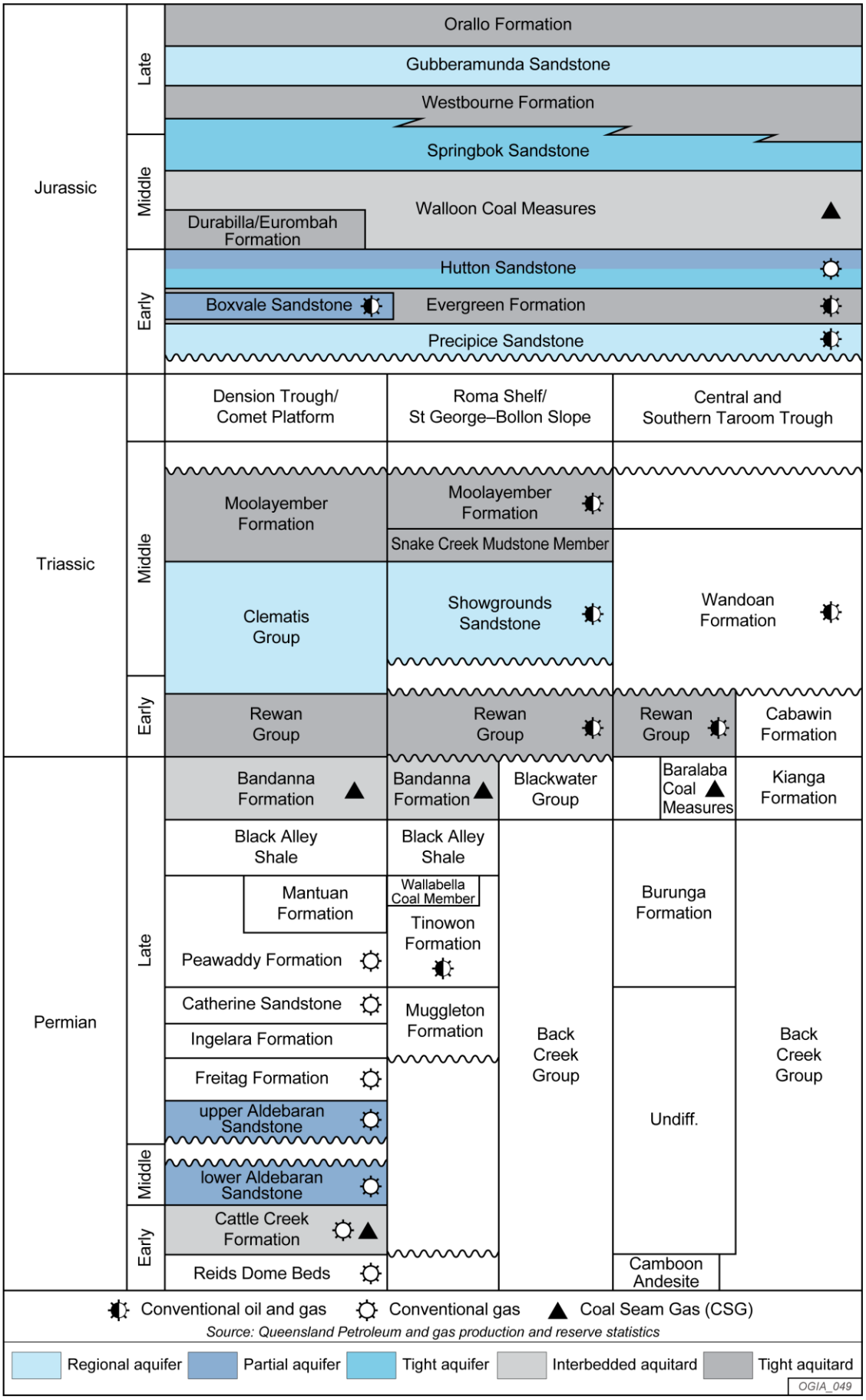

Figure 2-2: Target formations for petroleum and gas development

In the context of groundwater, there are some fundamental differences between conventional and unconventional methods. The volume of associated water extracted (i.e. incidental groundwater extraction during the production process) is much less using conventional production methods than during CSG production. CSG requires a large number of production wells to extract gas and water extraction peaks early, while for conventional production, water extraction increases over time before declining again in mature stages of development.

3 Coal seam gas

CSG is a natural gas – typically methane with small percentages of other gases such as ethane, butane, propane and pentane. It is attached to the surface of coal particles, along fractures and cleats, and is held in place by water pressure. The coal is both the source and the reservoir of the gas. The gas is extracted by drilling a well into the coal formation and pumping groundwater out of the well to depressurise the formation. The volume of water that needs to be pumped to achieve the pressure reduction varies from well to well and is highly dependent on the geology intersected by the well.

A typical layout of a CSG well is shown in Figure 3-1. To produce gas, the water pressure in the well is reduced to 35–120 psi, which is equivalent to 25–80 metres head of water. Once the desired pressure is reached, pumping continues at the rate necessary to maintain the pressure, until gas production becomes uneconomical. Initially, as shown in Figure 3-2, groundwater alone is extracted, but as the pressure drops, more and more gas is released and extracted together with water, leading to an increasing ratio of gas to water over time. The flow of water and gas together is known as 'dual-phase flow' (Morad et al., 2008).

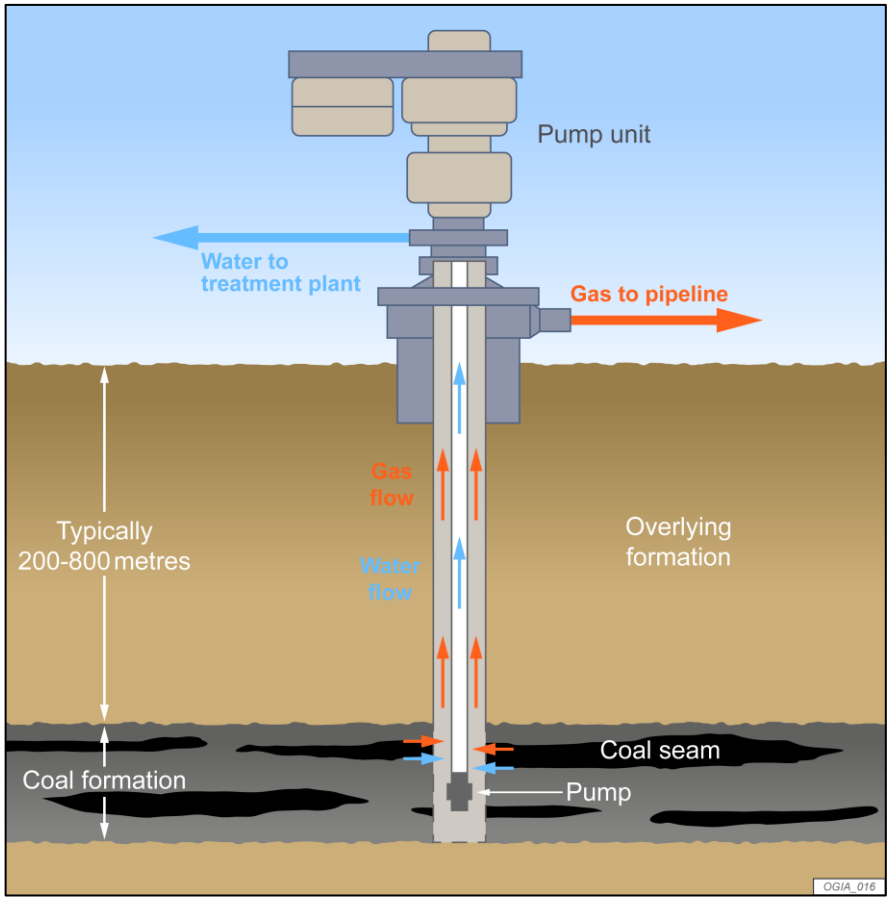

Figure 3-1: Typical CSG well construction

CSG has grown to become the dominant source of natural gas in Queensland, comprising more than 95% of the gas produced and more than 99% of the remaining proved and probable gas reserves (Department of Natural Resources, Mines and Energy, 2017). The CSG produced from the Surat and

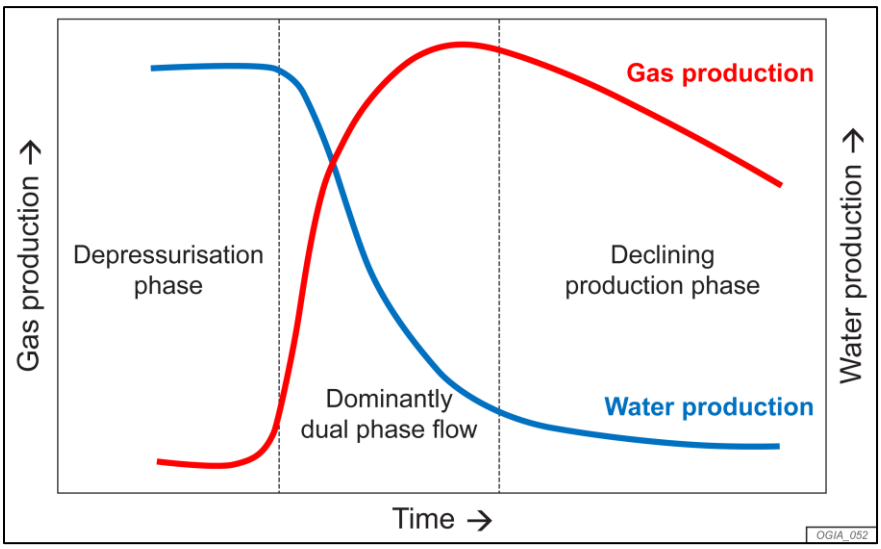

Figure 3-2: Typical gas and water flow profile during CSG production

Bowen basins is the feed stock for the liquefied natural gas (LNG) export industry based in Gladstone, with some reserves now solely dedicated to the domestic market.

The first commercial production of CSG was in the Bowen Basin Permian Coal Measures. This production began in 1996 at Dawson River (Baralaba Measures) near Moura, where permeabilities are reported to be relatively tight (10 millidarcy or mD), leading to surface, in-seam developments (Towler et al., 2016). This was followed by production in the Fairview area (Bandanna Formation) by 1998. By 2002, the Peat and Scotia fields had also started producing (both Baralaba Measures), which, similar to Fairview, are reported to have structurally enhanced permeability due to their anticlinal setting.

By the early 2000s, the focus for development had shifted to the overlying Surat Basin targeting the Jurassic Walloon Coal Measures. Commercial gas production began from the Surat Basin, Walloon Coal Seams in 2006 from the areas west of and between Dalby and Chinchilla (Tipton West, Kogan and Berwyndale fields). By 2011, the Surat Basin had overtaken the Bowen Basin as the chief supplier of natural gas in general, and of CSG in particular (Towler et al., 2016).

4 Conventional petroleum and gas

Conventional P&G is found in porous rock formations, such as sandstone. Gas and other petroleum products, formed over millions of years, move through the porous rock in a generally upward direction until a trap stops the movement and concentrates the hydrocarbons. The trap could be dome-shaped at the boundary between the permeable formation and the overlying impermeable formation, or it could be a faulted structure in the rock, having the same effect. As the gas concentrates, the porous rock becomes a gas reservoir.

Traps are formed either by folds and other structures in sedimentary layers (structural traps), or where more permeable formations transition into impermeable formations (stratigraphic traps). While both structural and stratigraphic traps are found within the Surat CMA, stratigraphic traps are more prevalent. The Moonie oil field and the Peat and Scotia gas fields are examples of structural traps (Department of Natural Resources and Mines, 2017), whereas the Roma and Surat gas fields are typical of stratigraphic traps on the western limb of the Taroom Trough (Figure 2-2).

Formation water (or connate water) exists naturally in the formation with the hydrocarbons. As the oil and gas migrates from its source rock, it moves slowly upwards through the water-filled pore spaces and fractures in porous and permeable sedimentary layers until it reaches an impermeable barrier. The water remains below the oil and gas saturation and the quality of water is generally saline.

Extraction of gas from conventional reservoirs requires a relatively small number of production wells compared to CSG reservoirs, because the gas tends to be localised and can move relatively easily though the porous rock towards the well. Although water is extracted along with the gas, there is no need to lower water pressure over large areas to produce the gas. The volume of water extracted varies, but is generally much less than for CSG.

Conventional oil and gas production in the CMA is at a mature stage, with most fields declining in production. Most of the exploration and development activities were undertaken from the 1960s through to the 1990s. Current gas production from conventional methods is less than one per cent of total gas production in the Surat and Bowen Basins and the proportion will continue to fall as CSG production progressively increases. The Moonie oil field, discovered in 1961, has been the most productive of all fields, accounting for the majority of total production.

Figure 4-1 shows the major P&G fields across the Surat CMA. The reservoirs are primarily contained in Permian, Triassic and Early Jurassic sediments along the western edge of the Taroom Trough. Figure 2-2 shows the reservoirs in relation to their stratigraphic sequence.

The geological regions associated with the Bowen Basin oil and gas fields are the Roma Shelf, the St George–Bollon Slope and the Taroom Trough. The Permian Aldebaran Sandstone and Tinowon Formation provide gas reservoirs in the northern part of the CMA, while the Rewan Group, Showgrounds Sandstone (Clematis equivalent) and Moolayember Formation/Wandoan Formation are the main Triassic oil and gas reservoirs. The Evergreen Formation and Precipice Sandstone are the primary reservoirs in the Surat Basin. The Precipice Sandstone is the main reservoir at the Moonie oil field, which lies about 200 km southeast of Roma. The Moonie field is a structural trap along an anticline. It is the largest oil resource in the Surat Basin but is nearing depletion. Most of the oil is contained within the Precipice Sandstone, with some in the permeable part of Evergreen Formation.

Generally, conventional production is not from the area where CSG production is proposed. The only exception is around Roma where there are conventional reservoirs (Bowen Basin sediments, Clematis Sandstone and Precipice Sandstone) underlying the proposed CSG development from the Surat Basin (Walloon Coal Measures).

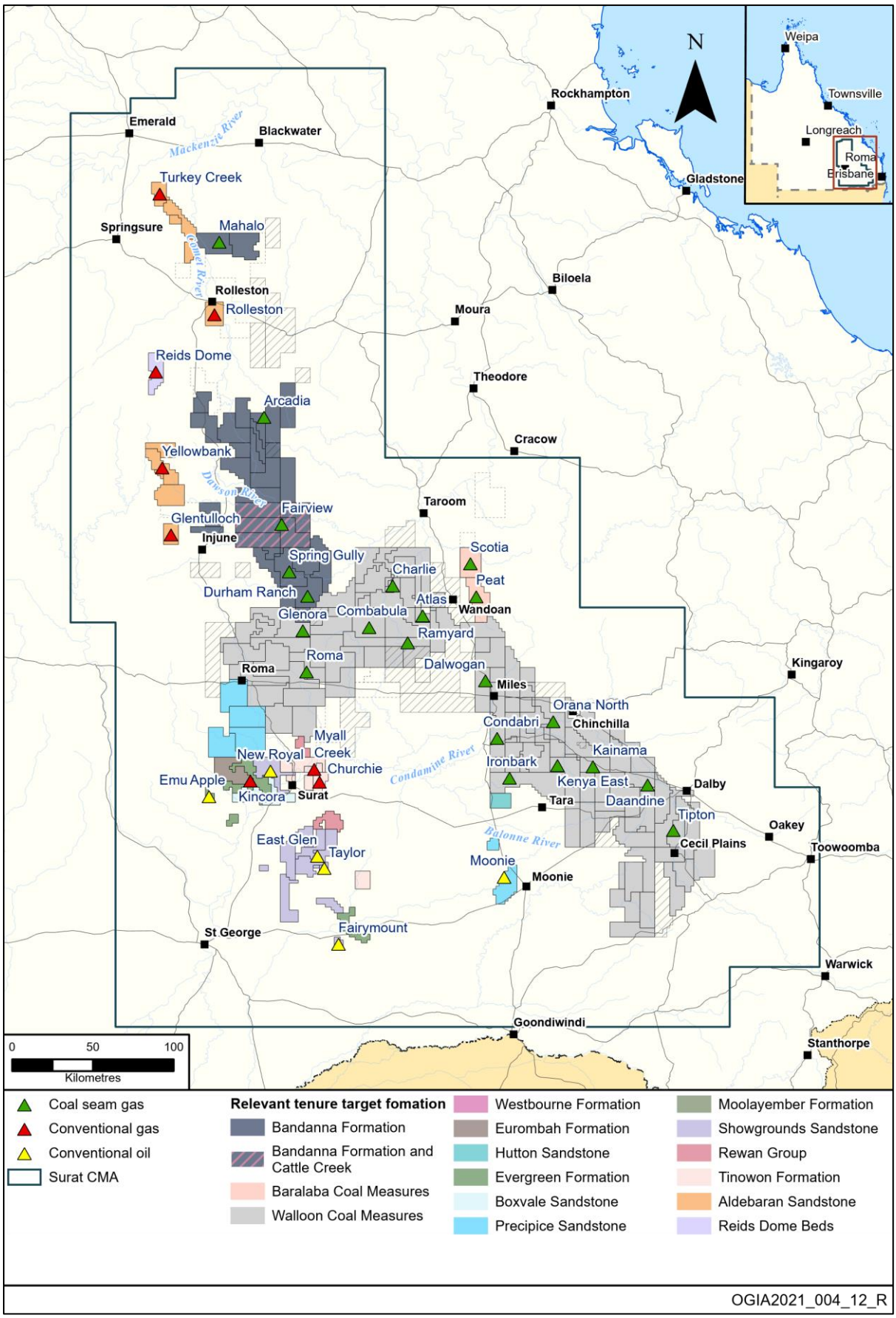

Figure 4-1: Location of major existing and proposed P&G fields in the Surat CMA

5 Petroleum and gas wells

5.1 Construction types

CSG wells in the CMA are generally constructed as traditional vertical wells that are screened into the coal formations across the productive coal seams. Wells are constructed to a finished diameter of 5–7 inches (127–178 mm) with a production casing that is typically opened through the production zone within the coal formation, accessed either through pre-perforated casing across the coal seams or by shooting holes through the casing and cement grout across the productive coal seams (Figure 5-1). Both construction types result in inlet intervals to provide access to formation fluids (water and gas).

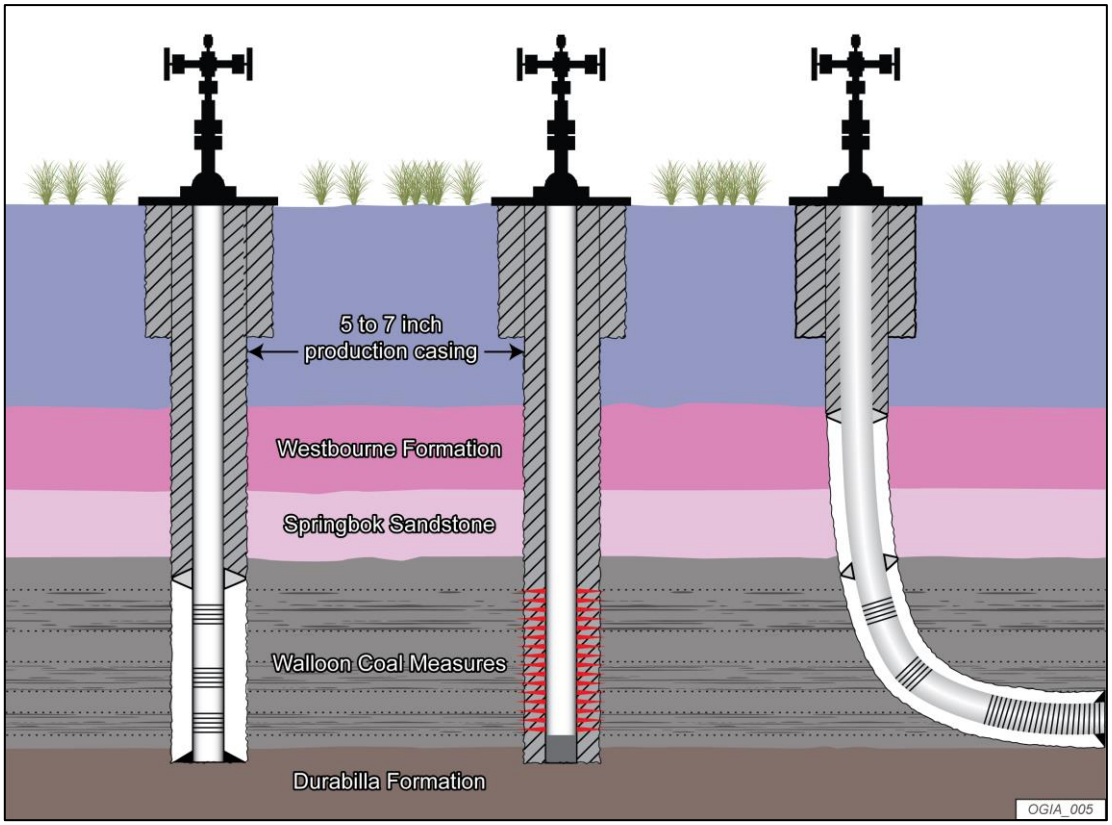

Figure 5-1: Typical construction of a CSG well

Directional and horizontal wells are also drilled, primarily to minimise the surface footprint and optimise production where coal seams are favourably disposed. Horizontal drilling is predominantly used in the Bowen Basin when conditions allow the well to be drilled to run along the target coal seam. This increases the contact the well has with the coal seam, allowing for greater production. In some instances, the accessed intake zone can be more than one kilometre from the well head (Figure 5-2).

In the Surat CMA, deviated drilling is becoming common around the Condamine Alluvium to minimise surface impact in prime agricultural land. Multiple wells are drilled in different directions, from a single well pad or cluster, to access multiple seams at different depths (Figure 5-2).

In the context of assessing groundwater impacts, the primary focus is on well intake zones and their location in terms of depth and coordinates, instead of well heads. This information is then used in determining where the groundwater is extracted from and how it may impact groundwater pressure.

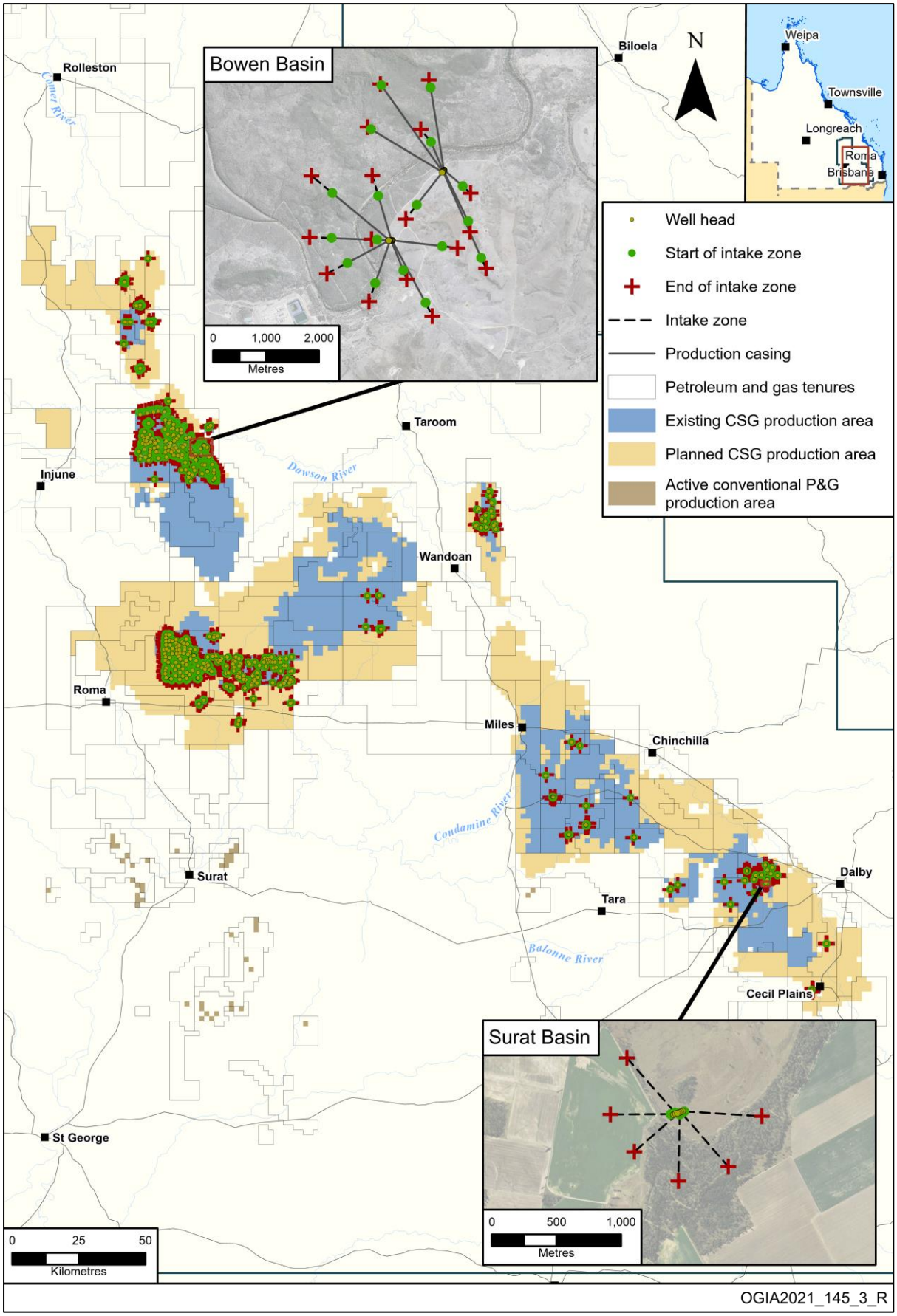

Figure 5-2: Directional wells drilled in the Surat Basin

The compiled CSG well data is processed further to estimate number of completed directional wells, assuming that a directional well deviates by at least 50 m from the well head.

The location of estimated directional wells in the Surat CMA is shown in Figure 5-2 with examples of two clusters at a local scale. There are approximately 730 directional or horizontal wells in 352 clusters – 314 in the Bowen Basin and 38 in the Surat Basin around the Condamine Alluvium.

General industry practice for well construction is to establish a 'set-back' distance of at least about 30 m between permeable water-bearing zones and the top of the CSG production zone. This also suggests that in instances where coal seams or gas flows are encountered in less permeable parts of the Springbok Sandstone, wells may be completed to access those zones.

Construction and design of conventional oil and gas wells depends upon the purpose but has largely remained unchanged since 1962. There are two broad construction types as presented in Figure 5-3: cased and cemented/partially cemented wells, primarily for the purpose of production or left as 'shut-in' wells for potential future production purposes; and open and plugged wells, for exploration or appraisal purposes, then left as abandoned or converted to water bores.

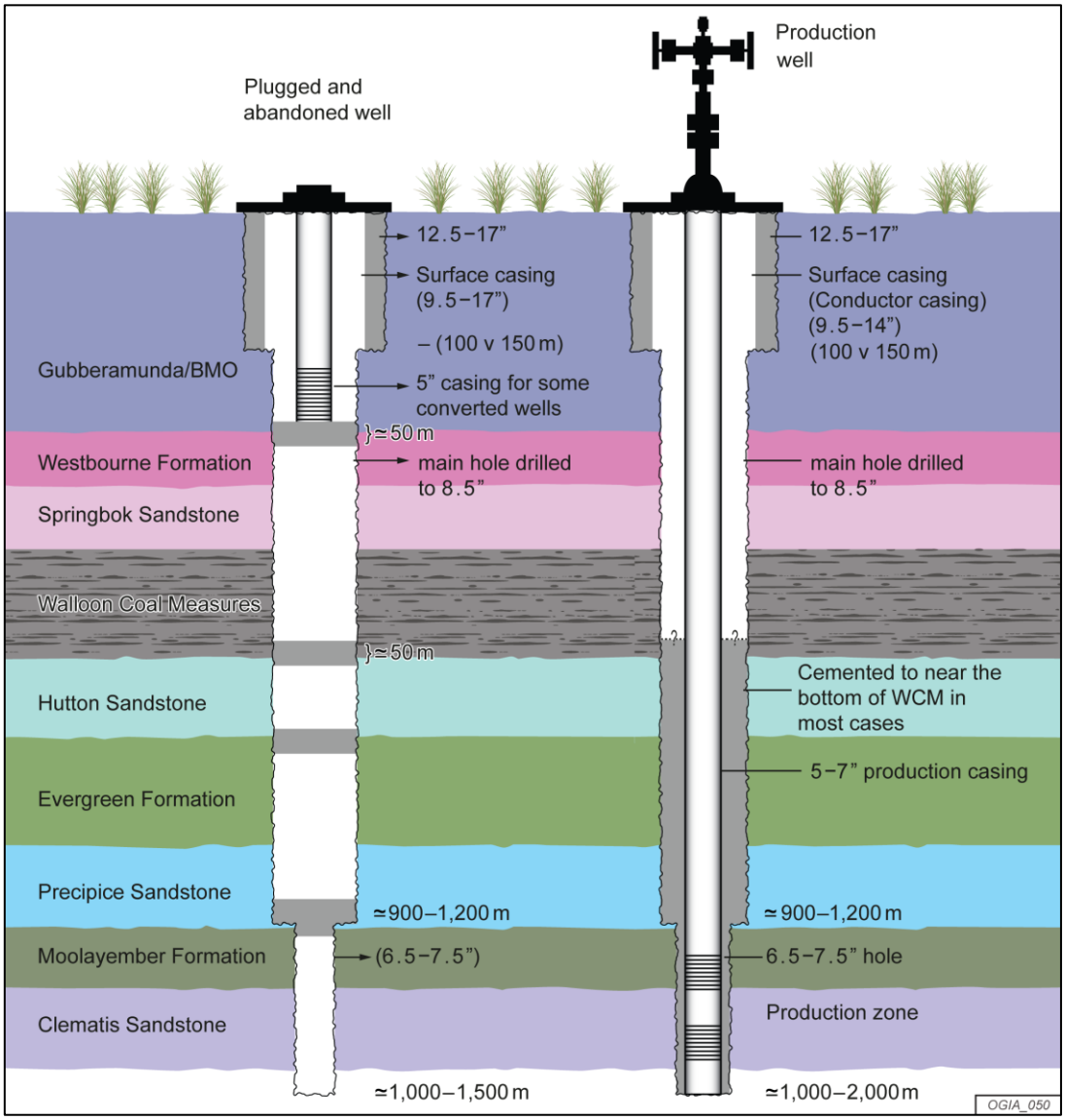

Figure 5-3: Typical construction types of conventional oil and gas wells

Almost all wells are cased and cemented from surface to a depth roughly corresponding to the Gubberamunda Sandstone (around 100 to 150 m). To this depth, the holes are drilled to a diameter of 12.5 to 17 in (317.5 to 431.8 mm) and a surface casing (referred to as conductor casing) 9.5 to 14 in (241.3 to 355.6 mm) in diameter is placed in this part of the hole. The annulus space is always cemented to provide a sound foundation for drilling deep wells and to avoid contamination to shallower aquifers. Around 2011, following the introduction of the code of practice for CSG well construction, cementing to isolate all formations became more prevalent. The code was updated in 2013 to provide more detailed requirements and guidance to CSG well and water bore construction and management, including abandonment and related drilling activities. This code is enforced through the Petroleum and Gas (Safety) Regulation 2018 and addresses safety and environmental issues in the construction and abandonment of CSG wells and water bores.

Typically, a **development well** is defined as a petroleum well that is drilled to produce or to inject petroleum for storage underground, while an **exploration well** is a petroleum well that is drilled to explore for the presence of petroleum or natural underground reservoirs suitable for storing petroleum or to obtain stratigraphic information.

The status of a well could be: a **producing well**; a **shut-in well** that has temporarily stopped producing petroleum; a **suspended well** that is capable of producing, but the productive interval in the well has not been completed for production; or **plugged and abandoned**.

5.2 Data provision and data register

Petroleum resource authority holders are required to submit well completion reports for all petroleum wells. The Petroleum and Gas (General Provisions) Regulation 2017, specifically section 36, prescribes a range of data and interpreted information about the well that must be included with the well completion report or well abandonment report. The report must be submitted within 12 months after the rig release day for the well and must include items such as details of well construction and equipment installed in the well or bore, details of the cementing and a geological interpretation of the stratigraphy that it intersects.

Previous data storage systems (Mineral and Energy Resources Location Information Network or MERLIN, Queensland Digital Exploration (QDEX) Data and Reports) have recently been replaced by Geological Survey of Queensland's (GSQ) cloud-based Open Data Portal. Tenure holders now submit their well completion reports, along with other survey data, through this system.

Information about well construction is currently reported by tenure holders through the GSQ Open Data Portal. The information is then stored for the confidentiality period of three years (exploration or appraisal well or bore) or five years (development well or bore) after the day on which the drilling rig was released, then made available via the GSQ Open Data Portal.

The Department of Resources has also established an online viewing platform, GeoResGlobe, which is capable of searching and displaying the available data from GSQ Open Data Portal, as well as MyMinesOnline, which is the system used to administer resource authorities in Queensland.

5.3 Distribution of wells

As at the end of 2020, approximately 12,000 P&G wells within the Surat CMA have been lodged with GSQ. The type of well and status stored is not directly aligned to the definitions in the GSQ Open Data Portal and the historical attribution of the various terms has not been consistently applied. Therefore, for the purpose of the UWIR, OGIA processes information to tag well types and status

based on location, depth, tenure types and water production. Well types and status from this analysis are presented in Figure 5-4 and summarised in Table 5-1, which suggests the following:

- As of late 2020, there are an estimated 8,600 CSG wells in the Surat CMA that are either in production or have been completed as production wells.
- Of these, 84% are in the Surat Basin and the rest are in the southern Bowen Basin.
- Although there are about 350 conventional oil and gas wells, only 52 of those are currently active.
- There are 500 additional wells outside CSG production areas for exploration or testing purposes.

Growth of wells over time is described further in section 5.8.

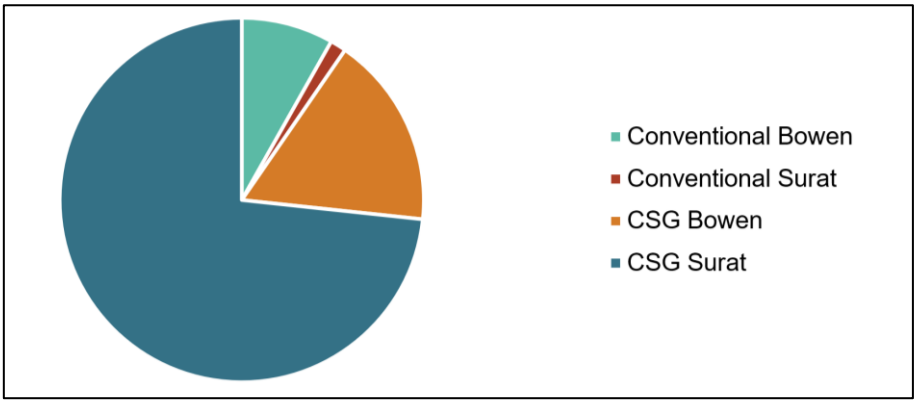

Figure 5-4: Proportion of P&G wells in the Surat CMA, by basin and well type

Table 5-1: Summary of P&G wells in the Surat CMA

		Conventional		CSG	
Well sub-type	**Status**	**Bowen**	**Surat**	**Bowen**	**Surat**
Petroleum storage	Active	12	-	-	-
	Suspended	11	18	-	-
Production	Active	52	18	1,109	6,031
	Potentially producing	7	2	229	354
	Suspended	293	104	96	471
Exploration	Existing	-	-	209	893
	Suspended	34	-	129	220
Plugged and abandoned		565	27	261	755
Total		**974**	**169**	**2,033**	**8,724**

5.4 Tenure and authorities

5.4.1 Tenure system

The Queensland *Petroleum Act 1923* and *Petroleum and Gas (Production and Safety) Act 2004* (P&G Acts) specify authorities that can be granted for activities related to P&G exploration and production.

The two authorities of relevance to this report are those that provide associated water rights to the tenure holders; namely, the authority to prospect (ATP) and the authority to operate a petroleum lease (PL). These authorities are referred to collectively in this report as **petroleum tenures**. Petroleum tenures provide rights in relation to gas and other petroleum products, such as oil.

There is no distinction between a petroleum tenure that supports conventional P&G production and a petroleum tenure that supports CSG production. However, the use of the tenure is constrained by the environmental authorities granted under Queensland's *Environmental Protection Act 1994* (the EP Act) or the development plans for the tenure approved under the P&G Acts.

An ATP gives the tenure holder the right to explore (or prospect) for petroleum resources. That right includes drilling test wells to evaluate petroleum resources, carrying out test production and taking groundwater in the course of carrying out those activities. A tenure holder may relinquish all or a part of a tenure at any time.

The holder of an ATP may apply for a PL if a commercially viable petroleum resource is discovered. The application must be accompanied by an initial development plan that details the nature and extent of the proposed activities. Once granted, a PL authorises the holder to carry out production testing, produce petroleum within the tenure area and take groundwater in the course of carrying out these activities. A PL can be granted for up to 30 years, with potential for renewal. All water extraction must be reported to the Department of Resources.

Petroleum tenures relate to specific areas of land which are generally described in terms of blocks and sub-blocks. Each block is about 75 km^2 and each sub-block is about 3 km^2.

The entities that hold petroleum tenures are referred to as ***petroleum tenure holders***. As tenures are often held as joint ventures, a single entity is assigned as the **authorised holder** when the tenure is granted. The authorised holder is the primary contact for the petroleum tenure and is legally responsible for dealing with served notices and other documents. All references to tenure holders in this report refer to the authorised holders.

5.5 Distribution of petroleum and gas tenures in the Surat CMA

The locations of all P&G tenures in the Surat CMA as of April 2021 are shown in Figure 5-5. Three types of tenures are presented: ATPs or exploration tenures; PLs, which authorise production; and petroleum lease applications (PLA), which are ATPs under application to become PLs. Together these tenures cover approximately 40% of the Surat CMA.

Since 2018, the Queensland Government has released approximately 20,000 km^2 of land for exploration within the Surat CMA. Almost 20% of the CMA is covered by ATPs that have little or no activity in relation to water extraction. Production of P&G is currently occurring, has occurred, or is proposed in the near term, from tenures that are either PLs or PLAs. There are some ATPs where EAs have been applied for, or where EISs have been completed or submitted but PLs have not yet been applied for.

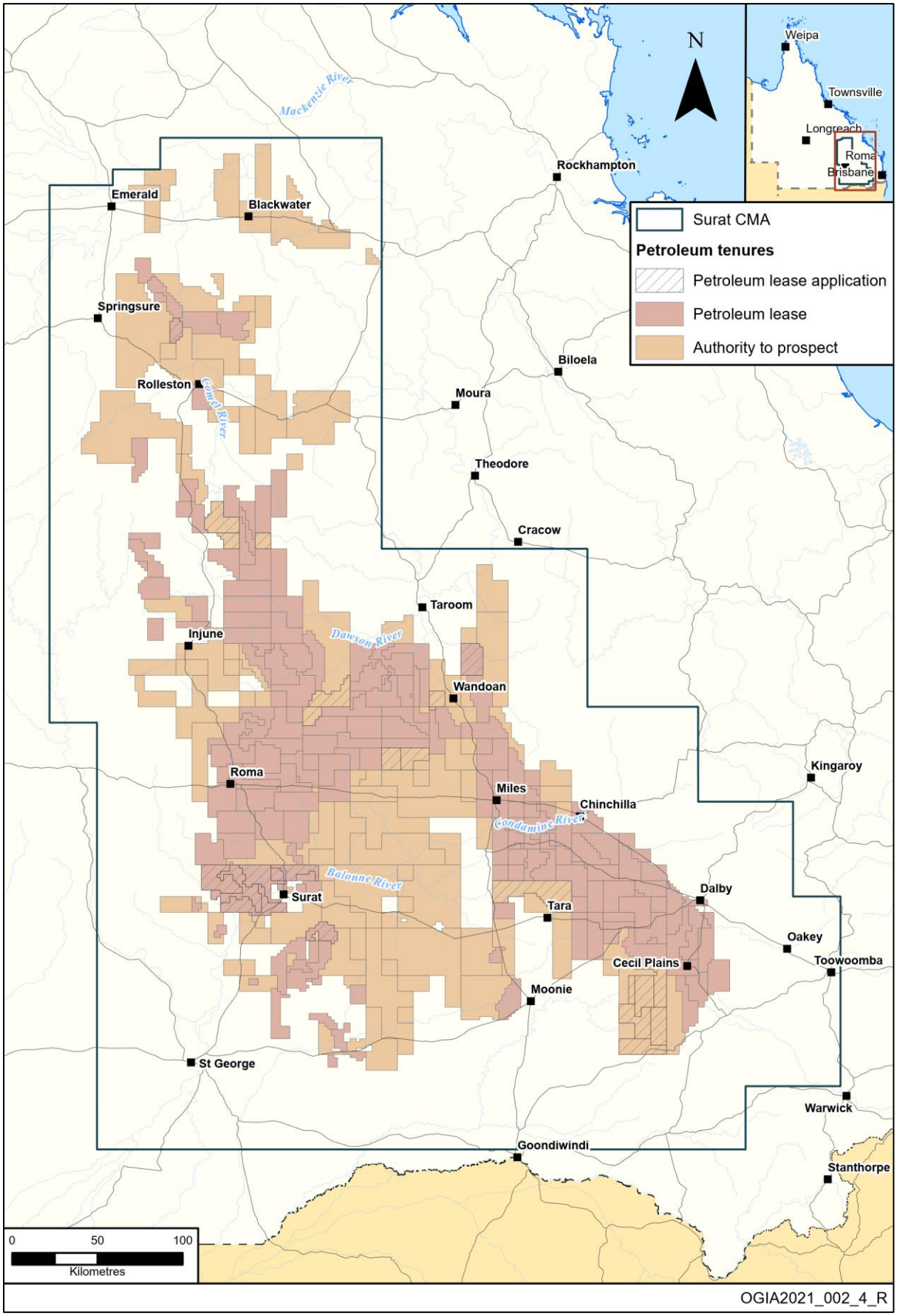

Figure 5-5: Distribution of petroleum and gas tenures in the Surat CMA

The distribution of PLs and PLAs is shown in Figure 5-6, grouped in different colours to show major authorised holders for those respective tenures, representing:

- AGL, its subsidiaries and joint venture partners (collectively referred to as **AGL**)
- Armour Energy, its subsidiaries and joint venture partners (collectively referred to as **Armour**)
- Arrow Energy, its subsidiaries and joint venture partners (collectively referred to as **Arrow**)
- Bridgeport, its subsidiaries and joint venture partners (collectively referred to as **Bridgeport**)
- Origin Energy, its subsidiaries and joint venture partners including Australia Pacific LNG (collectively referred to as **Origin**)
- Queensland Gas Company, its subsidiaries and joint venture partners (collectively referred to as **QGC**)
- Santos, its subsidiaries and joint venture partners (collectively referred to as **Santos**)
- Senex Energy, its subsidiaries and joint venture partners (collectively referred to as **Senex**)
- **other** authorised holders.

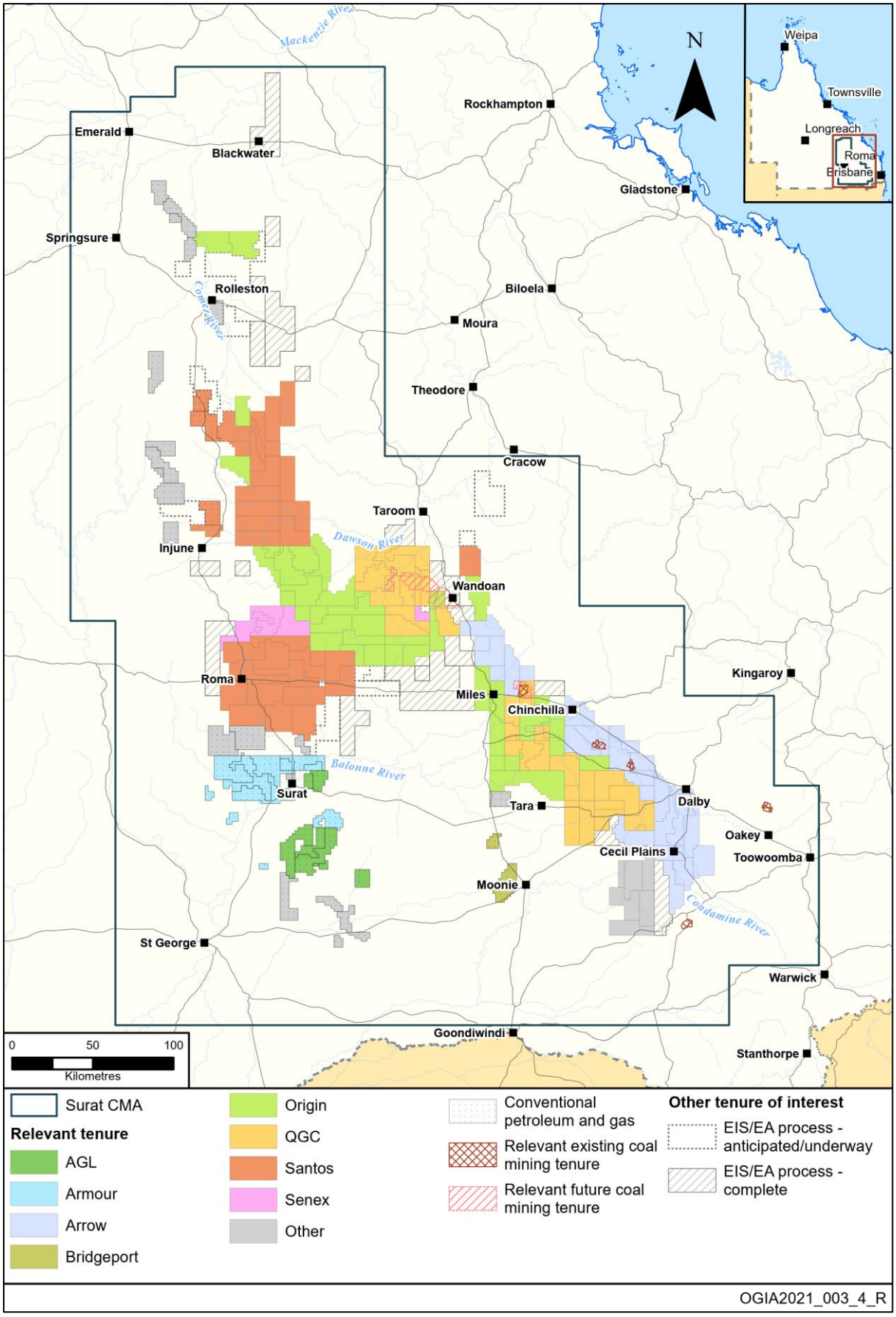

Figure 5-6: Distribution of tenure types and their authorised tenure holders in the Surat CMA

5.6 Production footprints and scheduling

PL tenure areas may be utilised by the tenure holder for production purposes and/or gas field development infrastructure. A tenure holder's plan for developing production fields in a tenure may vary over time due to emerging information about reservoir dynamics, availability of reserves and changing market conditions. Those changes to plans may affect the proposed development footprint, as well as the timing of production commencement and cessation. Some of the tenure area may never be developed. Typically, about 50 to 70% of the total tenure area is used for production purposes (Table A1-1).

In the context of this report, the part of the PL or PLA where production is occurring or proposed is referred to as the **production area**. The production footprint, with associated planned commencement, development sequencing and cessation, is collectively referred to as the **development profile**.

On an annual basis, OGIA compiles a whole-of-life cumulative **industry development profile** at the sub-block level, based on information received directly from tenure holders and verified information available to DoR through various reporting arrangements. The development profile is used as the input scenario for the regional groundwater flow model for impact predictions and development of various impact-management strategies.

Figure 5-7 shows the distribution of the production area as of late 2020, together with production areas from the previous UWIRs. Three categories are shown:

- **existing CSG production area** – land footprint on which CSG production was occurring at the end of 2020
- **planned CSG production area** – land footprint on which CSG production is proposed at some point in the future
- **active conventional P&G production area** – land footprint where conventional P&G production is still occurring.

A comparison of the spatial distribution of existing and planned production areas between UWIR 2021 and the previous UWIR is shown in Figure 5-8. Planned commencement and cessation of CSG production areas in the Surat and Bowen basins are shown in Figure 5-9 and Figure 5-10. Details of each of the production tenures, their current status, target formation, the existing and proposed CSG wells in those tenures and planned commencement timing are provided in Table A1-2. Overall, the CSG production area (existing and planned) has increased by 8% since the previous UWIR in 2019.

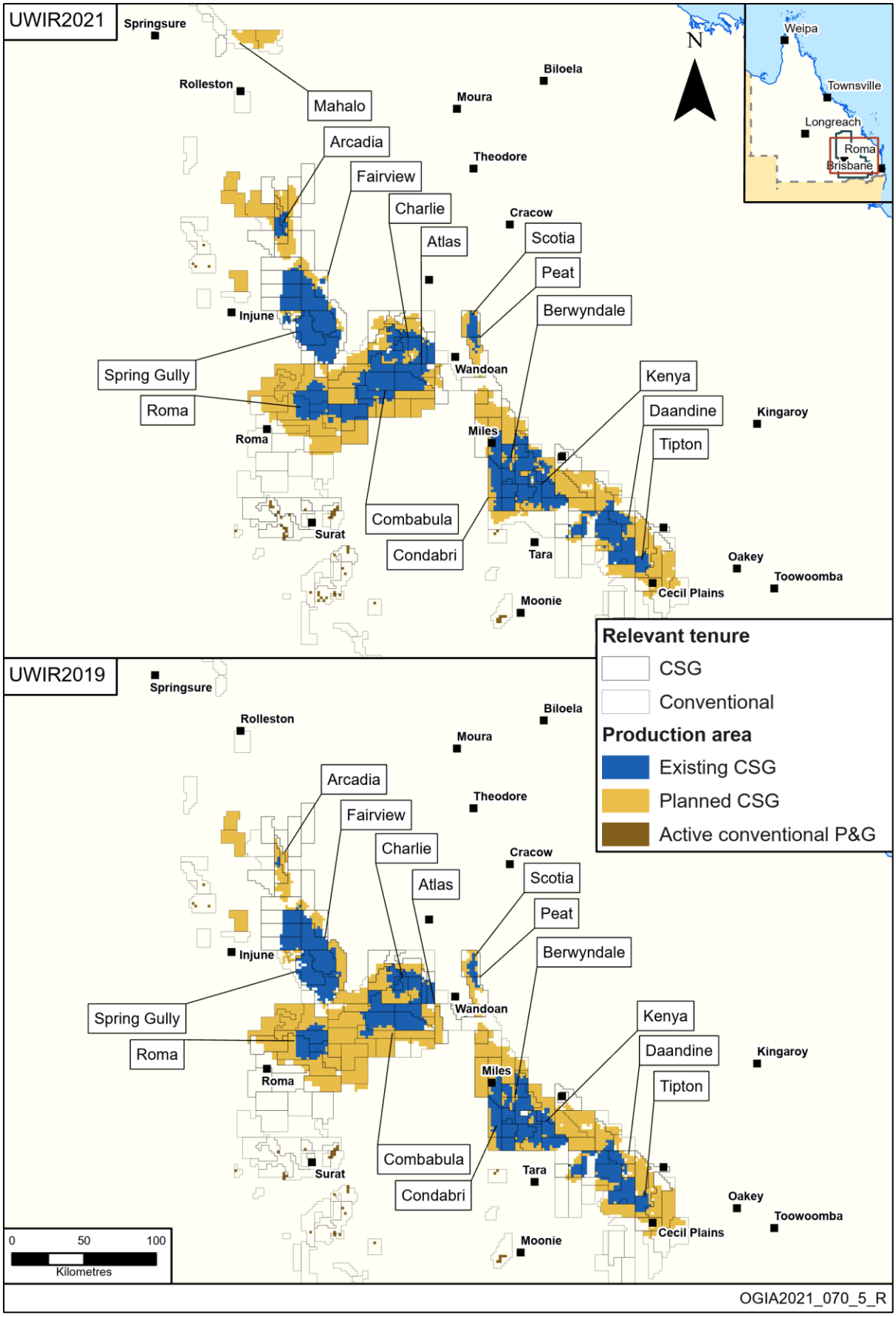

Figure 5-7: Distribution of production areas and their status (UWIR 2021 & UWIR 2019)

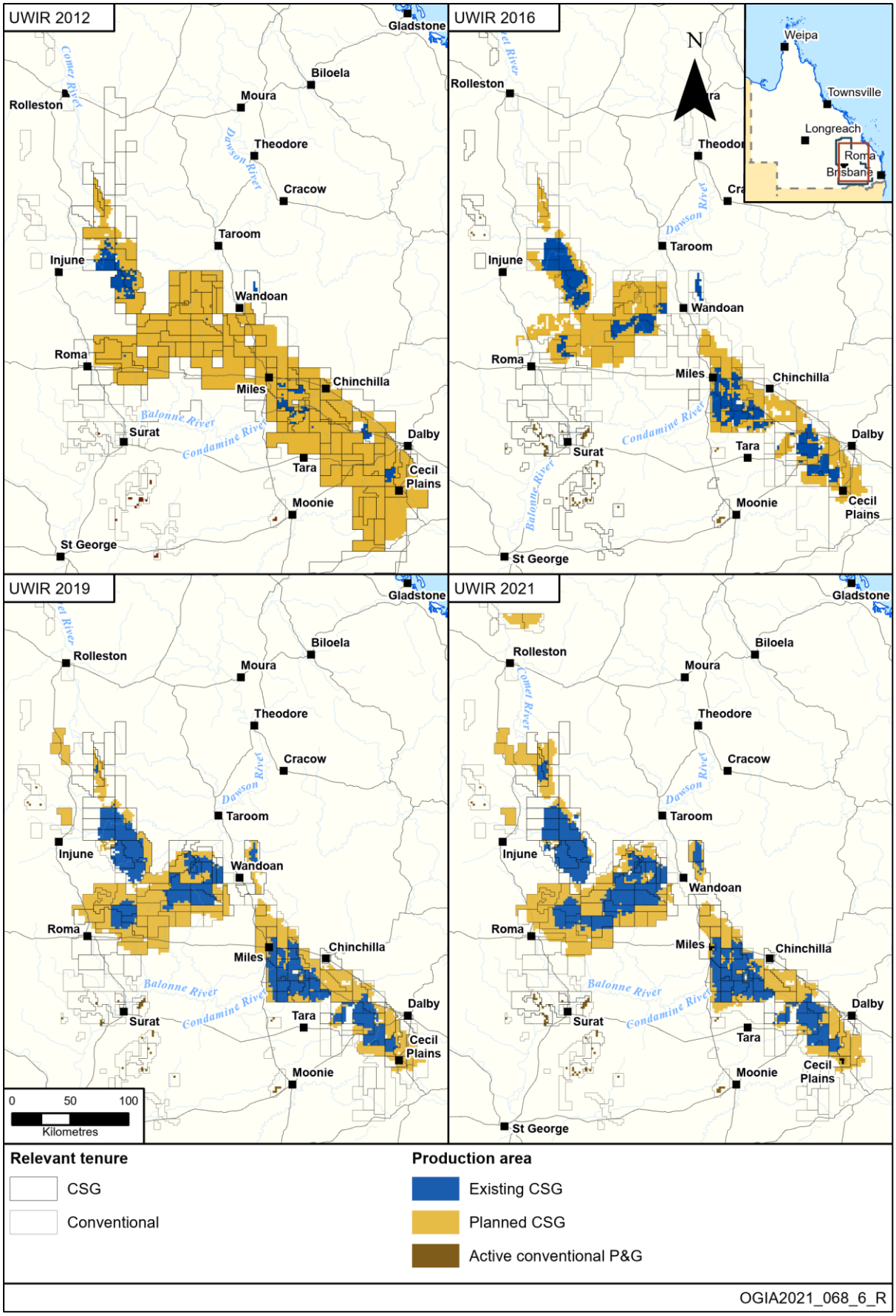

Figure 5-8: Distribution of production areas and their status (UWIR 2012, 2016, 2019 & 2021)

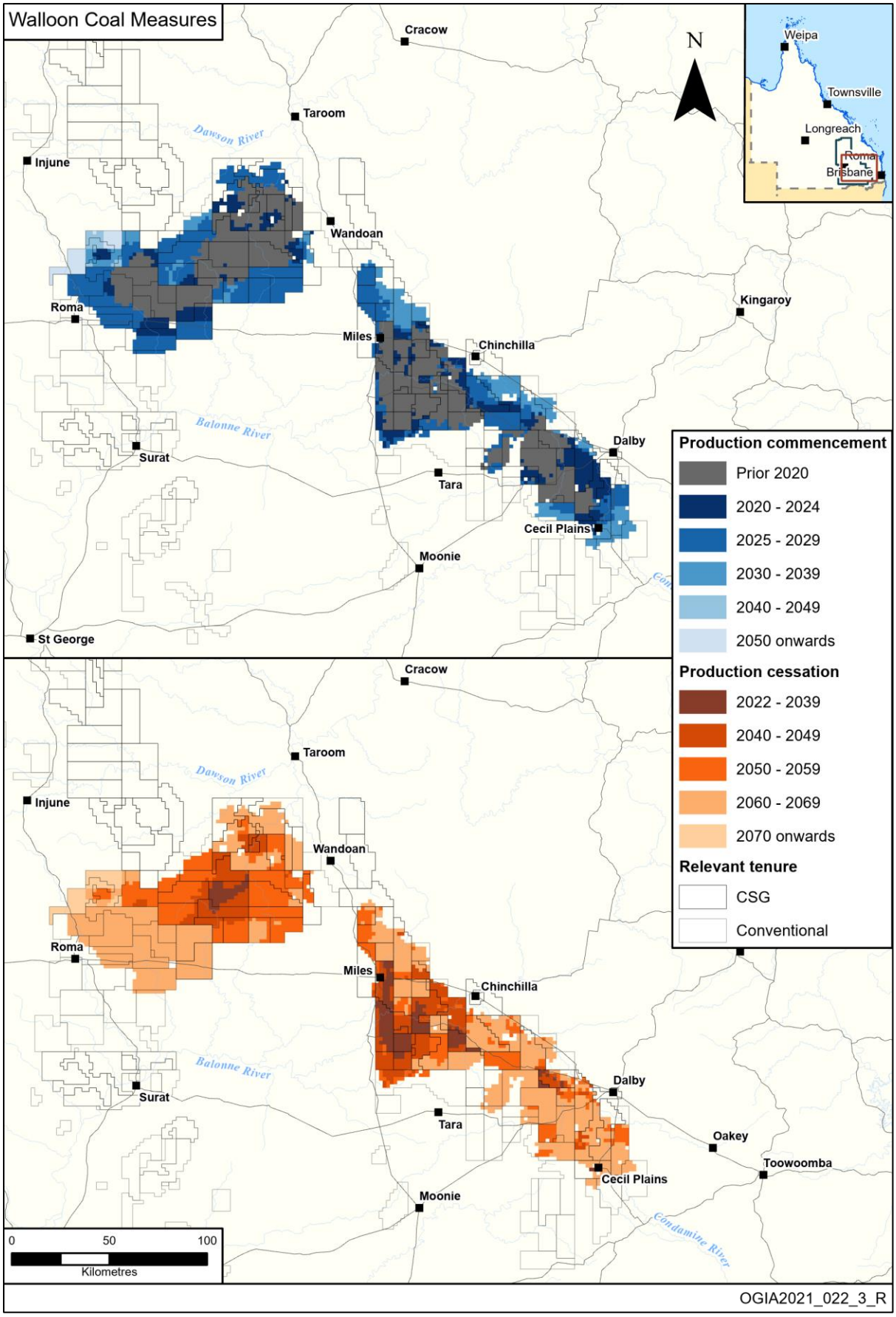

Figure 5-9: Planned commencement and cessation of CSG production areas in the Surat Basin – Walloon Coal Measures

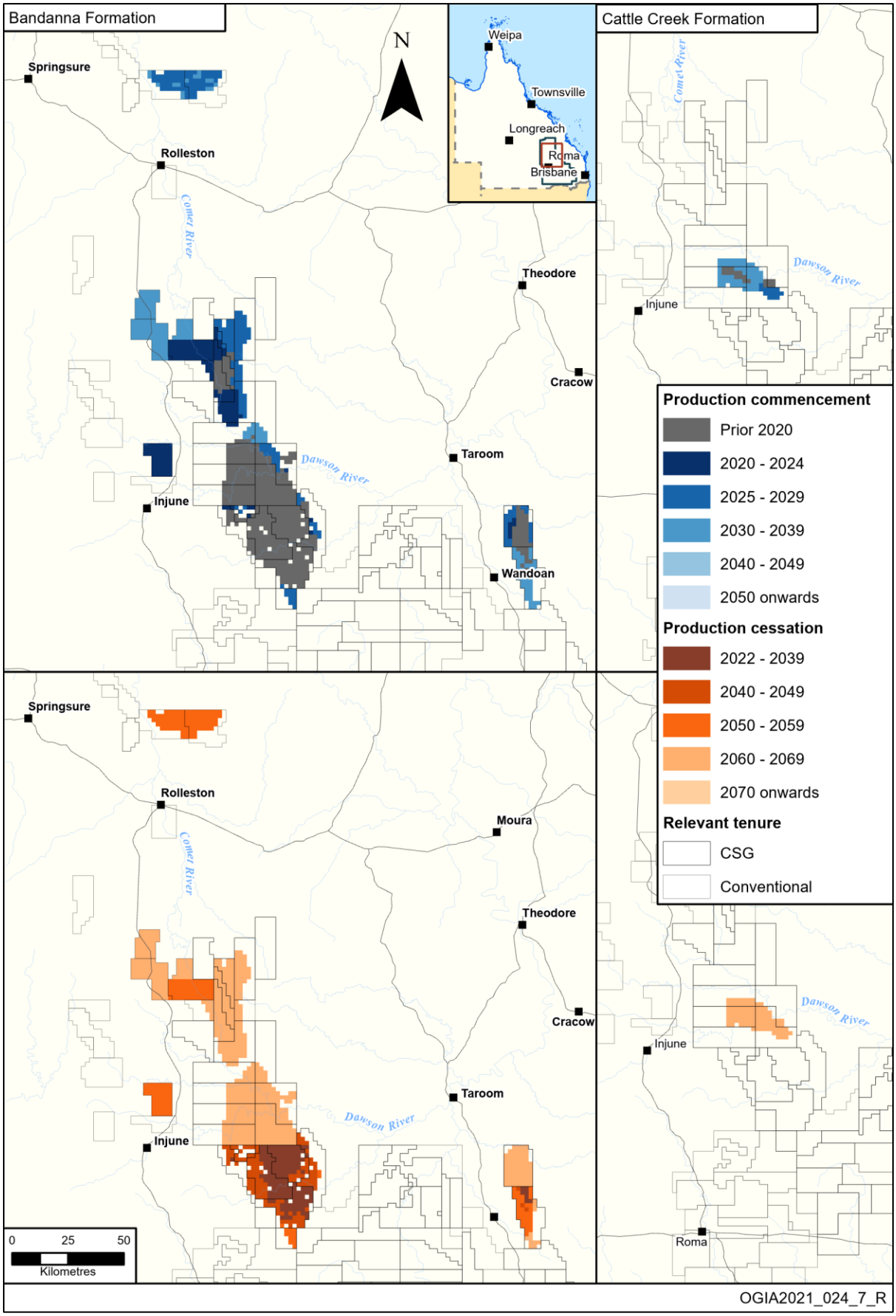

Figure 5-10: Planned commencement and cessation of CSG production areas in the Bowen Basin – Bandanna Formation

5.7 Major projects

Provided below is a brief description of CSG projects for each of the authorised tenure holders and their current development status.

5.7.1 Arrow

Arrow's Surat Gas Project is a joint venture with Royal Dutch Shell (Shell) and PetroChina. The development area originally covered approximately 8,600 km^2, however tenure area was relinquished throughout the EIS process, reducing the area to 6,100 km^2. The project originally extended from the township of Wandoan in the north, in an arc through Dalby, towards Goondiwindi in the south, with a total of 6,500 proposed production wells (Arrow Energy, 2013).

Sustained gas production is aimed at about 1,215 terajoules per day (TJ/d), with 80 TJ/d of gas for supply to the domestic gas market. An EIS for the project was lodged in December 2011 and a supplementary EIS was lodged in June 2013. The project received environmental approval from the Queensland Government on 25 October 2013 and from the Australian Government on 20 December 2013. The Surat Gas Project received a final investment decision approving the go-ahead of the project early in 2020. First gas is expected to be produced from the project in 2021.

Arrow currently has two main existing gas fields, Daandine and Tipton, with about 440 CSG wells. Daandine began supplying gas for domestic purposes in 2006; Tipton began in the following year. Production from these fields has continued with some slight expansion.

Although Arrow's planned development area has retracted in parts since the UWIR 2019, most notably west of Tipton, the total gas field footprint has reduced by less than five percent. There have, however, been some noticeable shifts in development timing. Development between Dalby and Cecil Plains has generally been brought forward, as has planned development between Kogan and Chinchilla. Arrow's northern development area, located north of Miles, has generally been scheduled later, except for the northernmost part of this gas field, which has been brought forward by up to 10 years. The northern development area is planned to begin production over a 17-year period from 2022 to 2039.

Arrow's plans show the overall well density across its gas fields has decreased compared to the UWIR 2019, with approximately 600 fewer development wells.

5.7.2 Origin

Origin's Australia Pacific LNG Project (APLNG) is a joint venture between Origin (37.5%), ConocoPhillips (37.5%) and Sinopec (25%). Project tenures run from the Chinchilla/Tara region northwest to 30 km east of Injune. The APLNG project originally included tenure southwest of Cecil Plains, known as Gilbert Gully; Gilbert Gully was transferred to Tri-Star Energy in late 2019.

The project includes existing gas fields Spring Gully and Peat in the southern Bowen Basin. In 2010, Origin submitted an EIS for the project to cover the 5,700-km^2 project area in the Surat Basin (Australia Pacific LNG, 2010). The project was approved by the Queensland Government in late 2010 and by the Australian Government in early 2011.

Since 2019, Origin has added a number of gas fields to its production plans. Mahalo, located 30 km north of Rolleston, is scheduled to commence production in 2025, with close to 130 wells planned. The Ironbark Project has been on-and-off in the plans since 2010. Located approximately 20 km northwest of Tara, Ironbark is now planned to commence production in 2024 and Origin intends to

construct approximately 165 wells across approximately 100 km^2; however, the project is yet to obtain the relevant tenure and approvals to allow progression to production.

Ramyard, 25 km southwest of Wandoan, has an increased planned production area since the UWIR 2019, extending a further 10 km to the south. Ramyard is now planned to progressively commence production between 2025 and 2029. Kainama, located 30 km south of Chinchilla, has been delayed and is now expected to come online in 2026 and 2027. Directly west of Miles, Dalwogan – although comparatively not a large gas field– has been significantly reduced in planned production area. As it is currently planned, Dalwogan gas field is expected to commence production in its entirety in 2025.

The existing fields will continue to expand progressively outward from their current production areas. Spring Gully is expected to expand 10 km towards Injune. At the time of the UWIR 2019, the development plans indicated the Combabula development area would expand 20 km to the west by 2024. Since the UWIR 2019, the Combabula existing production area has expanded 5 km to the west, with 15 km still planned to be developed, but now by 2029.

5.7.3 QGC

At the time of submitting an EIS for the Queensland Curtis LNG Project, QGC was operating as a subsidiary of the BG Group. In 2016, Royal Dutch Shell (Shell) acquired 100% of the BG Group. An EIS for the project was completed in 2009. Queensland's Coordinator-General released his report on the EIS in June 2010 and the project received Australian Government approval in October 2010. At the time of submission of the EIS, the gas field tenure area was approximately 4,600 km^2 (QGC Pty Ltd, 2009).

The Queensland Curtis LNG Project area was designed in three main gas field regions: the southern development area west of Dalby, the central development area between Chinchilla and Miles, and the northern development area west of Wandoan. The project also included pipelines and an LNG facility in Gladstone. Of the major CSG proponents, QGC was the first to export LNG from the Gladstone facilities.

The footprint of QGC's existing and planned gas fields have remained relatively unchanged since the UWIR 2019, with one notable change to the northern development area, where the planned production area has contracted slightly from the west and shifted to the north. The existing production area is set to expand with QGC planning to bring almost 300 wells online across its CMA acreage by the end of 2021, most of which will be located in the northern development area.

In the southern development area, there will be minimal expansion around the existing production areas. Parts of the southern section of the central development area consisting of the Codie, Kate and Kenya East gas fields are already in production, with the remainder of the planned production area to commence by 2026.

5.7.4 Santos

Santos's Gladstone LNG (GLNG) project is also a joint venture. In 2009, Santos submitted the initial EIS proposal for the project, which included tenure from Roma to Emerald. The EIS was assessed by the Queensland Government Coordinator-General in May 2010; the corresponding Australian Government approval was released in October 2010. In 2014, Santos submitted the GLNG Gas Field Development project EIS for additional tenure areas and expansion of the GLNG project tenure footprint to 10,676 km^2. The expansion received Queensland Government approval in December 2015 and Australian Government approval in March 2016.

Since the UWIR 2019, Santos has significantly increased its existing production area footprint in the Roma gas field, by 65% to 600 km^2. Another notable increase in existing production area footprint is in the Arcadia gas field, which has gone from 15 to 110 km^2. Despite little change in the existing production footprint for the Fairview gas field, Santos now plans to infill an area of approximately 700 km^2, increasing the well density from 1.2 to 2.0 wells per km^2.

The planned production footprint for the Roma gas field begins several kilometres from the Roma township and stretches approximately 30 km to the north and 70 km to the east. The planned production continues from the northeast corner of the gas field and progressively works back towards the township, with the entire field to be in production by 2028. Scotia gas field, northeast of Wandoan, now has some planned expansion around the flanks of the current production footprint with commencement from 2029.

There are two new gas fields to begin production as part of a new project area west of the current GLNG project. Kia Ora and Arcadia West gas fields are located west of Fairview and west of Arcadia, respectively. They are planned to begin production in two stages, the first being in 2023 and the second in 2030.

5.7.5 Senex

Senex is the owner and operator of the Western Surat Gas Project, a relatively small project compared to other operators' projects. The project is located 30 km north of Roma, between the gas fields of Fairview (Santos) and Spring Gully (Origin). Senex has obtained the necessary environmental approvals for the project.

To date, the Western Surat Gas Project has experienced better than predicted results from its gas fields; as such, Senex's planned production schedule has undergone major change since the UWIR 2019. The Rhea, Dione, Phoebe and Pandora gas fields have all been scheduled later, with the earliest production from these fields planned for 2043. The projected well numbers have also changed, with an increase to a total of approximately 750 wells planned across the project.

Senex has another project area in the Surat Basin: the Atlas project, west of Wandoan. The tenure was released by the Queensland Government for domestic gas supply only and fast tracked to PL status. Senex began production from Atlas in 2019 and will continue to bring wells online through to 2030. Senex plans to produce from approximately 880 wells across its CMA acreage.

5.8 Current trends

Currently, the predominant method for P&G production in the Surat CMA is CSG. This is evident from total reported gas production from these basins as presented in Figure 5-11, which shows a sharp rise in CSG production since around 2005 and a steady decline in conventional oil and gas production since 1995. In recent years, conventional production is focusing on resource extraction efficiencies, which has seen a slight increase gas production. However, conventional production still makes up less than 1% of total gas produced from the Surat CMA.

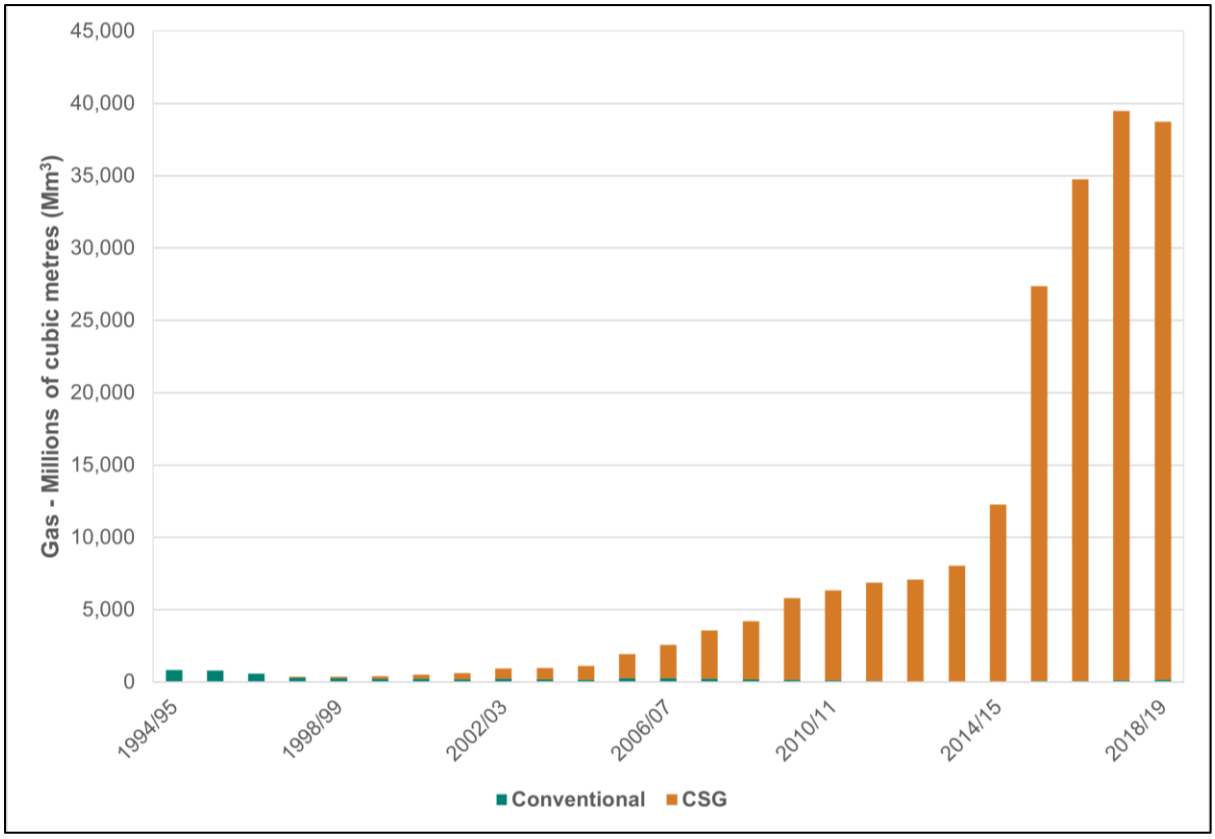

Figure 5-11: Trends in total conventional gas and CSG production in the Surat CMA

CSG projects providing gas for the domestic market have been in operation in the southern Bowen Basin since 1995 and in the Surat Basin since 2004. Four major projects were proposed in the last decade for using CSG to produce liquefied natural gas (LNG) for the export market, leading to a large expansion in CSG development in the Surat CMA. Three of these projects are already delivering gas and LNG to domestic and international markets. The fourth major project, Arrow's Surat Gas Project, received its final investment decision in early 2020. Arrow is already a domestic supplier of gas and first gas from its Surat Gas Project is expected to be delivered in 2021.

As described in section 5.3, there are estimated to be about 8,600 CSG wells currently in the Surat CMA that are either producing gas or have been completed as production wells. Of these, 84% are in the Surat Basin and the rest are in the southern Bowen Basin. There are also an additional 500 wells outside CSG production areas for exploration or testing purposes.

The number of CSG wells has now increased by about 1,800 wells compared to the ones reported in the UWIR 2019. With the increase in net footprint, the total number of projected wells has also slightly increased – from about 21,000 to about 22,000 – based on OGIA's estimates derived from the current development profile (Figure 5-12). The average well completion rate from 2012 to 2015, during the ramp-up phase, was about 1,000 wells per year. During the transition into the operational phase, 2016 to 2019, this dropped to about 710 wells per year. More recently, the rate has declined to about 680 well completions per year; this is likely due to disruptions relating to the COVID-19 situation. The average well density is about 1.5 wells per km^2, ranging from 1.2 to 1.7 wells per km^2 in the Surat basin, and 0.8 to 1.5 wells per km^2 in the Bowen basin.

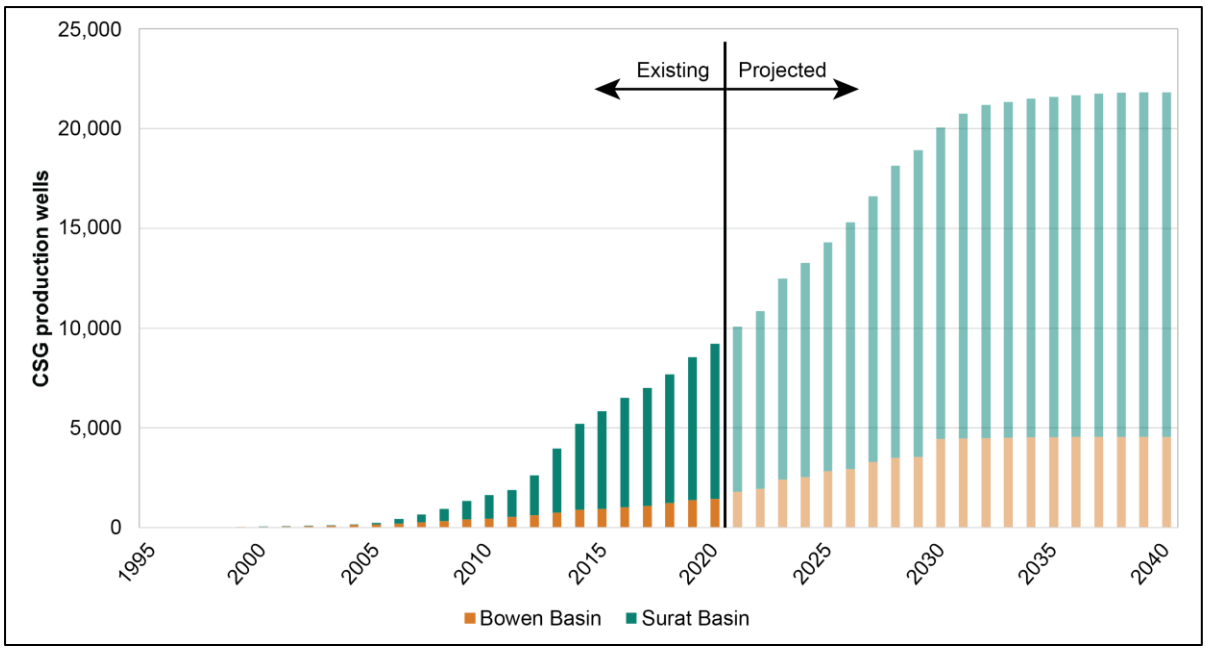

Figure 5-12: Existing and projected CSG wells in production areas

The majority of the conventional petroleum fields produce either exclusively gas or exclusively oil; very few fields produce both gas and oil. Fields north of Roma are primarily gas fields; those further south, from Roma to Moonie, tend to be either oil or gas, while Bridgeport's Moonie field, further south, is exclusively an oil field. Although there are about 30 oil fields that have recorded some production in recent years, Moonie is the major field, accounting for more than half the oil production within the CMA. Moonie's production is in a declining trend, as is the case for all conventional petroleum fields in the Surat CMA. This includes Armour's nearby Myall Creek gas fields and AGL's Churchie gas fields, located approximately 15 km east of Surat. These two fields produced almost 50% of the total conventional gas production from the Surat CMA during the period 2005-2016.

The cumulative industry development profile presented in the UWIR 2019 was based on information available as of late 2018. A number of changes have occurred since then in terms of the CSG production footprint and planned timing of commencement. A comparison of the current and previous planned development footprints is shown in Figure 5-7. Planned commencement date changes that have occurred between UWIR 2019 and UWIR 2021 are shown in Figure 5-13, with a comparison of production areas shown in Table 5-2.

Table 5-2: Production area difference between UWIR cycles

CSG production area		Tenure holder					Total
		Arrow	Origin	QGC	Santos	Senex	
UWIR 2019 (km^2)	Existing	219	1,755	2,145	1,056	39	5,214
	Planned	2,337	2,568	900	2,361	684	8,850
	Total	2,556	4,323	3,045	3,417	723	14,064
UWIR 2021 (km^2)	Existing	243	2,037	2,184	1,434	57	5,955
	Planned	2,208	2,463	915	2,931	669	9,186
	Total	2,451	4,500	3,099	4,365	726	15,141

CSG production area		Tenure holder					Total
		Arrow	Origin	QGC	Santos	Senex	
Difference (%)	Existing	11%	16%	2%	36%	46%	14%
	Planned	-6%	-4%	2%	24%	-2%	4%
	Total	-4%	4%	2%	28%	-	8%

Key observations from the comparison are summarised as follows:

- The area that is currently in production (existing CSG production area) has increased by 14% (approximately 740 km^2) since the UWIR 2019.
- The total production area (existing and planned) has increased by 8% to approximately 15,000 km^2. This is about half the area that was proposed in EIS submissions made for the four major CSG projects between 2009 and 2013, and a quarter of the total tenure area collectively held by P&G operators in the CMA.
- The expansion of the existing CSG production area is noticeable across most development areas between Dalby and Miles. There is also noticeable expansion to the east of Roma, just north of Wallumbilla.

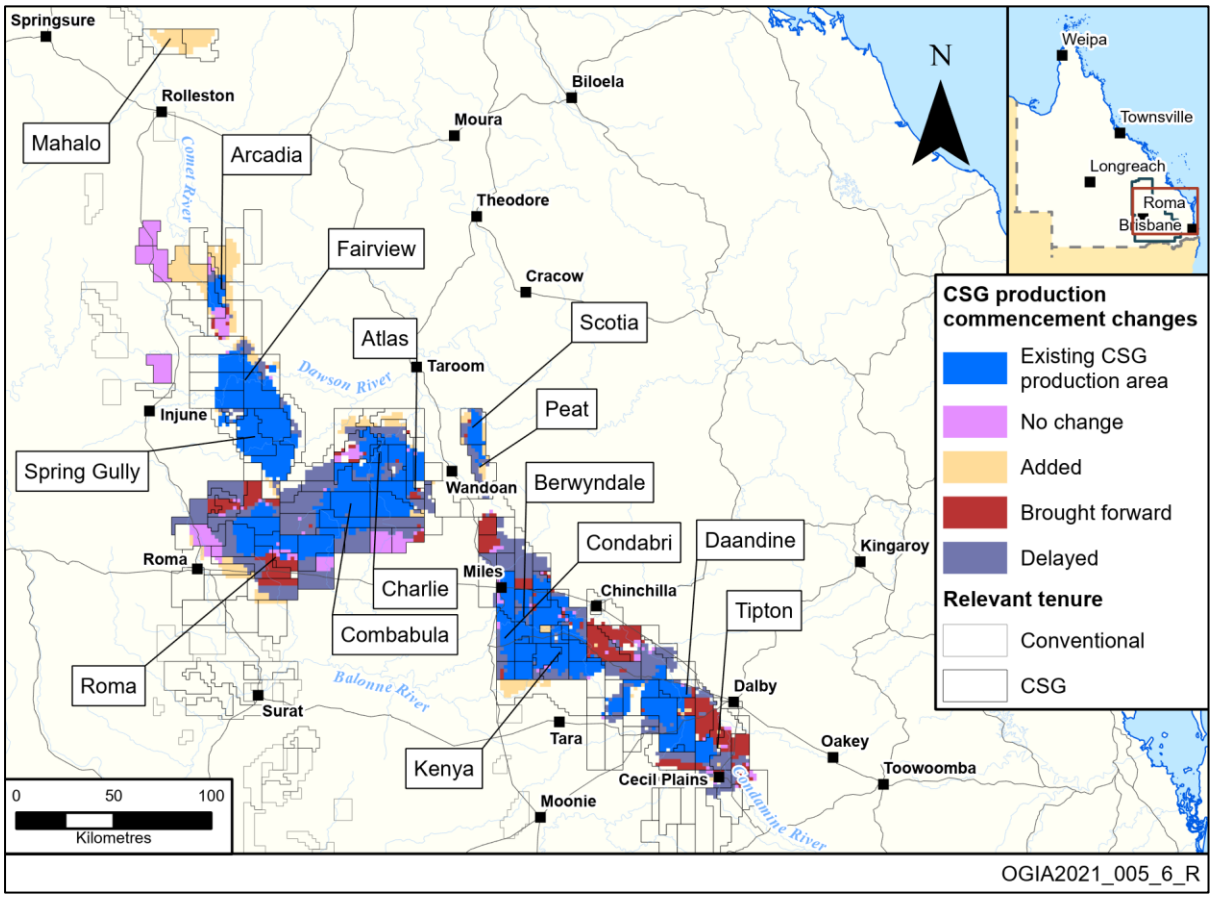

Figure 5-13: Changes in planned commencement timing of production areas from UWIR2019 (late 2018) to UWIR 2021 (late 2020)

- There are notable additions to the planned CSG production area, with Origin's new Mahalo gas field included in the current development plans and the reintroduction of its Ironbark gas field. Also, Santos has expanded its planned production area for Arcadia and Arcadia West gas fields and included a new parcel of planned production area east of Rolleston.
- Despite an increase in the planned production area over the longer term and a bringing forward of production in some fields, there has been a net slowdown in development in the shorter term. The slowdown is likely to be in response to current market conditions related to the COVID-19 situation.
- The production schedule for the majority of Santos's Roma gas field has been delayed, except for a portion around Wallumbilla.
- Senex's proposed Western Surat Gas Project has experienced better than predicted results from its gas fields and Senex's planned production schedule has undergone major change since the UWIR 2019. The Rhea, Dione, Phoebe and Pandora gas fields have all been scheduled later, with the earliest production from these fields planned for 2043.
- There have been some noticeable shifts in development timing. Development between Dalby and Cecil Plains has generally been brought forward, as has planned development between Kogan and Chinchilla. Arrow's northern development area, located north of Miles, has generally been scheduled later, except for the northernmost part, which has been brought forward by up to 10 years.

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Appendix 1 Details of P&G tenures

Table A1-1: Summary of petroleum and gas tenure type held in the Surat CMA

P&G tenure holder	Total tenure area (km_2)	Total ATP area (km_2)	Total PLA area (km_2)	Total PL area (km_2)	Relevant tenure area (km_2)	Pct. of tenure that is relevant	Pct. of total tenure held in CMA	Pct. of total ATP tenure held in CMA	Pct. of total PL tenure held in CMA	CSG production wells	
										Existing	Planned
AGL	1,008	123	-	885	885	88%	2%	< 1%	3%		
Armour	3,438	2,019	-	1,419	1,419	41%	6%	6%	5%		
Bridgeport	846	594	-	252	252	30%	1%	2%	1%		
Other	13,380	10,980	1,071	2,400	3,471	8%	23%	33%	9%		
Arrow	5,913	1,845	-	4,068	4,068	69%	10%	6%	15%	510	2,439
Origin	8,634	3,375	1,161	5,259	6,420	74%	15%	10%	20%	2,843	3,556
QGC	8,658	4,044	-	4,614	4,614	53%	15%	12%	18%	3,303	1,980
Santos	15,660	8,964	384	6,696	8,505	54%	26%	27%	25%	1,876	4,856
Senex	1,794	1,068	-	726	726	40%	3%	3%	3%	113	767
Total	**59,331**	**33,012**	**2,616**	**26,319**	**30,360**	**51%**				**8,645**	**13,598**

Table A1-2: Summary of production commencement and cessation in the Surat CMA

Tenure holder	Gas field	Production commencement	Production cessation	Production wells[1]		Formation[3]	Tenure[4]
				Existing[2]	Planned		
Arrow	Daandine	Prior to 2020	2060–2069	200 (54)	109	WCM	PL 230
							PL 252
							PL 260
	FCS_2	2020–2024	2060–2069	15	565	WCM	PL 1044
							PL 304
							PL 305
							PL 491
							PL 492
							PL 494
	FCS_8	Prior to 2020	2060–2069	22	679	WCM	PL 1039
							PL 1040
							PL 1041
							PL 1042
							PL 1043
							PL 198
							PL 238
							PL 258
	FCS_David	2020–2024	2060–2069	-	143	WCM	PL 253
							PL 493
	FCS_Harry	Prior to 2020	2060–2069	6	293	WCM	PL 1039
							PL 198

Tenure holder	Gas field	Production commencement	Production cessation	Production wells[1]		Formation[3]	Tenure[4]
				Existing[2]	Planned		
							PL 238
							PL 252
							PL 260
	FCS_Jammat	Prior to 2020	2060–2069	7	300	WCM	PL 185
							PL 253
							PL 493
	Kogan	Prior to 2020	2060–2069	79	176	WCM	PL 1052
							PL 1053
							PL 194
	Tipton	Prior to 2020	2060–2069	181 (8)	174	WCM	PL 1039
							PL 198
							PL 238
							PL 258
							PL 260
Origin	Alfredson	Prior to 2020	2050–2059	63	66	WCM	PL 1011
	Clifford	2025–2029	2050–2059	2	137	WCM	PL 419*
	Clifford East	Prior to 2020	2050–2059	49	6	WCM	PL 403
	Combabula	Prior to 2020	2040–2049	398	2	WCM	PL 297
	Combabula North	Prior to 2020	2050–2059	228	142	WCM	PL 408
	Condabri	Prior to 2020	2050–2059	273	148	WCM	PL 265
	Condabri North	Prior to 2020	2050–2059	255	79	WCM	PL 267
	Condabri South	Prior to 2020	2040–2049	136	7	WCM	PL 266

Tenure holder	Gas field	Production commencement	Production cessation	Production wells[1]		Formation[3]	Tenure[4]
				Existing[2]	Planned		
	Dalwogan	2025–2029	2050–2059	2	79	WCM	PL 216
	Durham Ranch	Prior to 2020	2050–2059	115	39	BAN	PL 200
							PL 268
	Durham West	Prior to 2020	2040–2049	17	6	BAN	PL 418
	Expedition Creek	Prior to 2020	2040–2049	4	8	BAN	PL 414
	Horse Creek	2025–2029	2050–2059	-	26	WCM	PL 471*
	Humboldt	2025–2029	2050–2059	6	121	BAN	PL 1082
	Ironbark	2020–2024	2050–2059	11	154	WCM	PL 1106*
	Kainama	2025–2029	2050–2059	1	138	WCM	PL 225
	Kainama Central	2025–2029	2050–2059	-	5	WCM	PL 225
	Kainama North	2025–2029	2050–2059	-	83	WCM	PL 225
	Lucky Gully	2020–2024	2050–2059	28	230	WCM	PL 412
	Mahalo	2025–2029	2050–2059	7	120	BAN	PL 1083
	Meeleebee	2025–2029	2050–2059	1	98	WCM	PL 406*
	Muggleton	Prior to 2020	2050–2059	16	338	WCM	PL 405
	Murrungama	2020–2024	2040–2049	-	26	WCM	PL 1084
	Orana	Prior to 2020	2040–2049	149	2	WCM	PL 215
	Orana North	Prior to 2020	2050–2059	94 (1)	202	WCM	PL 272
	Peat	Prior to 2020	2060–2069	39	141	BAN	PL 101
	Pine Hills	Prior to 2020	2050–2059	64	298	WCM	PL 407
	Ramyard	2025–2029	2050–2059	8	216	WCM	PL 470
	Ramyard Central	2025–2029	2050–2059	4	98	WCM	PL 469*

Tenure holder	Gas field	Production commencement	Production cessation	Production wells[1]		Formation[3]	Tenure[4]
				Existing[2]	Planned		
	Ramyard South	2025–2029	2060–2069	18	219	WCM	PL 469* & PL 471*
	Reedy Creek	Prior to 2020	2040–2049	247	32	WCM	PL 404
	Reedy Creek South	Prior to 2020	2050–2059	67	109	WCM	PL 413
	Riley	Prior to 2020	2040–2049	10	-	WCM	PL 1018
	Scott Creek	Prior to 2020	2040–2049	2	1	BAN	PL 415
	Spring Creek	Prior to 2020	2040–2049	3	-	BAN	PL 416
	Spring Gully	Prior to 2020	2040–2049	149	14	BAN	PL 195
	Spring Gully East	Prior to 2020	2050–2059	32	21	BAN	PL 417
	Strathblane	Prior to 2020	2040–2049	124	19	BAN	PL 204
	Talinga	Prior to 2020	2050–2059	219	58	WCM	PL 226
	Woleebee	2025–2029	2050–2059	2	60	WCM	PL 209
	Wolleebee North	2030–2039	2050–2059	-	8	WCM	PL 445*
QGC	Acrux	Prior to 2020	2060–2069	57	42	WCM	PL 398
							PL 399
	Anya	Prior to 2020	2030–2039	25		WCM	PL 1025
	Argyle	Prior to 2020	2060–2069	88	53	WCM	PL 179
							PL 229
	Arthur	Prior to 2020	2060–2069	41	77	WCM	PL 498
	Avon Downs	Prior to 2020	2060–2069	50	65	WCM	PL 461
							PL 472
	Bellevue	Prior to 2020	2060–2069	79	47	WCM	PL 247
	Berwyndale	Prior to 2020	2060–2069	67 (1)	63	WCM	PL 201

Tenure holder	Gas field	Production commencement	Production cessation	Production wells[1]		Formation[3]	Tenure[4]
				Existing[2]	Planned		
							PL 211
	Berwyndale South	Prior to 2020	2040–2049	134 (4)	20	WCM	PL 201
							PL 212
	Bloodworth	Prior to 2020	2060–2069	21	56	WCM	PL 506
	Borrowdale	Prior to 2020	2060–2069	27	52	WCM	PL 505
							PL 507
	Botany	2025–2029	2060–2069	1	17	WCM	PL 507
	Broadwater	Prior to 2020	2060–2069	100	26	WCM	PL 279
	Cam	Prior to 2020	2050–2059	127 (1)	1	WCM	PL 276
							PL 277
	Cameron	Prior to 2020	2060–2069	42	80	WCM	PL 401
							PL 467
							PL 498
	Cassio	2020–2024	2060–2069	-	4	WCM	PL 1008
	Celeste	Prior to 2020	2060–2069	77 (3)	53	WCM	PL 442
	Charlie	Prior to 2020	2040–2049	122	13	WCM	PL 299
							PL 498
	Charlotte	2025–2029	2060–2069	1	34	WCM	PL 506
							PL 507
	Clunie	Prior to 2020	2060–2069	23 (1)	105	WCM	PL 466
							PL 474
	Codie	Prior to 2020	2060–2069	41 (3)	90	WCM	PL 180

Tenure holder	Gas field	Production commencement	Production cessation	Production wells[1]		Formation[3]	Tenure[4]
				Existing[2]	Planned		
							PL 228
	David	Prior to 2020	2060–2069	105	20	WCM	PL 273
	Fishburn	2025–2029	2060–2069	-	29	WCM	PL 505
							PL 507
	Friendship	2025–2029	2060–2069	-	20	WCM	PL 1008
							PL 506
	Glendower	Prior to 2020	2050–2059	115	10	WCM	PL 274
							PL 279
	Golden Grove	Prior to 2020	2060–2069	37	42	WCM	PL 397
							PL 464
							PL 505
							PL 506
	Harry	Prior to 2020	2060–2069	121	9	WCM	PL 274
							PL 279
	Isabella	Prior to 2020	2060–2069	123 (4)	11	WCM	PL 275
	Jammat	Prior to 2020	2060–2069	56	32	WCM	PL 257
							PL 278
	Jen	Prior to 2020	2060–2069	77	65	WCM	PL 275
	Jordan	2025–2029	2060–2069	2	30	WCM	PL 442
	Kate	Prior to 2020	2060–2069	53	86	WCM	PL 228
	Kathleen	Prior to 2020	2050–2059	125 (1)	3	WCM	PL 276
							PL 277

Tenure holder	Gas field	Production commencement	Production cessation	Production wells[1]		Formation[3]	Tenure[4]
				Existing[2]	Planned		
	Kenya	Prior to 2020	2050–2059	118	18	WCM	PL 180
							PL 228
	Kenya East	Prior to 2020	2060–2069	103 (2)	35	WCM	PL 278
	Lauren	Prior to 2020	2040–2049	134 (5)	6	WCM	PL 180
							PL 263
	Mamdal	Prior to 2020	2060–2069	28	93	WCM	PL 276
							PL 277
	Matilda-John	Prior to 2020	2030–2039	96 (4)	24	WCM	PL 263
	McNulty	Prior to 2020	2060–2069	100 (2)	26	WCM	PL 458
							PL 459
	Michelle	Prior to 2020	2060–2069	1	4	WCM	PL 503
	Owen	Prior to 2020	2030–2039	23	3	WCM	PL 443
	Paradise Downs	2020–2024	2060–2069	-	8	WCM	PL 510
	Penrhyn	Prior to 2020	2060–2069	32	102	WCM	PL 505
	Phillip	Prior to 2020	2060–2069	42	102	WCM	PL 498
	Polaris	Prior to 2020	2060–2069	122	6	WCM	PL 398
							PL 399
	Poppy	Prior to 2020	2060–2069	42	10	WCM	PL 273
	Portsmouth	Prior to 2020	2060–2069	106	34	WCM	PL 401
	Ridgewood	2020–2024	2060–2069	2	29	WCM	PL 1010
	Ross	Prior to 2020	2050–2059	126 (1)	9	WCM	PL 276
	RubyJo	Prior to 2020	2060–2069	108 (1)	21	WCM	PL 275

Tenure holder	Gas field	Production commencement	Production cessation	Production wells[1]		Formation[3]	Tenure[4]
				Existing[2]	Planned		
	Scarborough	2025–2029	2060–2069	-	47	WCM	PL 1008
							PL 506
	Sean	Prior to 2020	2060–2069	53	49	WCM	PL 273
	Thackery	2020–2024	2060–2069	2	75	WCM	PL 505
							PL 507
	Will	2020–2024	2060–2069	1	4	WCM	PL 1009
	Woleebee Creek	Prior to 2020	2050–2059	127 (3)	20	WCM	PL 276
							PL 277
Santos	Arcadia	Prior to 2020	2060–2069	228 (27)	652	BAN	PL 1059*
							PL 1017*
							PL 234
							PL 235
							PL 420
							PL 421
							PL 440
							PL 90
	Arcadia West	2020–2024	2050–2059	2	550	BAN	PL 1062*
							PL 450
							PL 451
	Fairview	Prior to 2020	2060–2069	596 (252)	669	BAN	PL 100
							PL 232
							PL 233

Tenure holder	Gas field	Production commencement	Production cessation	Production wells[1]		Formation[3]	Tenure[4]
				Existing[2]	Planned		
							PL 90
							PL 91
							PL 92
							PL 99
				47 (27)	218	CCK	PL 100
							PL 232
							PL 91
							PL 92
							PL 99
	Kia Ora	2020–2024	2050–2059	4	180	BAN	PL 457
	Roma	Prior to 2020	2060–2069	957 (304)	2175	WCM	PL 1019
							PL 1020
							PL 1021
							PL 11
							PL 281
							PL 282
							PL 3
							PL 314
							PL 315
							PL 317
							PL 320
							PL 322

Tenure holder	Gas field	Production commencement	Production cessation	Production wells[1]		Formation[3]	Tenure[4]
				Existing[2]	Planned		
							PL 8
						WCM	PL 93
	Scotia	Prior to 2020	2060–2069	34 (19)	269	BAN	PL 176
	Waranilla	2030–2039	2060–2069	1	143	BAN	PL 451
Senex	Atlas	Prior to 2020	2060–2069	23	98	WCM	PL 1037
	Dione	2050 onwards	2070 onwards	5	63	WCM	PL 1023
							PL 1024
	Eos	Prior to 2020	2050–2059	41	61	WCM	PL 1022
	Glenora	Prior to 2020	2050–2059	33	70	WCM	PL 1022
	Mimas	2020–2024	2070 onwards	2	92	WCM	PL 1022
							PL 1023
							PL 1024
	Pandora	2050 onwards	2070 onwards	1	82	WCM	PL 1023
	Phoebe	2050 onwards	2070 onwards	2	90	WCM	PL 1023
	Rhea	2040–2049	2070 onwards	-	72	WCM	PL 1023
							PL 1024
	Tethys	2020–2024	2070 onwards	5	91	WCM	PL 1023
							PL 1024
	Titan	2025–2029	2060–2069	1	48	WCM	PL 1022
							PL 1024

1. Wells as at late 2020
2. Brackets indicate the number of wells that are deviated further than 50 m from the well head
3. WCM = Walloon Coal Measures, BAN = Bandanna Formation, CCK = Cattle Creek Group
4. Tenure as at April 2021; * denotes tenure under application

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