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Document No: AE-SUB-REP-01

Underground Water Impact Report ATP688P

1. Executive Summary

The *Water Act 2000* requires that petroleum tenure holders adequately manage the potential impacts resulting from the exercise of underground water rights necessary to produce coal seam gas (CSG) and other petroleum. This Underground Water Impact Report (UWIR) has been prepared to satisfy the requirements of the *Water Act 2000* which requires that a UWIR is prepared, publicly notified and approved as triggered by the commencement of water production. This UWIR has been prepared to satisfy all requirements of the Act, including:

- Information about underground water extraction resulting from the exercising of the petroleum tenure holder's underground water rights,
- Information about the aquifers affected, or likely to be affected,
- Maps showing the area of the affected aquifer(s) where underground water levels are predicted to decline,
- A water monitoring strategy, and
- A spring impact management strategy.

This UWIR relates to pilot activities which have occurred on and are proposed for ATP688P. ATP688P is located in the northern extent of the Bowen Basin, near Collinsville. Appraisal activities have and will target coal seams of the Moranbah Coal Measures in two areas within ATP688P - Tilbrook (PCA 286) and Mt St Martin A (PCA 287). The previous exercise of underground water rights ceased in 2010, with no associated water production thereafter. It is proposed that the exercise of underground water rights will recommence in 2023 with the installation of up to six vertical-horizontal well pairs. Each well pair will target a separate coal seam. Each well pair is planned to undergo six months of test production, with water production from appraisal activities on ATP688P planned to cease at the end of July 2024.

A numerical groundwater flow model was used to identify those areas where water level drawdown is predicted to exceed the *Water Act 2000* bore trigger threshold (5 m) and spring trigger threshold (0.2 m) due to the exercise of underground water rights.

The model drawdown predictions identify an Immediately Affected Area (IAA) and Long Term Affected Area (LTAA) for the Moranbah Coal Measures only. No registered water supply bores that access the Moranbah Coal Measures are located within either the IAA or LTAA. No IAA or LTAA applies to other formations. No springs were identified within the spatial extents of the predicted spring trigger threshold exceedances. Model sensitivity analyses did not result in predicted drawdown that changes these outcomes.

This UWIR presents a Water Monitoring Strategy (WMS) for the Permian coal measures. Monitoring locations, schedules and the parameters to be tested have been detailed in the WMS and include monitoring of:

- water production rates; and
- produced water quality.

Monitoring data will be submitted to the Office of Groundwater Impact Assessment every six months.

A Spring Impact Management Strategy is not required as not springs are predicted to be impacted.

Drawdown maps will be reviewed annually.

2. Abbreviations and Acronyms

The following abbreviations and acronyms are used in this report:

Acronym	Description
AE	Airlie Energy
mAHD	Meters relative to the Australian Height Datum
ATP	Authority to Prospect
CSG	Coal Seam Gas
CMA	Cumulative management area
DEM	Digital elevation model
DES	Department of Environment and Science
DST	Drill Stem Test
GWBD	Groundwater Bore Database
Kh	Horizontal hydraulic conductivity (permeability to water in a horizontal sense)
Kv	Vertical hydraulic conductivity (permeability to water in a vertical sense)
IAA	Immediately Affected Area
LTAA	Long Term Affected Area
mbgl	meters below ground level
mD	Millidarcies (unit of measure of intrinsic permeability)
m/day	meters per day
MSM	Mt St Martin
OGIA	Office of Groundwater Impact Assessment
PCA	Potential Commercial Area
PL	Petroleum Lease
SCADA	Supervisory Control and Data Acquisition
SRTM	Shuttle Radar Topography Mission
Til	Tilbrook
UWIR	Underground Water Impact Report

3. Introduction

Airlie Energy (AE) is the operator of Authority to Prospect (ATP) 688P, near Moranbah in the Bowen Basin. ATP688P was transferred to AE from WestSide Corporation in June 2022.

The *Water Act 2000* requires that petroleum tenure holders adequately manage the impacts of underground water extraction necessarily associated with the extraction of coal seam gas (CSG), other petroleum resources, and mineral resources. Since 1 December 2010, the *Water Act 2000* has been amended to include, among other requirements, provisions for the preparation, consultation and submission of an Underground Water Impact Report (UWIR) – a requirement that is triggered by the exercise of underground water rights, corresponding to the extraction of water necessary for petroleum, gas or mineral production or testing. The key aspects of an UWIR include:

- Information about underground water extraction resulting from the exercising of the petroleum tenure holder's underground water rights;
- Information about the aquifers affected, or likely to be affected;
- Maps showing the area of the affected aquifer(s) where underground water levels are predicted to decline;
- A water monitoring strategy; and
- A spring impact management strategy.

A UWIR was approved for ATP688P (with conditions) on 20 September 2013 (CDM Smith, 2013). The UWIR was updated in 2017 (Arris, 2017) and was approved on 14 November 2017. WestSide did not undertake any petroleum activities on ATP688P in the period from 2013 to 2017. On the basis that WestSide proposed no petroleum activities on the tenure in the period 2017 to 2020, WestSide applied for an exemption under section 370B of the *Water Act 2000* in 2019. This exemption was granted removing the need to prepare an updated UWIR in 2020.

AE intends to exercise its underground water rights in ATP688P, commencing in 2023. Pursuant to Section 376 of the *Water Act 2000*, this document constitutes the updated UWIR for ATP688P. ATP688P is not within a declared Cumulative Management Area (CMA).

4. Legislation

Primary Queensland legislation that governs the management of resources, including groundwater, with respect to the CSG exploration and appraisal activities on ATP688P is summarised below.

4.1 Petroleum and Gas (Production and Safety) Act 2004

The *Petroleum and Gas (Production and Safety) Act 2004* legislates for the safe and efficient exploration for, recovery of and transport of petroleum and fuel gas.

The Act establishes underground water rights for petroleum tenure holders. This allows the tenure holder to take or interfere with underground water in the spatial extent of the tenure, if that interference or take occurs while undertaking another authorised activity for the tenure. There is no volumetric limit to the amount of water that may be taken, however the tenure holder is subject to the provisions of Chapter 3 of the *Water Act 2000*. The associated water can be used for any authorised purpose, within or off tenure.

4.2 Water Act 2000

The *Water Act 2000* provides the regime for the planning and management of all water resources in Queensland. With respect to petroleum and gas production, Chapter 3 of the *Water Act 2000*:

- Identifies the obligations of CSG producers in relation to groundwater monitoring, reporting, impact assessment and management of impacts on other water users,
- Provides a framework and conditions for preparing a Baseline Assessment Plan and outlines the requirements of bore owners to provide information that the petroleum tenure holder reasonably requires to undertake a baseline assessment of the relevant bore,
- Sets out the process for assessing, reporting, monitoring, and negotiating with other water users regarding the impact of CSG production on aquifers.

The management of impacts on groundwater caused by the exercise of groundwater rights by petroleum tenure holders is achieved by providing a regulatory framework that requires:

- Petroleum tenure holders to monitor and assess the impact of the exercise of underground water rights on water bores and to enter into “make good” agreements with the owners of potentially impacted bores,
- The preparation of UWIRs that establish underground water obligations, including obligations to monitor and manage impacts on aquifers and springs.

The Queensland Government’s Office of Groundwater Impact Assessment (OGIA) is responsible for managing these requirements in a declared Cumulative Management Area (CMA). Outside of the CMAs, individual tenure holders are responsible for the preparation of the UWIR. The requirements of a UWIR are specifically identified in the *Water Act 2000*, with additional description of the requirements provided in the UWIR guideline (DES, 2021). These requirements, and the conformance of this UWIR to those requirements are identified in TABLE 1.

A UWIR will identify whether an Immediately Affected Area or Long Term Affected Area will result from CSG activities. An Immediately Affected Area (IAA) is defined as an area where the predicted decline in water level within 3 years is greater than the bore trigger threshold. A Long Term Affected Area (LTAA) is defined as the area where bore trigger thresholds are exceeded at any time. The *Water Act 2000* defines the trigger thresholds as:

- Bore trigger threshold - 5 m for a consolidated aquifer;
- Bore trigger threshold - 2 m for an unconsolidated aquifer; and
- Spring trigger threshold - 0.2 m

UWIRs are published to enable the community, including bore owners and other stakeholders, within the relevant area, to make submissions on the UWIR. These submissions are then required to be summarised by the petroleum tenure holder and submitted with the UWIR to DES for approval. The approved UWIR must then remain available on the petroleum tenure holder's website.

TABLE 1 REQUIREMENTS OF A UWIR (DES, 2021)

Reporting requirements (*Water Act 2000*)	Underground Water Impact Report Guidelines (DES, 2021)	Section(s) of this UWIR
Section 376		
For the area to which the report relates – (i) The quantity of water produced or taken from the area because of the exercise of any previous relevant underground water rights; and	PART A UNDERGROUND WATER EXTRACTION	5.2
(ii) an estimate of the quantity of water to be produced or taken because of the exercise of the relevant underground water rights for a 3 year period starting on the consultation day for the report		5.3
For each aquifer affected, or likely to be affected, by the exercise of the relevant underground water rights – (i) A description of the aquifer, and	PART B AQUIFER INFORMATION AND UNDERGROUND WATER FLOW	6
(ii) an analysis of the movement of underground water to and from the aquifer, including how the aquifer interacts with other aquifers; and		6.4, 6.7
(iii) an analysis of the trends in water level change for the aquifer because of the exercise of the rights mentioned in paragraph (a)(i); and		6.4
(iv) a map showing the area of the aquifer where the water level is predicted to decline, because of the taking of the quantities of water mentioned in paragraph (a), by more than the bore trigger threshold within 3 years after the consultation day for the report; and	PART C PREDICTED WATER LEVEL DECLINES FOR AFFECTED AQUIFERS	0 Figure 21
(v) a map showing the area of the aquifer where the water level is predicted to decline, because of the exercise of relevant underground water rights, by more than the bore trigger threshold at any time		0 Figure 23
a description of the methods and techniques used to obtain the information and predictions under paragraph (b);		8.2
a summary of information about all water bores in the area shown on a map mentioned in paragraph (b)(iv), including the number of bores, and the location and authorised use or purpose of each bore;		8.5.1
(da) a description of the impacts on environmental values that have occurred, or are likely to occur, because of any previous exercise of underground water rights;		8.5
(db) a description of the impacts on environmental values that have occurred, or are likely to occur, because of the exercise of underground water rights-		8.5

Reporting requirements (*Water Act 2000*)	Underground Water Impact Report Guidelines (DES, 2021)	Section(s) of this UWIR
(i) during the period mentioned in paragraph (a)(ii); (ii) over the projected life of the resource tenure;		
a program for – (i) conducting an annual review of the accuracy of each map prepared under paragraph (b)(iv) and (v); and		9.3
(ii) giving the chief executive a summary of the outcome of each review, including a statement of whether there has been a material change in the information or predictions used to prepare the maps;		9.3
a water monitoring strategy;	PART D WATER MONITORING STRATEGY	9.1
a spring impact management strategy;	PART SPRING IMPACT MANAGEMENT STRATEGY	9.2
if the responsible entity is the office – (i) a proposed responsible tenure holder for each report obligation mentioned in the report; and		Not applicable
(ii) for each immediately affected area – the proposed responsible tenure holder or holders who must comply with any make good obligations for water bores within the immediately affected area;		Not applicable
other information or matters prescribed under a regulation		Not applicable
Section 378		
1) A responsible entity's water monitoring strategy must include the following for each immediately affected area and long-term affected area identified in its underground water impact report or final report— a) a strategy for monitoring— i) the quantity of water produced or taken from the area because of the exercise of relevant underground water rights; and ii) changes in the water level of, and the quality of water in, aquifers in the area because of the exercise of the rights;	PART D WATER MONITORING STRATEGY	9.1
(b) the rationale for the strategy;		9.1
(c) a timetable for implementing the strategy;		9.1.2
(d) a program for reporting to the office about the implementation of the strategy.		9.1.2
(2) The strategy for monitoring mentioned in subsection (1)(a) must include— (a) the parameters to be measured; and		9.1.2
(b) the locations for taking the measurements; and		9.1.2
(c) the frequency of the measurements.		9.1.2
(3) If the strategy is prepared for an underground water impact report, the strategy must also include a program for the responsible tenure holder or holders under the report to undertake a baseline assessment for each water bore that is— (a) outside the area of a petroleum tenure; but		Not applicable
(b) within the area shown on the map prepared under section 376(b)(v).		Not applicable
(4) If the strategy is prepared for a final report, the strategy must also include a statement about any matters under a previous strategy that have not yet been complied with.		Not applicable

5. Petroleum Activities on ATP688P

5.1 Location and Layout

ATP688P is located in the northern Bowen Basin, south of Collinsville and approximately 100 km west of Mackay (FIGURE 1). The Bowen Developmental Road runs north-south through the western edge of the tenement.

ATP688P is divided into four Potential Commercial Areas (PCA), as shown on FIGURE 1. AE's activities on ATP688P are divided into two appraisal areas: PCA 286 (Tillbrook (Til))in the south and PCA 287 (Mt St Martin (MSM)) in the north.

The topography is generally flat with hillocks formed where there are intrusions and basalt remnants, and higher ground in the southwest where the more arenaceous Triassic units (Rewan Formation, Clematis Sandstone – refer Section 6.1) outcrop in the core of a syncline.

The tenement is drained by the Bowen River in the north. Kangaroo Creek which runs from south to north, becomes Rosella Creek, and drains into the Bowen River.

There are no active petroleum leases (PL) adjacent to ATP688P. ATP742, operated by Arrow Energy, abuts the southern boundary of ATP688P. The Drake coal mine abuts the northwest corner of ATP688P, with the Collinsville coal mine to its north. The Byerwern, Newlands, Eastern Creek and Suttor Creek coal mines are to the south of ATP688P (FIGURE 1).

5.2 Historical Activities and Water Production

A total of 24 CSG exploration and appraisal wells have been drilled across ATP688P (FIGURE 1). Of these, 21 wells have been plugged and abandoned, and MSM-2, MSM-3 and MSM-4 are suspended.

Pilot (appraisal) testing and the exercise of underground water rights in ATP688P commenced in December 2007 and ceased in August 2010.

Monthly water production volumes are provided in TABLE 2. A total of 19,332 kilolitres[1] (kL) was produced from Til-7 and Til-8, with only 6 kL produced from MSM-4. Til-8 was a vertical-horizontal well pair, similar to what is proposed for future appraisal activities (Section 5.3). Til-7 and MSM-4 were vertical wells. Arris (2017) indicates that initial production testing during December 2007 included MSM-2 and MSM-3 but not water production data was included for those wells. It is assumed that the volume was negligible.

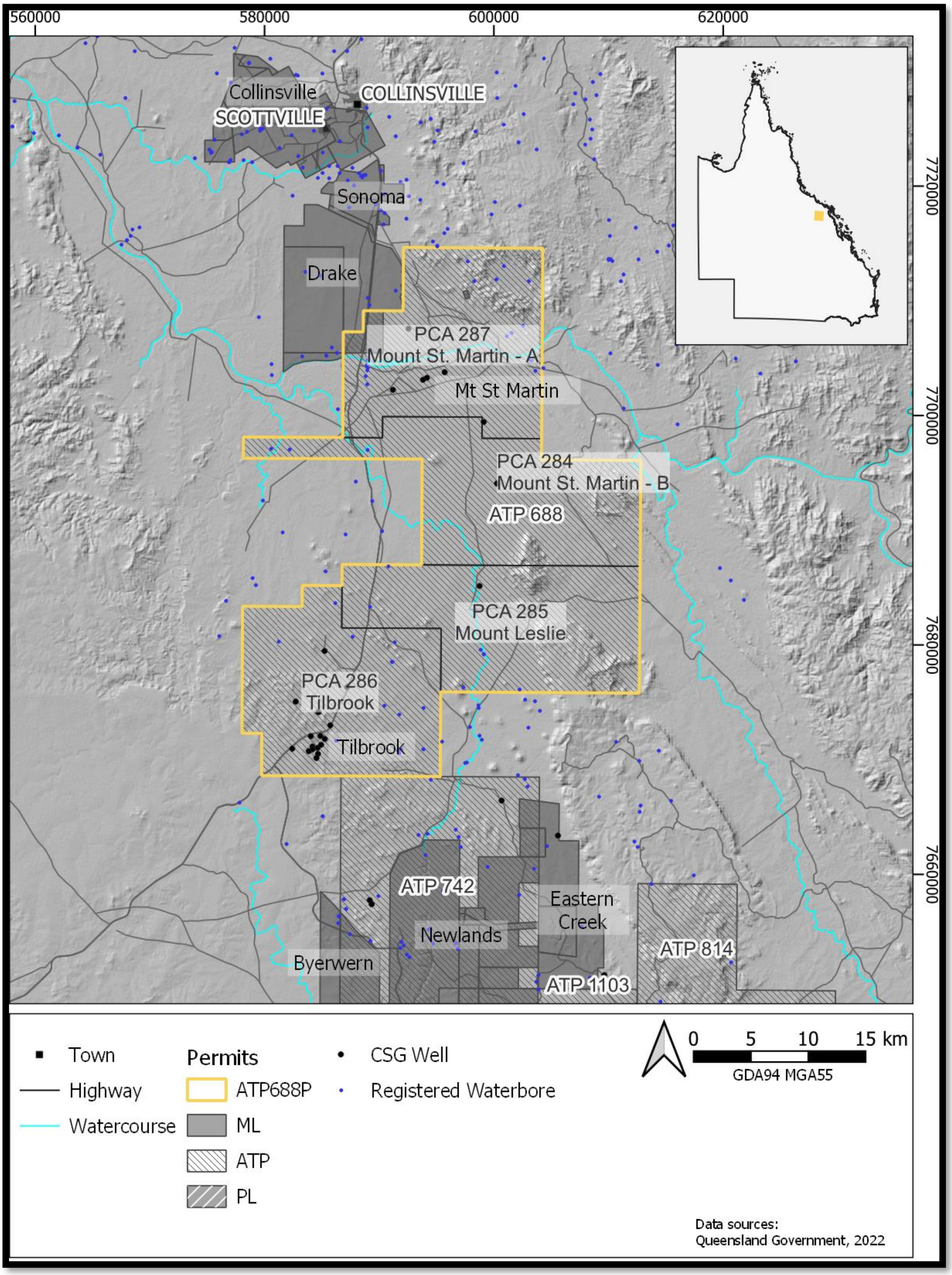
TABLE 2 HISTORICAL WATER (KL) PRODUCTION FROM ATP688P (ARRIS, 2017)

Month Ending	MSM4	TIL7 + TIL8
12/2007	6	5

[1] 1 kL = 1 m^3

Month Ending	MSM4	TIL7 + TIL8
01/2008	0	49
02/2008	0	71
03/2008	0	0
04/2008	0	5
05/2008	0	21
06/2008	0	76
07/2008	0	43
08/2008	0	41
09/2008	0	37
10/2008	0	35
11/2008	0	40
12/2008	0	108
01/2009	0	126
02/2009	0	137
03/2009	0	145
04/2009	0	138
05/2009	0	106
06/2009	0	95
07/2009	0	1090
08/2009	0	1268
09/2009	0	2014
10/2009	0	1778
11/2009	0	1577
12/2009	0	1501
01/2010	0	1338
02/2010	0	1121
03/2010	0	1156
04/2010	0	106
05/2010	0	904
06/2010	0	1696
07/2010	0	1299
08/2010	0	1206
Total (kL)	**6**	**19,332**

FIGURE 1 LOCATION AND LAYOUT OF ATP688P



5.3 Planned Activities and Quantity of Water to be Produced in the Next Three Years

The anticipated CSG appraisal activities over the current UWIR period (2023 to 2026) are as follows:

- The drilling and construction of up to six well pairs - five in Mt St Martin A and one in Tilbrook. Each well pair will comprise a lateral targeting a single coal seam of the Moranbah Coal Measures, with an intersecting vertical at the heel from which water and gas are extracted to surface. The wells in Mt St Martin will be spread across two sites, with multiple wells drilled off one pad.
- Six months of production per well pair starting in October 2023. It is assumed that the wells will be sequentially commissioned with three week intervals between the start of production in each well pair. Production is anticipated to cease at the end of July 2024.

Water production type curves for the different coal seams have been estimated using a reservoir model and are shown on FIGURE 2. The Tilbrook water rates are expected to start high (maximum 29 kL/day) relative to Mt St Martin, but are expected to decrease rapidly. The water rates in Mt St Martin are expected to start at about half those at Tilbrook, but are expected to decline more slowly.

The type curves shown on FIGURE 2 have been used to forecast the estimated water production for the appraisal program described above for the period 2023 to 2026 (FIGURE 3). The exercise of underground water rights is expected to commence in November 2023 and end at the end of July 2024, with no further production anticipated for the remainder of the current UWIR period. A total of 18.5 megaliters (ML) is forecast to be produced at a maximum of combined rate 2,300 kL/month.

FIGURE 2 ATP688P RESERVOIR ENGINEERING WATER PRODUCTION TYPE CURVES

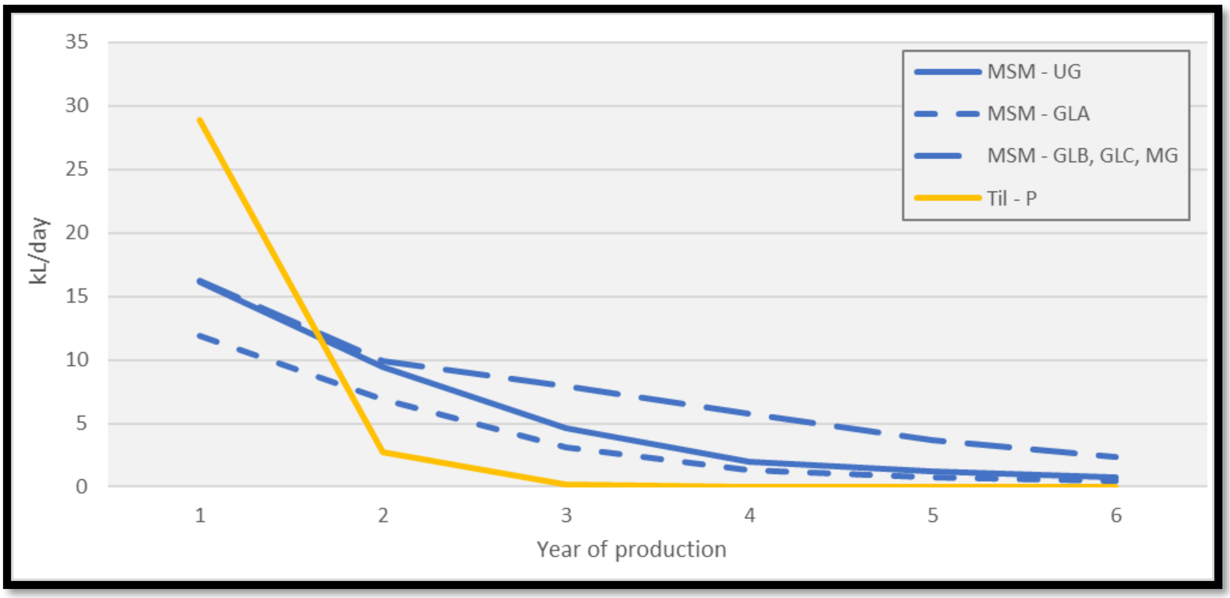
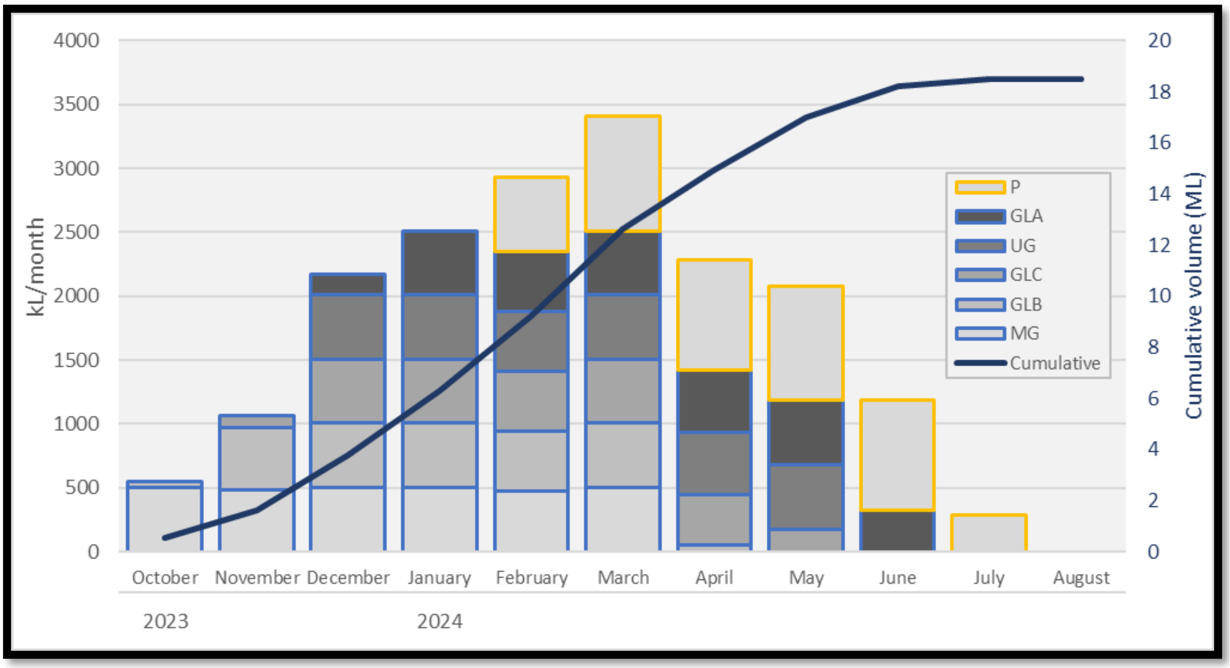


FIGURE 3 ATP688P FORECAST WATER PRODUCTION



6. Geological and Hydrogeological Regime

6.1 Geological Setting

The geology within ATP688P comprises early Permian, Triassic, Tertiary and Quaternary sediments and volcanics (Table 2). Surface geology is mapped as FIGURE 4 and the underlying solid geology is mapped as FIGURE 5 (Sliwa et al, 2017). FIGURE 4 has been simplified from the 2018 detailed geological mapping data (DNRM, 2018).

The Bowen Basin is an elongated, north-south-trending basin extending over an area of 160,000 km^2 from central Queensland, south beneath the Surat Basin, and into New South Wales. ATP688P is located within the Collinsville Shelf and Nebo Synclinorium in the northern extent of the Bowen Basin.

The depositional history of the Bowen Basin is complex due to varying rates of uplift and subsidence, hence the periods of sedimentation were not always consistent across the basin and the geological units are not always laterally extensive or correlatable (Draper, 2013). Deposition in the Bowen Basin commenced during the Early Permian, with fluvial and lacustrine sediments and volcanics being deposited in the east and a thick succession of coals and non-marine sediments in the west (Geoscience Australia, 2015). The basin then entered a thermal subsidence phase that extended from the mid Early Permian to the Late Permian, during which deltaic and shallow marine sediments and extensive coal measures were deposited (Mallet et al. 1995).

In the Late Permian, the basin entered an extensive period of foreland loading, resulting in accelerated subsidence that allowed the deposition of a thick succession of Late Permian marine and fluvio-deltaic sediments, including the Moranbah, Fort Cooper and Rangal Coal Measures and Early to Middle Triassic fluvial and lacustrine sediments - Rewan Group, Clematis Group and Moolayember Formation (Draper 2013). Sedimentation in the Bowen Basin ceased in the Late Triassic, followed by a period of widespread erosion (Cadman, Pain & Vukovic 1998).

The tectonic history of the basin has resulted in two broad fold synclines of Permo-Triassic strata through ATP688 (Section B-B' on FIGURE 6). The two synclines are separated by the northern extension of the Jellinbah Thrust Belt (FIGURE 5). The Tilbrook area is in the western syncline and the Mt St Martin is in the eastern syncline. The western limbs of the synclines dip steeply compared with the eastern limbs. The Jellinbah Thrust Belt is a northwest trending zone of thrust faults with throws in the order of 100 m to 500 m. Individual faults are typically 10 to 80 km long. The majority of thrust faults dip at shallow angles to the east and propagate up into the Permian sediments. The thrust belt follows the northwest trending synclinal axis of the Basin as most of the fault segments trend northwest suggesting inheritance from earlier basement structure (Arrow, 2013).

The Moranbah Coal Measures are the target of CSG appraisal on ATP688P. FIGURE 7 summarises the stratigraphy and coal characteristics in the Tilbrook and Mt St Martin appraisal areas. The average depth of top of Moranbah Coal Measures is similar in both areas - approximately 210 m below ground level. The target formation is significantly thicker in the Mt St Martin area, with an associated increased in net coal. The closest mapped outcrop of the Moranbah Coal Measures from the Tilbrook and Mt St Martin appraisal areas is less than 2 km and less than 1 km respectively.

FIGURE 8 presents cross sections of the coal seam geometry generated from AE's geological model through the Tilbrook and Mt St Martin appraisal areas. The geological model is based on exploration drilling and seismic interpretations. The sections show that in the Tilbrook area, the geology is relatively undeformed, with the coal seams dipping to east at gradient of roughly 7.5%. In the Mt St Martin area, the geology is more deformed by faulting. The upper seams slope upward to the east and the lower seams slope downward at roughly 3.5%. To the west, the seams plunge at over 40% due to the faulting. In both areas, the coals are present as multiple thin seams, separated by a significant thickness of interburden.

Surface geology predominantly comprises the Permo-Triassic strata with small inliers of Cretaceous-aged intrusions (FIGURE 4). Extensive Tertiary sediments (Suttor Formation) are present in the southwestern corner of ATP688P – the Tilbook area - and extending further south and west off tenement. The geological logs from the Tilbrook exploration wells identify unconsolidated material up to 42 m thick, with an average thickness of 21 m.

Tertiary-aged basalt is mapped along the southern boundary of ATP688P and is only present elsewhere across the tenement as small remnant caps. Feeder dykes to the basalt flows are mapped throughout ATP688P (FIGURE 5). Well completion reports for the Tilbrook exploration and appraisal wells identify that intersected formations were intruded or heat affected.

Quaternary sediments are associated with the major drainage lines (Bowen River, Rosella Creek, Kangaroo and Cockatoo Creeks), and underly part of the Mt St Martin appraisal area. The geological logs from the Mt St Martin exploration wells identify unconsolidated material up to 37.5 m thick, with an average thickness of 26 m.

6.2 Target Geological Formations

The planned vertical-lateral well pairs will be drilled to target the following coal seams of the Moranbah Coal Measures:

- **Mt St Martin Location X** – Middle Goonyella seam, Goonyella Lower B seam, Goonyella Lower C seam
- Mt St Martin Location Y – Upper Goonyella seam, Goonyella Lower A seam
- Tilbrook – P-seam

The locations of the Mt St Martin X and Y locations are shown on Figure 21.

TABLE 3 STRATIGRAPHIC COLUMN OF THE NORTHERN BOWEN BASIN AND APT688P

Age	Stratigraphic Unit			Lithology
Quaternary	Alluvium Alluvium, colluvium and other sediments in floodplains, alluvial fans and high terraces			Clay, silts, sand, gravel
Tertiary	Suttor Formation			Quartz sandstone, clayey sandstone, mudstone and conglomerate; fluvial and lacustrine sediments; minor interbedded basalt.
	Basalt			Olivine rich weathered basaltic sands, weathered basalt, and fresh basalt flows
	Duaringa Formation			Mudstone, sandstone, conglomerate, siltstone, oil shale, lignite and basalt
Triassic	Mimosa Group	Moolayember Formation		Mudstone, lithic sandstone, interbedded siltstone, mudstone, sandstone and thin coal seams
		Clematis Group		Cross-bedded quartz sandstone, some quartz conglomerate and minor red-brown mudstone
		Rewan Group		Green lithic sandstone, pebble conglomerate, red and green mudstone
Late Permian	Blackwater Group	Rangal Coal Measures		Coal seams, carbonaceous shale and mudstone, tuff, siltstone and mudstone
		Fort Cooper Coal Measures	Burngrove Formation	Coal, brown and green sandstone, conglomerate, carbonaceous shale, tuff
			Fairhill Formation	Labile sandstone, quartzose sublabile sandstone, siltstone, mudstone, calcareous and tuffaceous sandstone, volcanic conglomerate, carbonaceous mudstone, coal
		Moranbah Coal Measures		Quartzose to sublabile, locally argillaceous sandstone, siltstone, mudstone, carbonaceous mudstone and coal
Early to Middle Permian	Back Creek Group	Exmor Formation		Quartzose to sublabile sandstone, siltstone, mudstone, rare limestone
		Blenheim Formation		Carbonaceous and micaceous sandstone, siltstone, shale, coquinite, minor conglomerate
		Gebbie Formation		Fine to coarse, quartzose and siltstone, shale, coquinite
		Tiverton Formation		Fine to medium bioturbated sandstone, siltstone, mudstone, shale, coquinite
		Lizzie Creek Volcanics		Andesite, basalt, andesitic rudite, sandstone, siltstone

FIGURE 4 SURFACE GEOLOGY

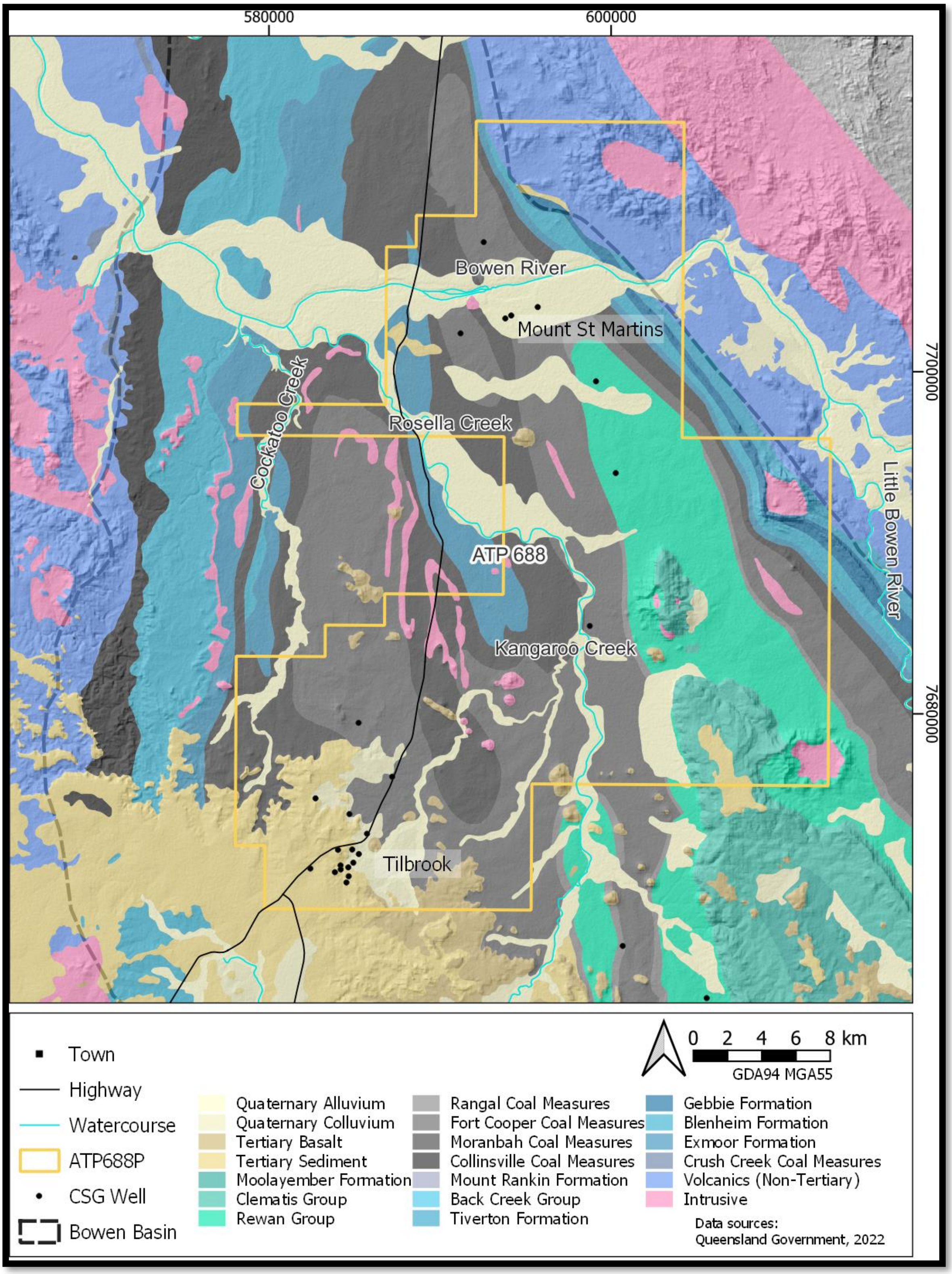


FIGURE 5 SOLID GEOLOGY

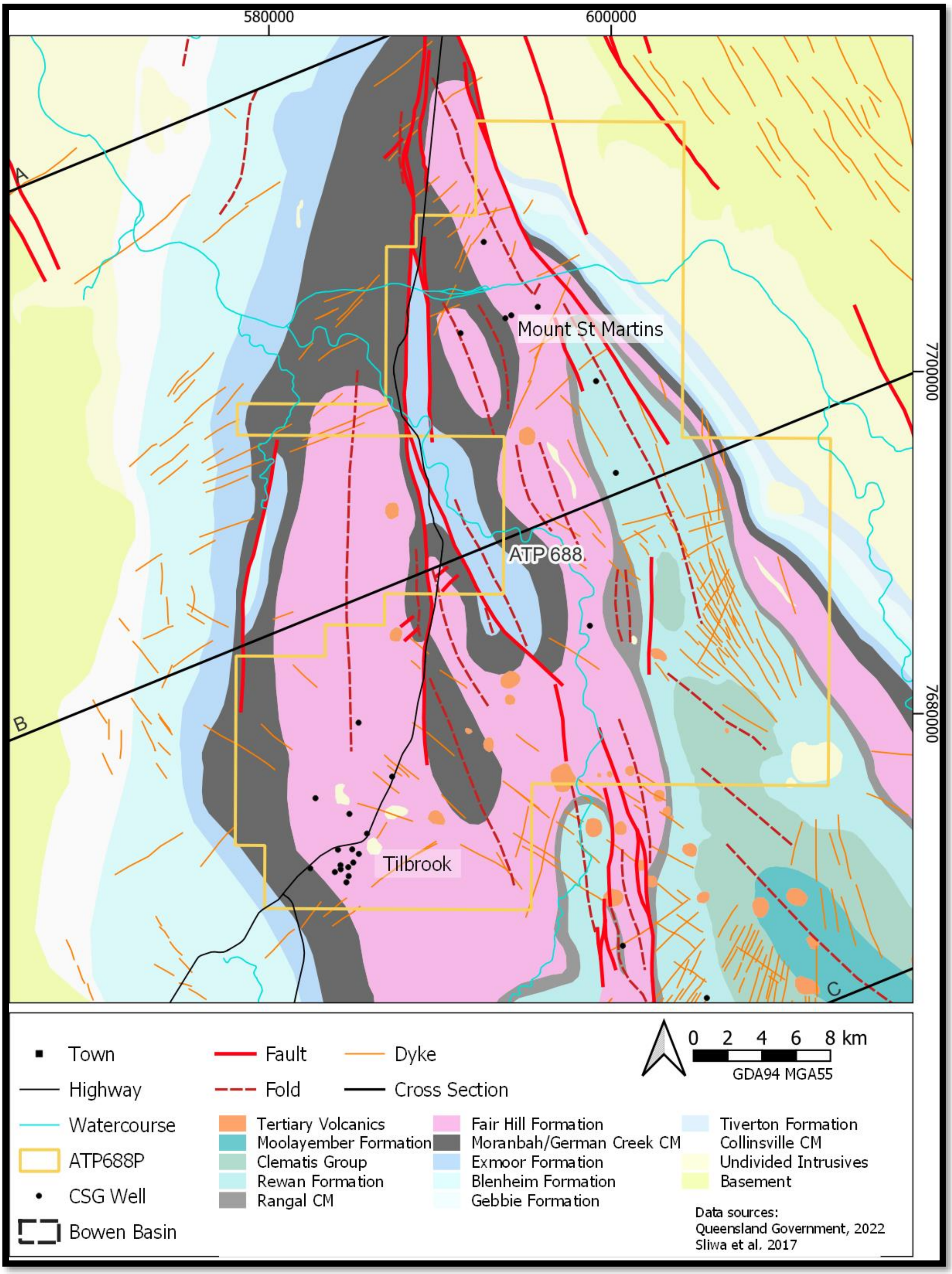


FIGURE 6 REGIONAL SCALE GEOLOGICAL CROSS-SECTIONS (SLIWA AND DRAPER, 2003)

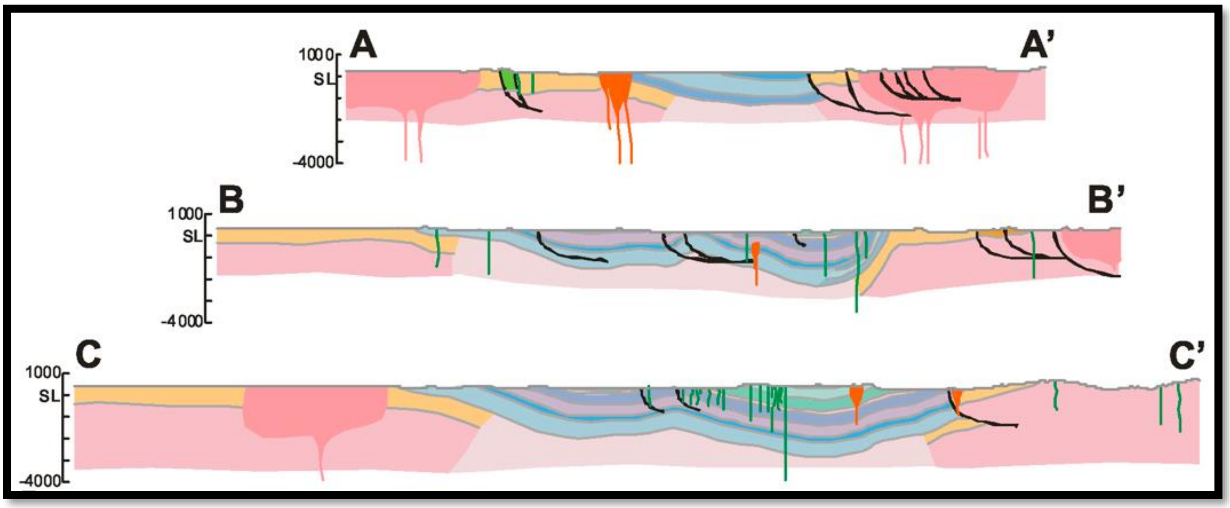


FIGURE 7 ATP688P STRATIGRAPHIC SUMMARY

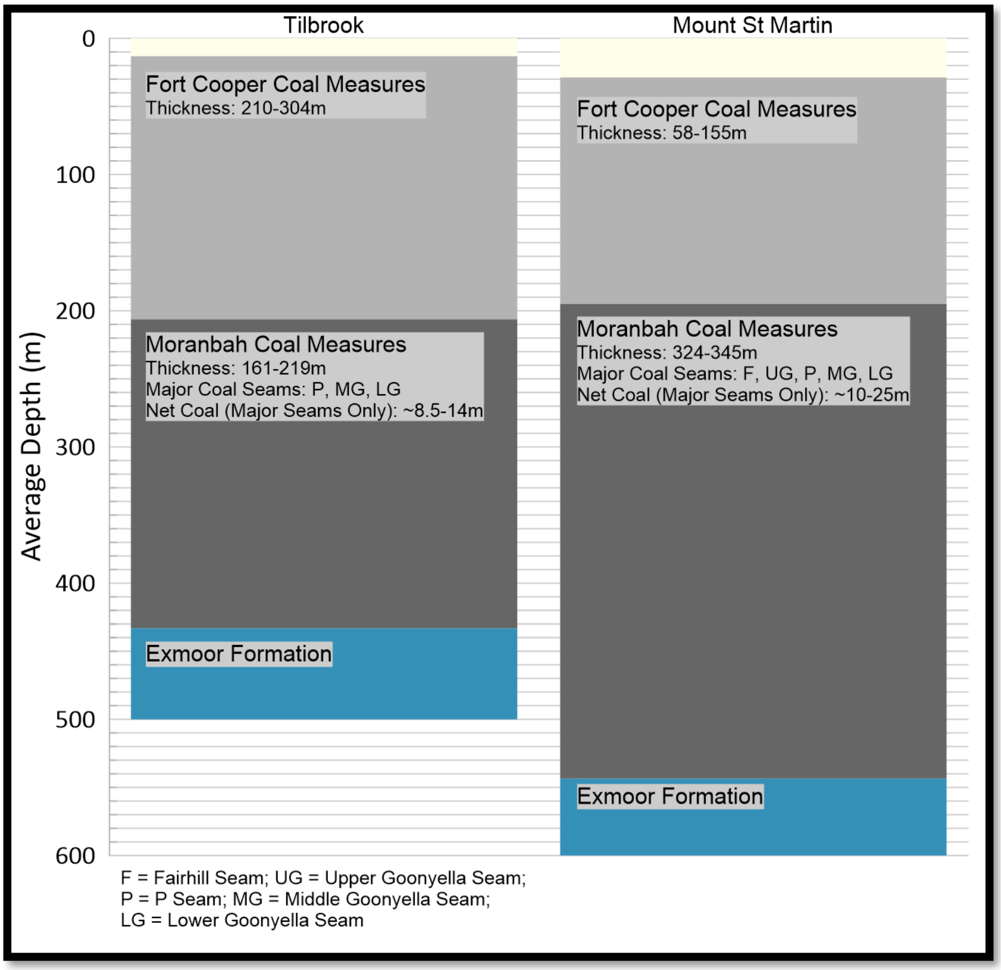
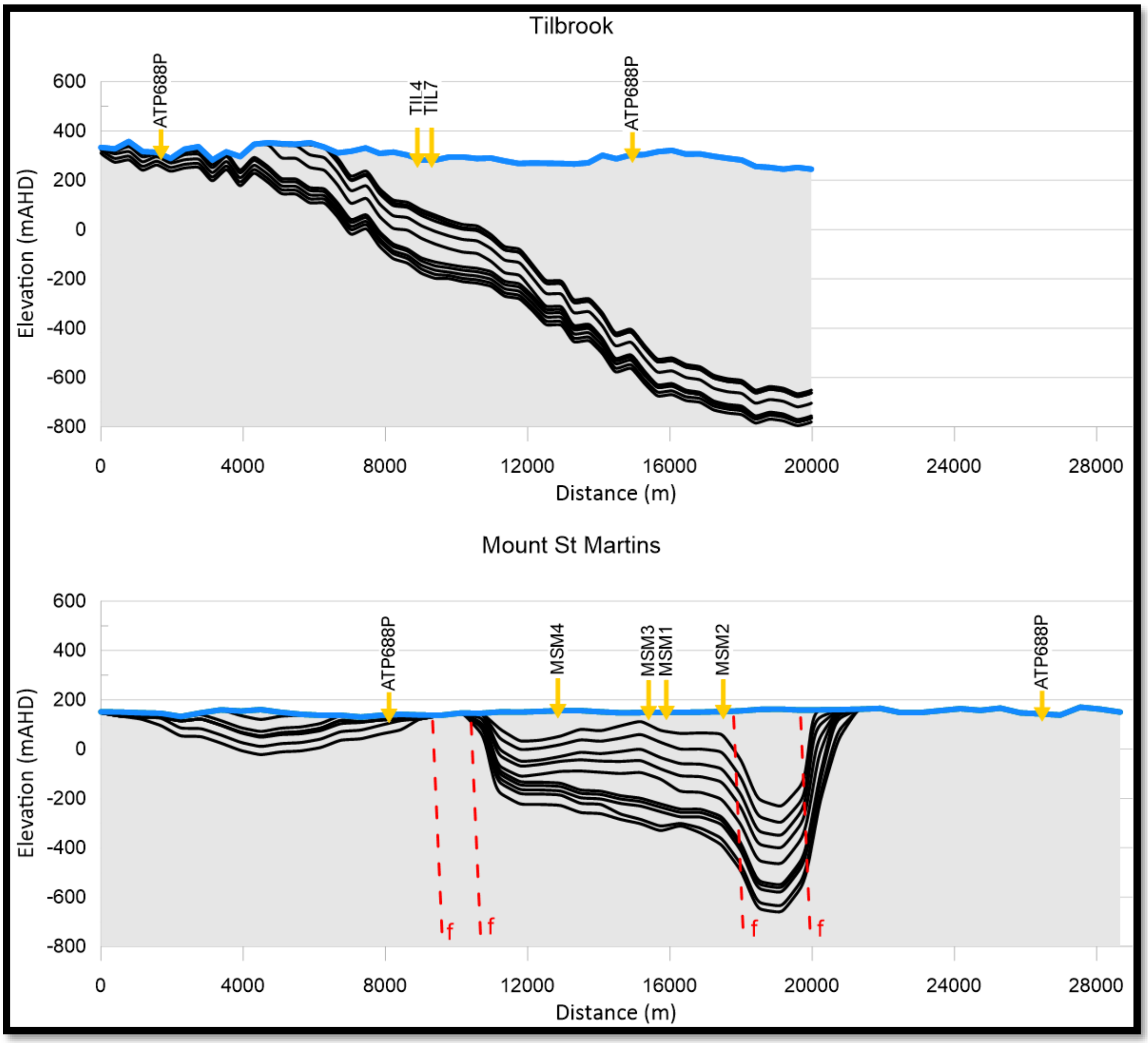


FIGURE 8 CROSS SECTIONS OF THE COAL SEAM GEOMETRY



6.3 Hydrostratigraphic Summary

The small number of groundwater supply bores across ATP688P attests to the poor aquifer development in the region. The geology across ATP688P can be divided into the following hydrostratigraphic units:

- Quaternary alluvium – present along drainage lines and most extensive is association with the Bowen River and Rosella Creek, reaching a maximum thickness in the range of 10 m to 30 m. Likely to be unconfined to semi-confined with intermittent connection to the surface water. Local-scale aquifers may be perched and not connected to the regional water table.
- Tertiary Basalt – where present (primarily in the southwestern corner of ATP688P), will form a fractured rock aquifer, likely unconfined to semi-confined. Local scale aquifers within the basalt may not be connected to the regional water table.

- Regolith including Tertiary Sediments and weathered rock – up to 40 m thick and more akin to an aquitard due to the high clay content of original lithologies
- Coal seams – although they are of low permeability, the coal seams form the primary aquifers in ATP688P. They are laterally extensive and continuous, and are confined by the regolith, overburden, interburden and under burden. They comprise less than 10% of the total thickness.
- Overburden and interburden – the overburden and interburden comprise very low permeability sandstone, siltstone, mudstone and shale of the Permo-Triassic Formations. It forms the aquitards that separates and confines the coal seams.
- Basement - the Back Creek Group and Lizzie Creek volcanics form the hydrogeological basement to the Bowen Basin sequence.

6.4 Water Level Trends

There is insufficient water level data available from the GWBD and other literature sources to generate potentiometric surfaces for the different hydrostratigraphic units.

FIGURE 9 presents the water level elevation for those bores for which at least one water level was available in the GWBD. The elevation was calculated by subtracting the measured water level from the Shuttle Radar Topography Mission (SRTM) 1- second digital elevation model. (DEM) elevation at the bore's location. FIGURE 9 identifies the majority of data to be associated with bores immediately adjacent to the Bowen River in the Mt St Martin area.

The available data indicates a general south to north fall in the groundwater elevation across ATP688P, with water level elevations in the Tilbrook area of approximately 200 mAHD and in the Mt St Martin area of 130 mAHD.

Groundwater level elevations generally mimic topography.

The GWBD was interrogated to identify bores with multiple water level measurements in the vicinity of ATP688P. Fourteen bores were identified within ATP688P or its immediate vicinity with three or more water level measurements, and all bar one was associated with investigations of the Bowen River alluvium. The bores have been grouped for interpretation purposes. The locations of the bores and groups are shown on Figure 10 and their associated hydrographs are presented as Figure 11 to Figure 14.

Temporal water level trends can be described as follows:

- **Area A** (Figure 11) – This single bore (RN12030094) is located roughly 8 km southwest of the Tilbrook appraisal area adjacent to the headwaters of the Suttor River. The bore is 73 m deep and is interpreted to be constructed in the Blenheim Formation of the Back Creek Group and thus monitors the hydrogeological basement. The standing water level is between 23 m and 24 m below ground level (mbgl). It shows relatively stable water levels during the 1980s, declining during the 1990s and early 2000's and then rising in the measurements post 2010.
- **Area B** (Figure 12) – This area includes seven bores ranging in depth from ~14 m to 28 m and constructed in the alluvium, Exmoor Formation (hydrogeological basement), the

Moranbah Coal Measures, or the weathered regolith adjacent to the Bowen River roughly 2.5 km west-northwest of the Mt St Martin appraisal area. Standing water levels range from 7.5 mbgl to 22.3 mbgl and are generally relatively stable over the period of monitoring. The shallowest water levels were measured in a bore that is constructed in the alluvium (RN12020003), but there is otherwise no correlation between the formation the bore is constructed in and the standing water level. Early, higher frequency data for RN12020003 shows a seasonal fluctuation of up to 2.3 m between seasons. This bore is constructed in the alluvial gravels. The lack of seasonal fluctuation in RN12020007, and the difference in depths of standing water indicates variable hydraulic connection between the Bowen River and the alluvial aquifers, and between the aquifers within the alluvium. The high degree of seasonality of the RN12020003 is indicative of an aquifer of limited storage capacity.

- **Area C** (Figure 13) – There are two bores in Area C, which is roughly 10 km east of the Mt St Martin appraisal area. The bores are 18.5 m (RN12020002) and 25 m (RN12020001) deep and constructed in alluvium and regolith respectively. The water levels show no long term trends. The sudden rise in water level in RN12020001 in 1997 is considered to most likely to be an artefact rather than a true reflection of the water level response in the regolith. The difference in depths between the water levels is partially related to the relative elevations of the bores - the riverbank is terraced and RN12020001 is about 12 m higher in elevation – but there is a downward vertical hydraulic gradient from the alluvium to the regolith of approximately 7.3 m. This difference indicates potential for hydraulic disconnection between the alluvium, and the underlying water table which is hosted by the regolith. Saturated alluvium may provide a source of recharge to the regolith.
- **Area D** (Figure 14) – Area D is roughly 23 km northwest of the Mt St Martin appraisal area is outside of the geological extent of the Bowen Basin. The bores range in depth from 12.5 m to 51 m and are constructed in alluvium and basement, including andesite. The water level data can be grouped into two sets:
- RN12020011 and RN12020013 - shallow water levels (~12 mbgl) and showing no significant trends. These bores are constructed in alluvium.
- RN12020012 and RN12020021 – deeper water levels (~20 mbgl) and showing a strong correlation to longer term preceding rainfall. These bores are constructed in basement (andesite and dark grey/brown rock).
- The ground level of the bores is similar, thus there is a downward vertical hydraulic gradient of approximately 8 m. This difference indicates potential for hydraulic disconnection between the alluvium, and the underlying water table which is hosted by the regolith.

FIGURE 9 WATER LEVEL ELEVATIONS IN THE VICINITY OF ATP688P

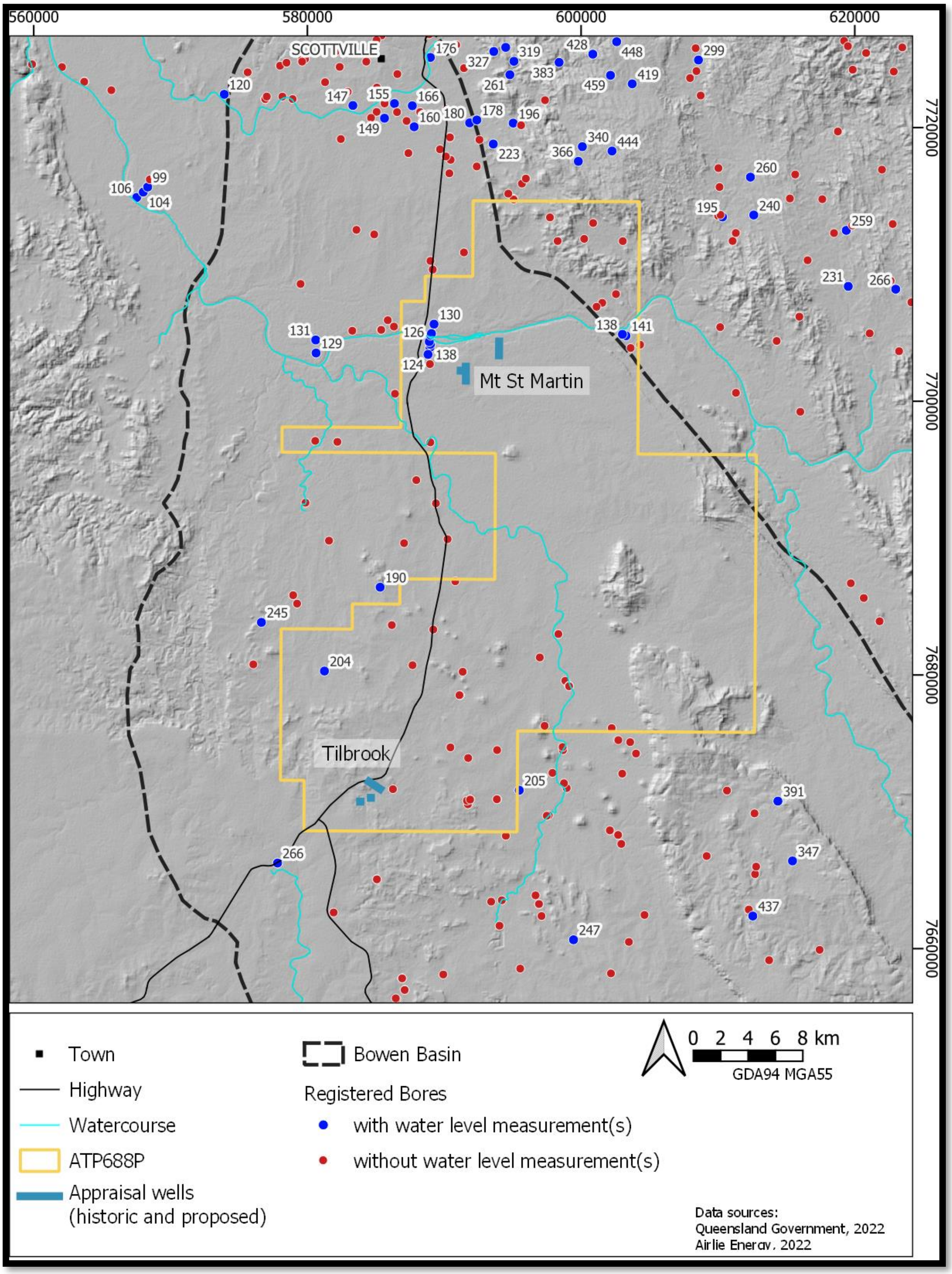


FIGURE 10 LOCATIONS OF BORES WITH TIMESERIES WATER LEVEL DATA

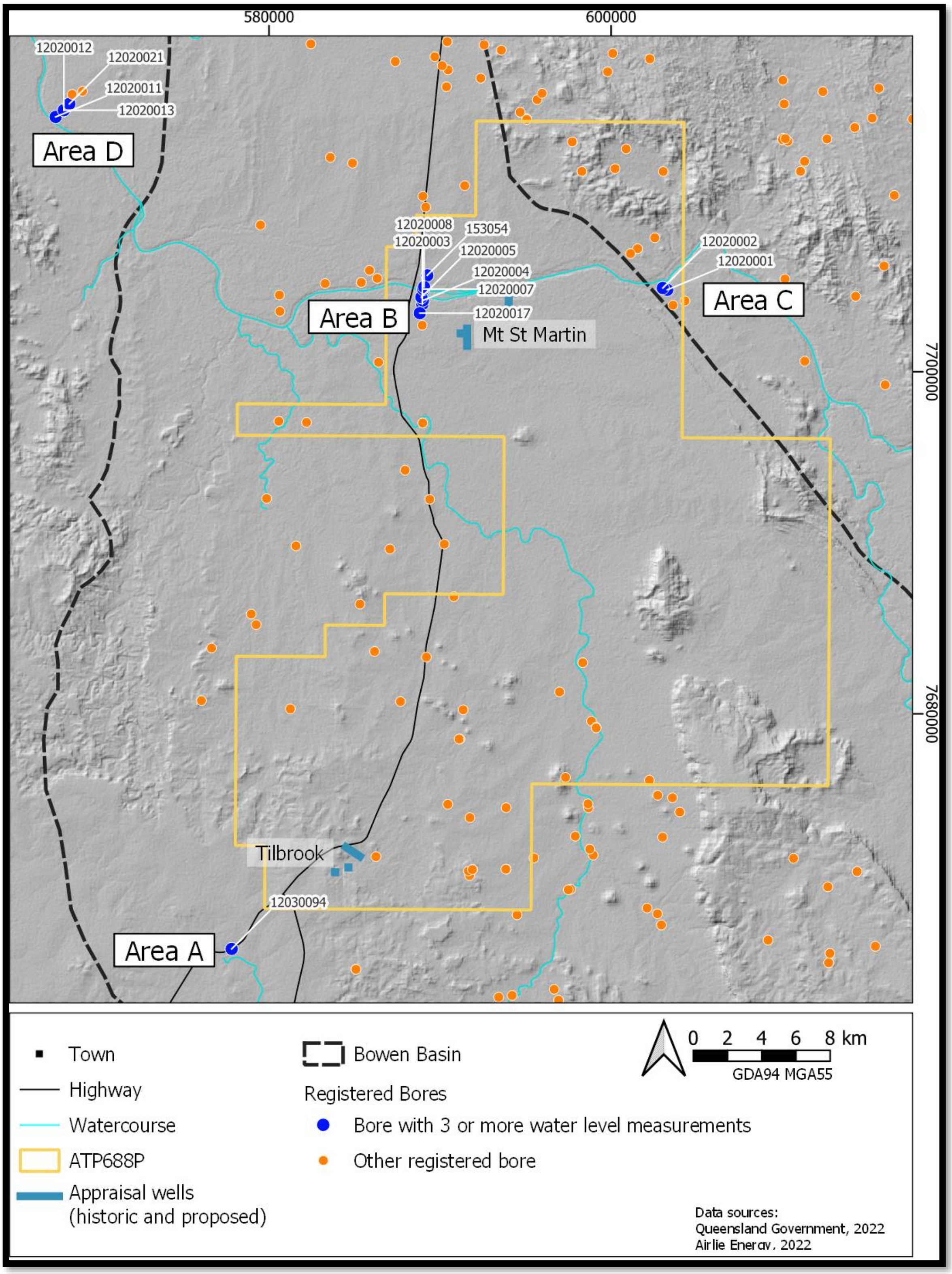


FIGURE 11 WATER LEVEL HYDROGRAPHS - AREA A

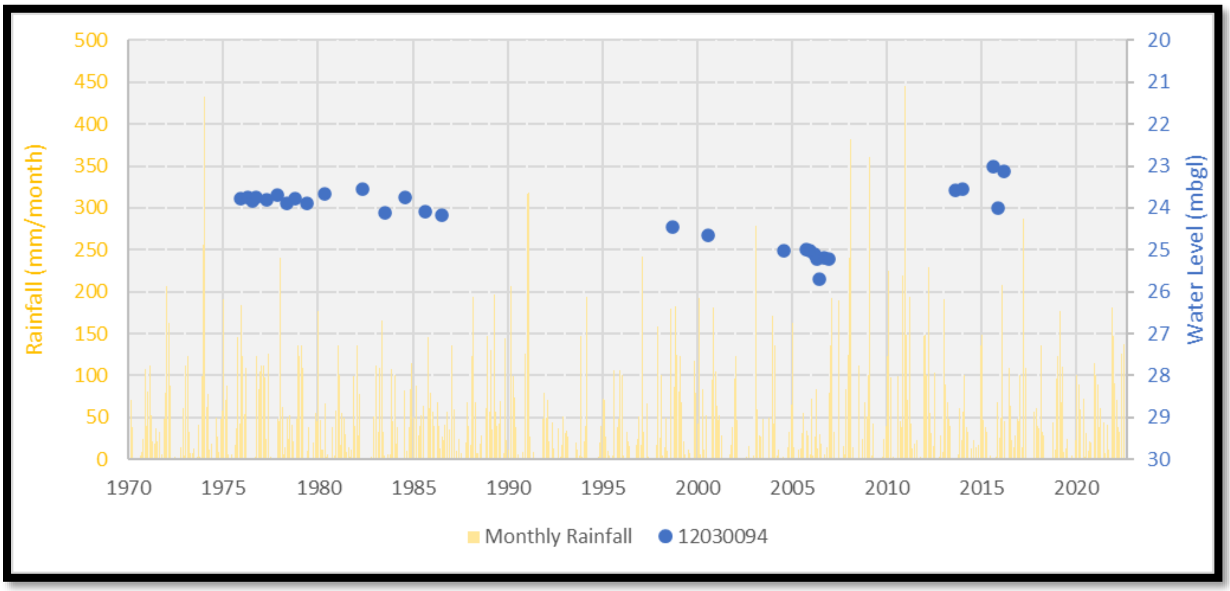


FIGURE 12 WATER LEVEL HYDROGRAPHS - AREA B

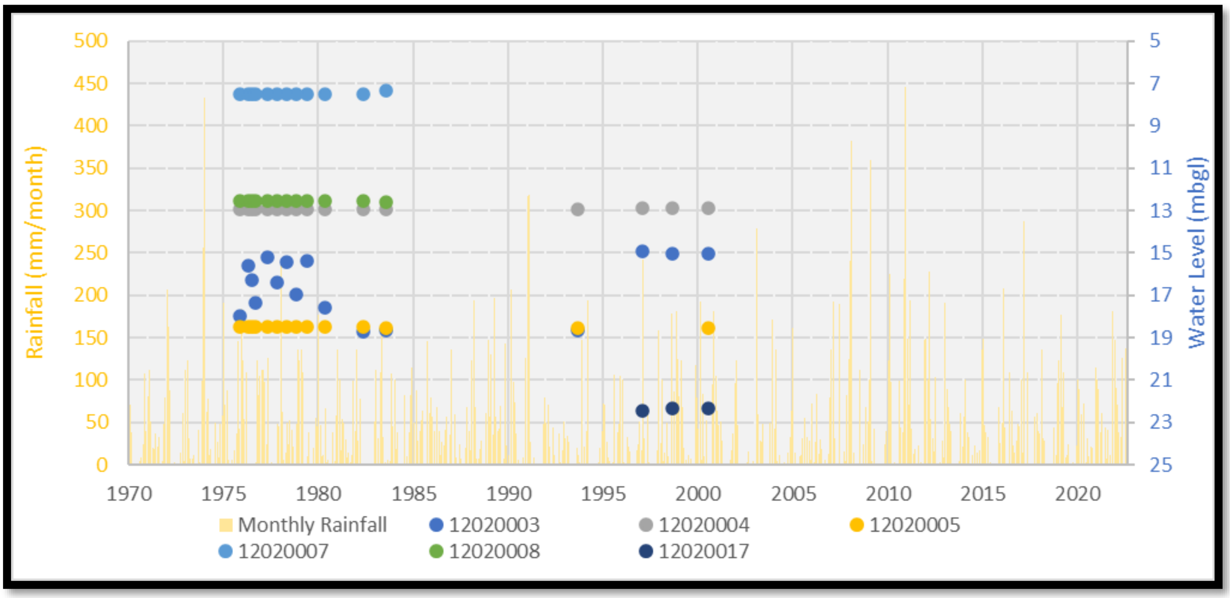


FIGURE 13 WATER LEVEL HYDROGRAPHS - AREA C

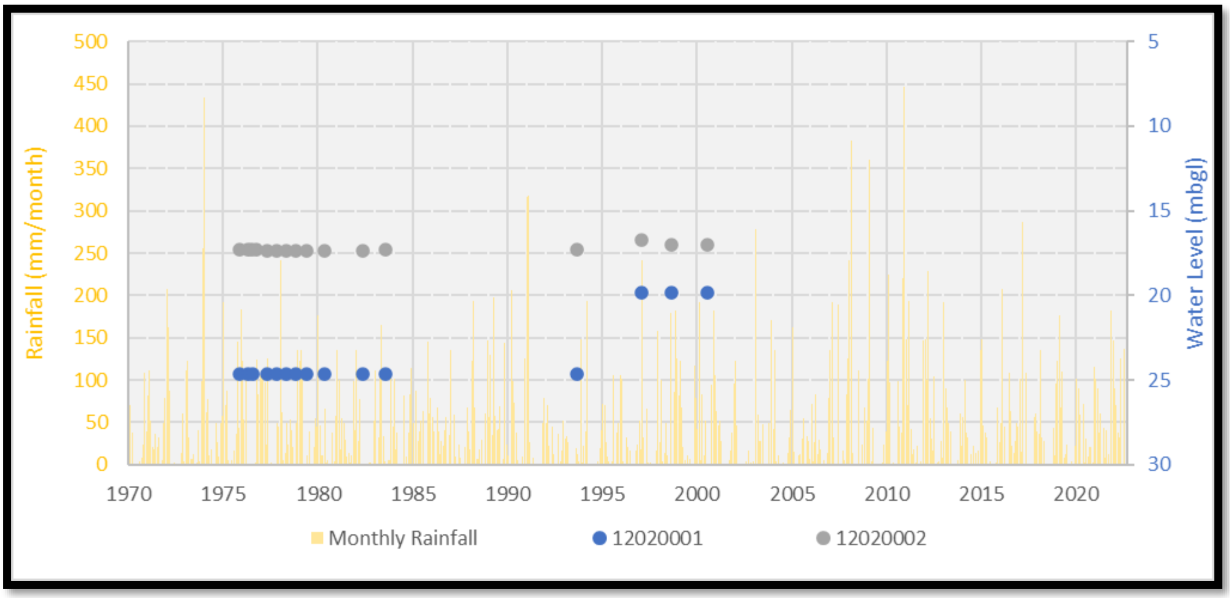
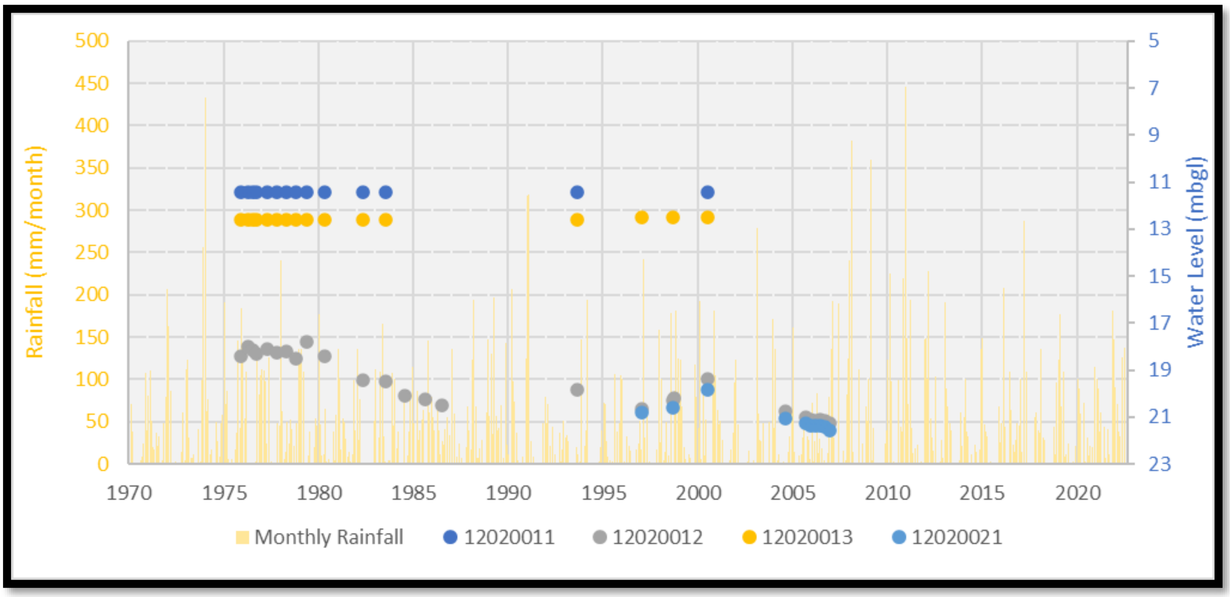


FIGURE 14 WATER LEVEL HYDROGRAPHS - AREA D

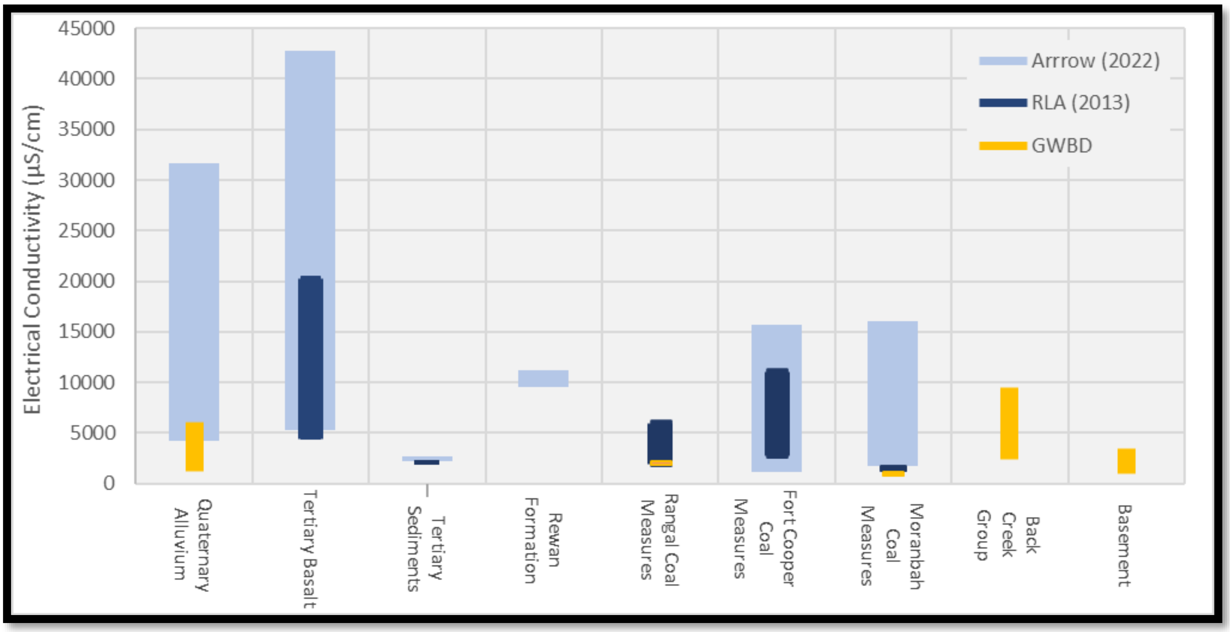


6.5 Groundwater Quality

There is a paucity of raw groundwater quality data in the vicinity of ATP688P. Figure 15 summarises the electrical conductivity ranges with data from 12 samples sourced from the GWBD on and within the immediate vicinity of ATP688P, and ranges from Arrow (2022) and the Byerwern coal mine (RLA, 2013). These data show a wide range in salinity from fresh to saline, with the surficial formations –

alluvium and Tertiary basalts – contain the most saline groundwater. The electrical conductivity of the Moranbah Coal Measures ranges from 870 µS/cm to 16,000 µS/cm (~500 mg/L – 10,000 mg/L total dissolved solids[2]).

FIGURE 15 ELECTRICAL CONDUCTIVITY COMPARISONS



6.6 Hydraulic Parameters

Hydraulic parameter data has been compiled from drill stem tests (DSTs) performed in exploration wells on ATP688P and from groundwater studies from surrounding mines. While there is a plethora of hydraulic parameter data from further afield in the Bowen Basin, the identified data has been limited to surrounding areas only, and includes the Drake mine, Byrerwern mine, ATP814P and the Arrow Energy acreage.

Figure 16 presents a summary results of permeability values derived from DSTs[3] on ATP688P for different coal seams. It shows a clear decrease in hydraulic conductivity with depth of approximately two orders of magnitude over 300 m. The permeability in the Tilbrook area is approximately one order of magnitude greater than Mt St Martin. There is approximately two orders of magnitude variability in permeability at any given depth.

Hydraulic conductivity data was also available from field testing for the Bywerwen Mine (RLA, 2013) for bore depths ranging from 52 m to 268 m. Average values of hydraulic conductivities from this testing were as follows:

[2] Based on a conversion of 0.65
[3] Permeability converted to hydraulic conductivity using a conversion factor of 0.0831 m/day = 1,000 millidarcies (Bouwer, 1978)

- Basalt – 0.05 m/day
- Tertiary Sediments – 1.4 m/day
- Rangal Coal Measures – 0.02 m/day
- Fort Cooper Coal Measures – 0.05 m/day
- Moranbah Coal Measures – 0.02 m/day
- Exmoor Formation – $4x10^{-5}$ m/day

TABLE 4 summarises the adopted hydraulic conductivity values from models from the previous ATP688P UWIR (Arris, 2017) and surrounding mines and gas fields.

No empirical vertical hydraulic conductivity (Kv) data has been identified in literature for the Bowen Basin. Most models utilised a 0.1 multiplier of vertical to horizontal hydraulic conductivity (Kh) (i.e. vertical is ten time less than horizontal). OGIA (2019), using numerical permeameters to upscale data, derived Kh/Kv ratios of ranging from ~0.5 to $1x10^{6}$ for the coal measures, and 0.5 to $5x10^{-4}$ for the clastic formations.

Specific storage represents the volume of water a formation releases from storage per unit change in hydraulic head under fully saturated conditions and relates to the expansion of the water (decompression) or compression of the aquifer as a result of the change in pressure. It imparts influence on the rate and extent of drawdown propagation and recovery. Arrow (2022) explored the uncertainties relating to the adopted specific storage values and tested the following ranges in this parameter:

- **Coal Measures** – $2x10^{-5}$ m-1 to 1x10-6 m-1
- Interburden - 1x10-6 m-1 to 4x10-6 m-1
- Tertiary - 1x10-6 m-1 to $2x10^{-5}$ m^{-1}

The Drake coal mine (QCoal, 2014) used specific storage values of $5x10^{-5}$ m^{-1} for the coal seams and $1x10^{-6}$ m^{-1} for the interburden.

FIGURE 16 COAL SEAM HYDRAULIC CONDUCTIVITY VS DEPTH (AIRLIE ENERGY DST DATA)

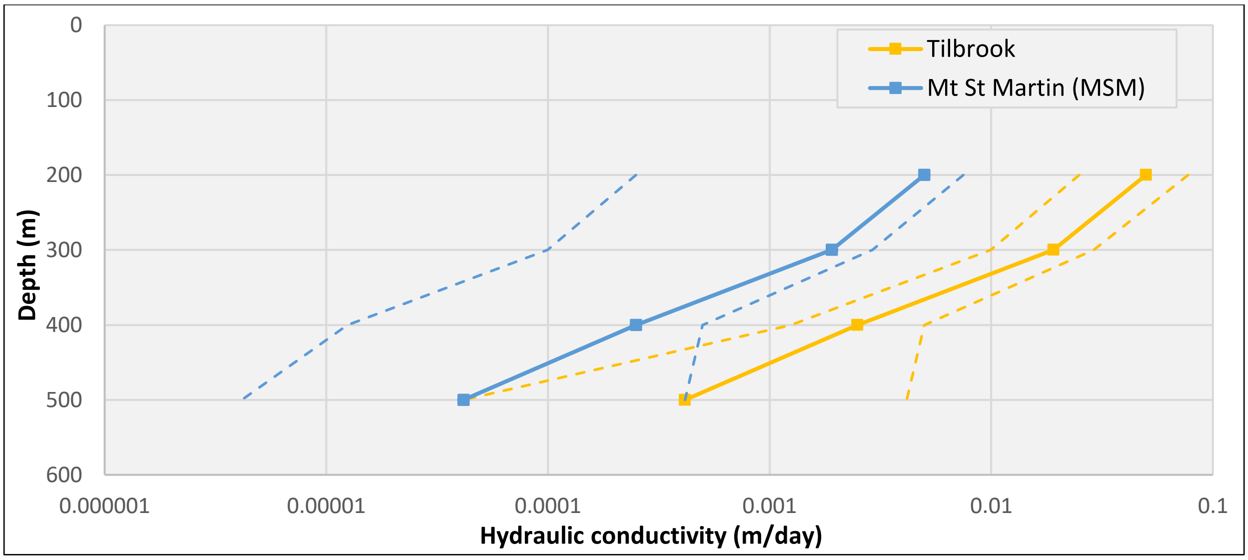


TABLE 4 MODEL HYDRAULIC CONDUCTIVITY VALUES

Unit	ATP688P (Arris, 2017)	Drake (QCoal, 2014)	Byerwern (RLA, 2013)	ATP814 (Blue Energy, 2016)
	Hydraulic conductivity (m/day)			
Alluvium	1	1	-	35
Basalt	1.00E-04	-	-	0.014
Regolith	-	0.001	-	-
Interburden	1.00E-04	1.00E-04	-	0.0007
Coal	0.05	0.01	0.002 to 0.07	0.01
Back Creek Group	1.00E-04	9.00E-07	-	-

6.7 Aquifer Interactions

Alluvium is present along major drainage lines. The alluvium hosts local scale aquifers they are variably connected to the surface water systems and streams are most likely losing, i.e., water drains from the watercourse to the underlying alluvium. The alluvial aquifers are most likely perched, i.e., they are hydraulically disconnected from the regional water table, and will therefore not be affected by potential underdrainage resulting from CSG activities.

Despite being of low permeability the coal seams form the primary aquifers within the Permian-aged sequence. There are multiple coal seams separated by thick packages of interburden. The coal seams subcrop beneath a weathered regolith to the west, and dip deeply beneath overburden to the east of the appraisal areas. Further to the east, major faults are present that exhibit significant throw and are therefore believed to act as barriers to flow. Rainfall recharge to the Bowen Basin sediments is limited due to the high clay content of the material, leading to low permeability, especially where it outcrops.

7. Environmental Values

The environmental values (EVs) of water are the qualities that make it capable of supporting aquatic ecosystems and human uses. The Queensland Government's Environmental *Protection (Water and Wetland Biodiversity) Policy 2019* (EPP Water and Wetland Biodiversity) is the primary vehicle through which the EVs of waterways (including groundwater) in Queensland are protected. The following EVs are listed under Section 6(2) of the EPP Water and Wetland Biodiversity:

- Aquatic ecosystems associated with high ecological value, slightly disturbed, moderately disturbed and highly disturbed waters
- Aquaculture
- Agriculture
- Recreation (primary, secondary and visual)
- Drinking water
- Industrial use
- Cultural and spiritual values

The exercise of underground water rights has the potential to impact on these EVs through the degradation of water quality or the reduction in water availability through depressurisation. The EVs are supported by either groundwater supply bores (aquaculture, agriculture, drinking water and industrial use) or through the surface expression of groundwater via springs and baseflow to surface water bodies and their associated wetlands (aquatic ecosystems, recreation and cultural and spiritual values). Aquatic ecosystems also include terrestrial groundwater dependent ecosystems, for which there may not be a surface expression of the groundwater.

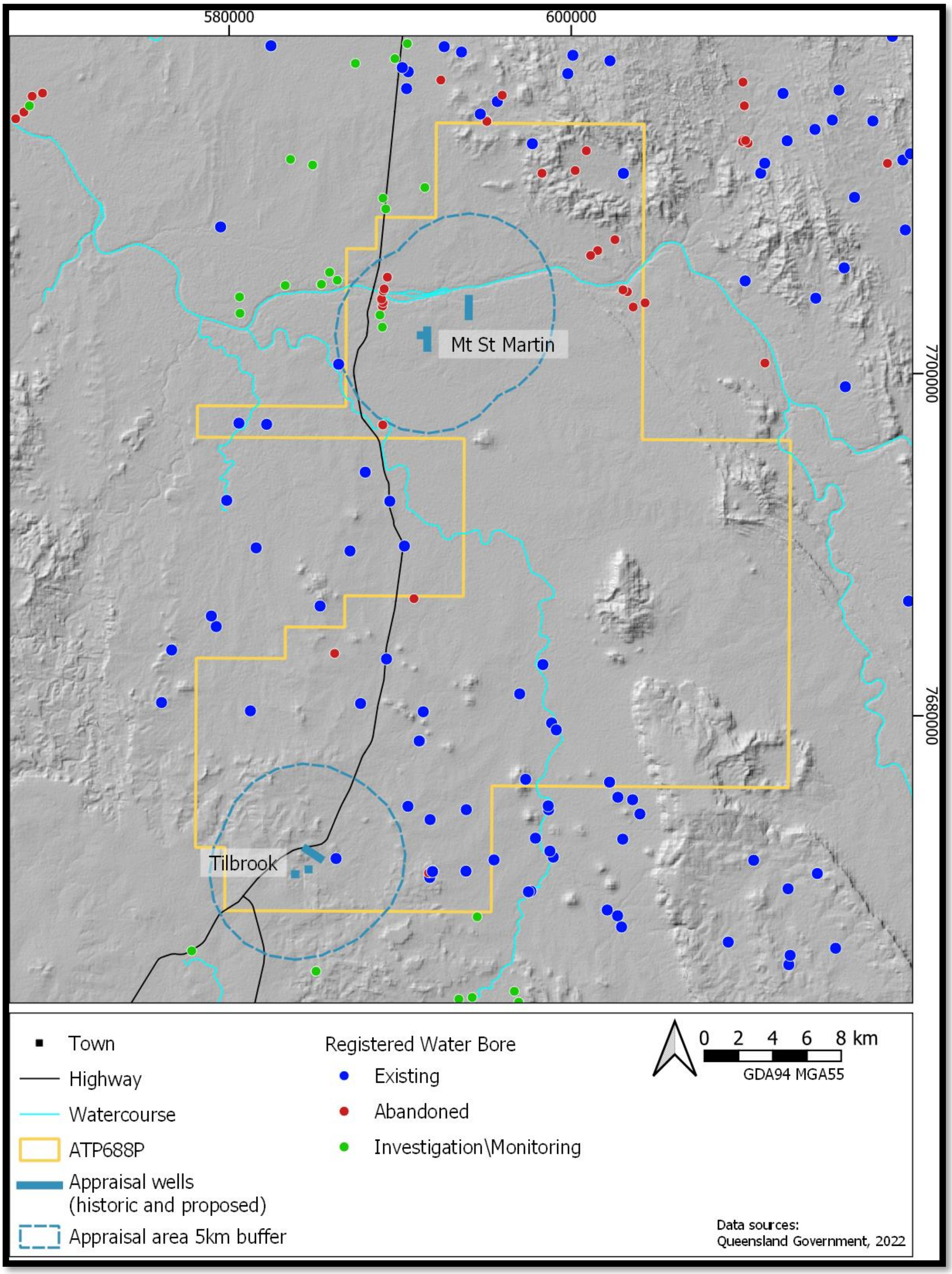
The environmental values within the vicinity of ATP688P and the pilot activities are described in the following sections.

7.1 Groundwater Bores

Figure 17 presents the location of registered waterbores identified from a search of the GWBD. Bores identified as abandoned have been preferentially identified as such. Monitoring and investigation bores have been identified based on the Queensland Globe identification of mine monitoring bores, the bore names, the bore purpose as identified in the bore reports accessed via Queensland Globe and based on construction details. All other bores are assumed to be active water supply bores.

Twenty four active water supply bores have been identified within ATP688P. None of these bores are within 5 km of the Mt St Martin appraisal activities and one (RN25621) is within 5 km of the Tilbrook appraisal area. RN25621 was drilled in 1967 to a depth of 91.5 m. It is interpreted to access the Fairhill Formation of the Fort Cooper Coal Measures.

FIGURE 17 REGISTERED WATER BORE LOCATION AND STATUS



7.2 Groundwater Dependent Ecosystems

Doody et al. (2019) defined groundwater dependent ecosystems (GDEs) as natural ecosystems which require access to groundwater on a permanent or intermittent basis to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services (Richardson et al., 2011). The broad types of GDEs are (Eamus et al., 2006):

- Ecosystems dependent on surface expression of groundwater – springs and aquatic ecosystems where baseflow contribution to watercourses occurs
- Ecosystems dependent on sub-surface expression of groundwater – terrestrial GDEs
- Subterranean ecosystems - stygofauna

Figure 18 presents the location of springs and aquatic ecosystems in the vicinity of ATP688P, which may also support recreational use and cultural and spiritual values. The data was sourced from the Queensland Springs Database (State of Queensland, 2022) and from the Bureau of Meteorology GDE Atlas (Commonwealth of Australia, 2017).

There are no mapped springs within or in the immediate vicinity of ATP688P. The closest mapped spring is over 60 km from the closest boundary of ATP688P and is outside of the Bowen Basin.

National scale assessments have identified high potential aquatic GDEs associated with the Bowen River and other watercourses and drainage lines, and some patches of moderate potential aquatic GDEs not associated with watercourses. All watercourses in ATP688P are ephemeral, and *Water Observations from Space* (GA, 2015) identifies the more regular presence of surface water to be limited to the Bowen River, and in particular associated with the Bowen River Weir. Water is detected in less than 1% of observations along Kangaroo Creek (Figure 19). Small patches of more frequent surface water presence not associated with the larger drainage lines are generally water storages such as farm dams. The national scale aquatic GDE mapping does not correspond well with the presence of surface water.

Figure 20 presents terrestrial GDE mapping from the GDE Atlas (Commonwealth of Australia, 2017). It shows a similar distribution of high potential terrestrial GDEs to aquatic GDEs, i.e. associated with the larger watercourses. There are fringing areas of moderate and low potential GDEs surrounding these high potential areas. There are also large swathers of low and medium potential terrestrial GDEs mapped across ATP688P and surrounds, generally associated with remnant vegetation and topographically diverse landscapes. All are mapped from national scale assessments.

Arrow (2022) undertook visual inspections of potential GDEs identified in the GDE Atlas and undertook a detailed analysis of the potential for GDEs within its project area. The findings were summarised as follows:

- Riparian vegetation along major watercourses may be facultative GDEs, i.e. they will use groundwater, but are capable of functioning without it.
- Non-riparian terrestrial vegetation is unlikely to be supported by regional groundwater systems because of the known rooting depth characteristics of the vegetation and the available depth to groundwater information. Site observations identified rapidly diminishing vegetation stature with distance from watercourse channels.

- Ecosystem types and groundwater conditions across ATP688P are likely to be similar to those within the Arrow tenements, which lie to the south of ATP688P.

FIGURE 18 MAPPED AQUATIC GDES AND SPRINGS

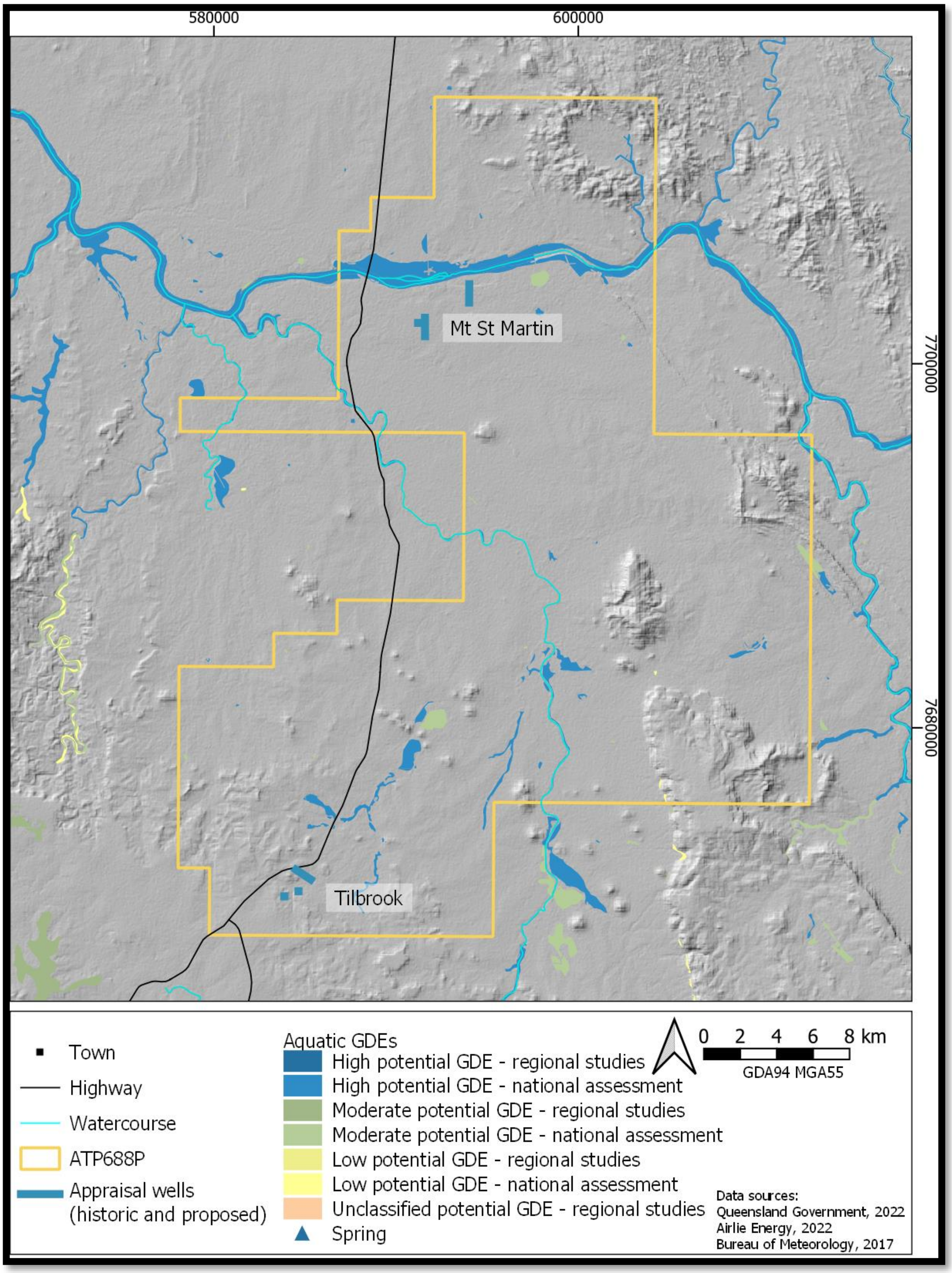


FIGURE 19 WATER OBSERVATIONS FROM SPACE (GA, 2015) – PRESENCE OF SURFACE WATER

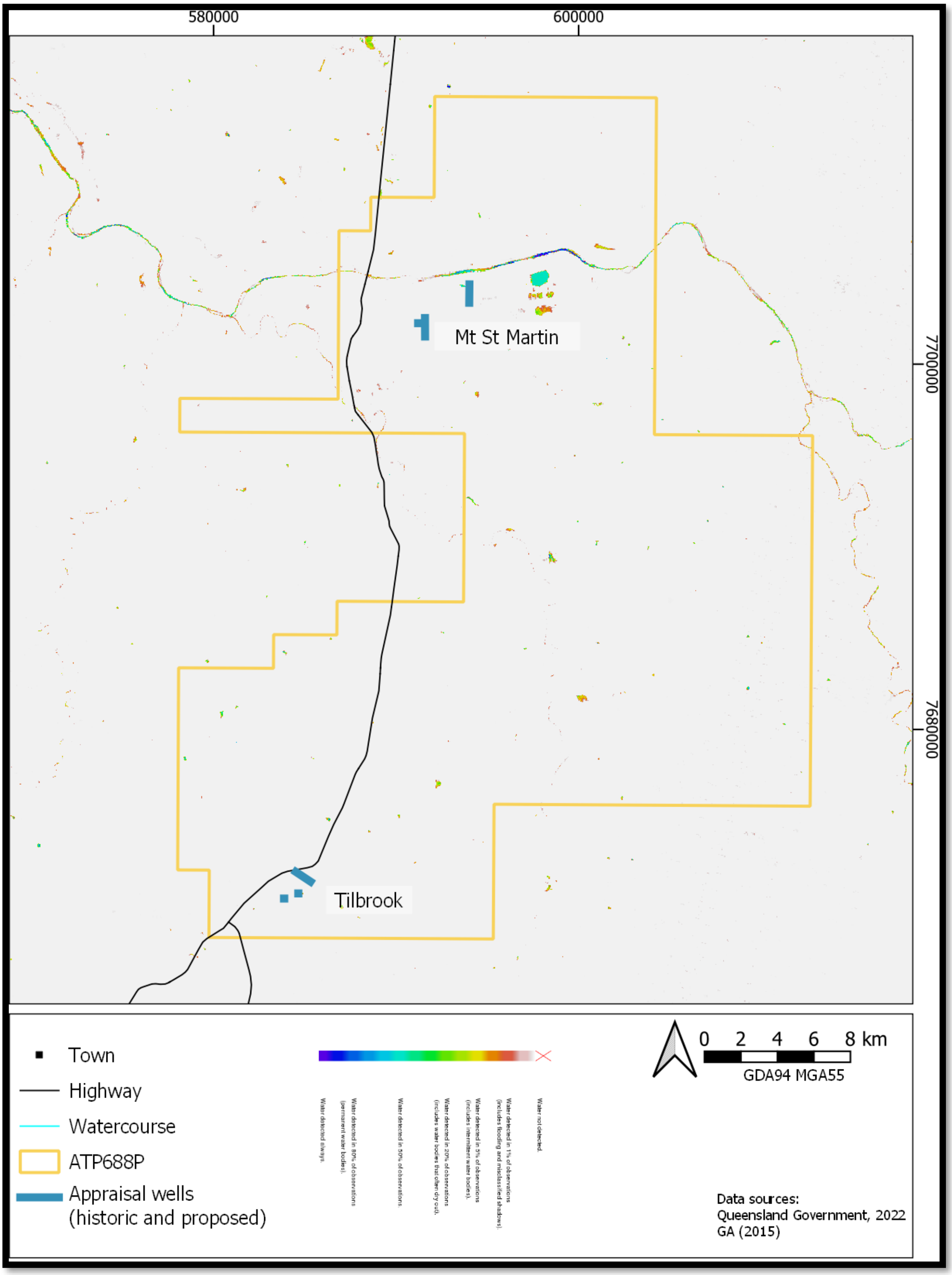
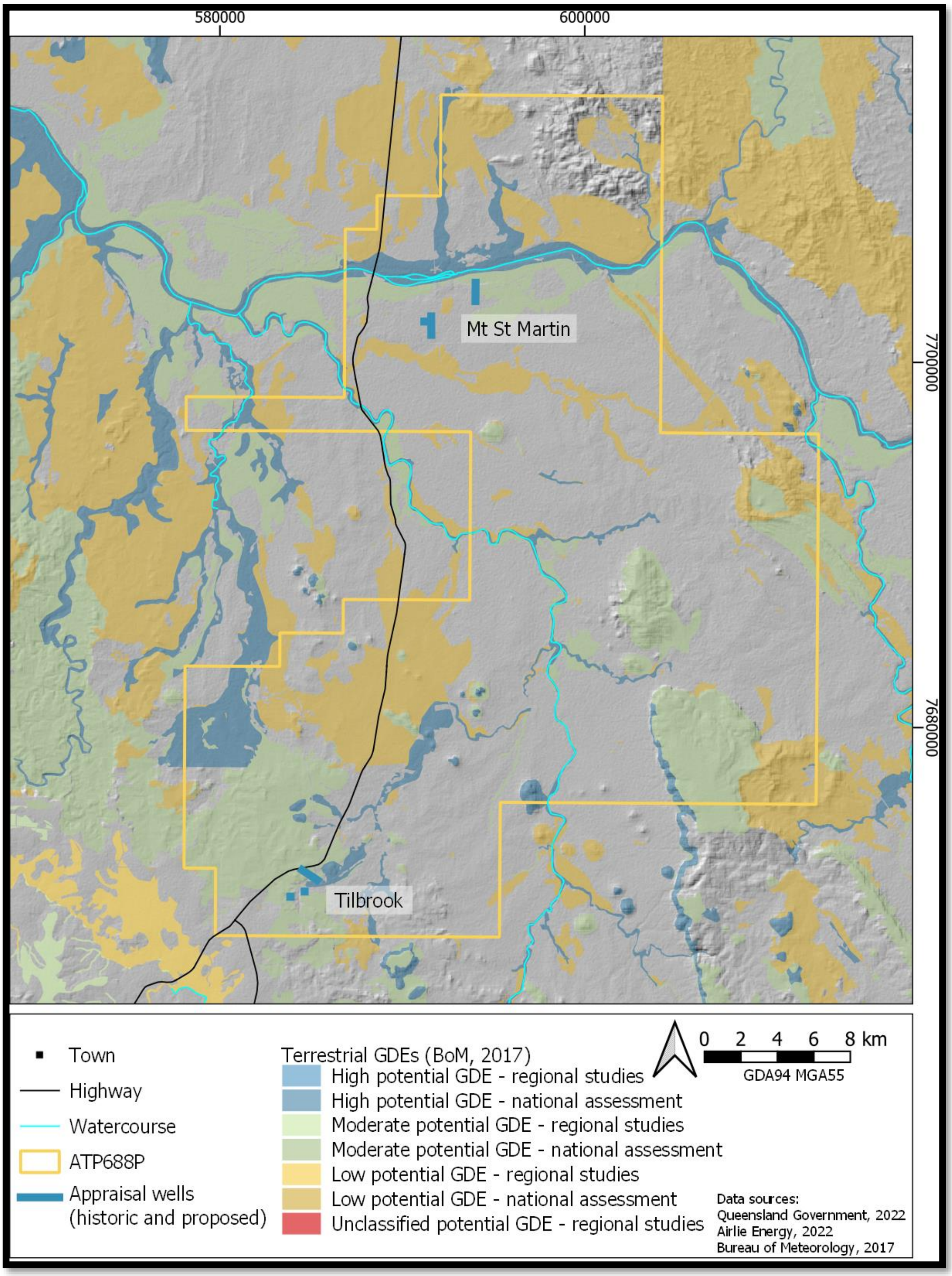


FIGURE 20 MAPPED TERRESTRIAL GDES



8. Prediction of Groundwater Impacts

8.1 Objective

A numerical groundwater flow model was constructed to enable the prediction of groundwater level drawdown due to the exercise of underground water rights on ATP688P. The objective of the modelling was to identify the extent of drawdown exceeding the *Water Act 2000* trigger thresholds as follows:

- Bore trigger threshold for a consolidated aquifer – 5 m
- Bore trigger threshold for an unconsolidated aquifer – 2 m
- Spring trigger threshold - 0.2 m

8.2 Method

A fourteen layer transient numerical groundwater flow model was constructed using a quadtree (unstructured) grid with Modflow-6. The model domain incorporated the majority of ATP688P, encompassing an area of 1,575 km^2 (Figure 21). The domain was discretised into 1,058 model cells per layer with a cell size across the majority of the model domain of 1.5 km x 1.5 km and reducing down to 375 m x 375 m around the Tilbrook and Mt St Martin appraisal areas.

The model layers (Table 5) utilised the AE geological model with only the coal seams that will be targeted by the planned appraisal activities discretely incorporated into the groundwater flow model. Layer 1 was included to represent the weathered zone, Tertiary Sediments and Tertiary Basalts at a constant thickness of 30 m and extending across the entire model domain. The overburden represents the thickness between the base of Layer 1 and the top coal seam (Upper Goonyella – Layer 3). The model geometry replicated the subcrop of the coal seams beneath the regolith as seen in FIGURE 8. Faults were not explicitly incorporated but were represented through the significant reduction in thickness in the geological model. The Quaternary Alluvium was not incorporated as it is considered to be hydraulically disconnected from the regional water table and would therefore not be affected by the exercise of underground water rights. Predicted drawdown in Layer 1 could be used as a conservative proxy for potential drawdown in the alluvium.

Base case horizontal hydraulic conductivities for each layer are included in Table 5, and are based on the figures and tabulated data in Section 6.6. The horizontal hydraulic conductivity of the coal seams was approximated using the depth relationship shown on Figure 16, with an upper bound of 0.05 m/day and a lower bound of $5x10^{-5}$ m/day. The Tilbrook relationship was applied to Layer 5 while the Mt St Martin relationship was applied to Layers 3, 7, 9, 11 and 13, based on the target formations identified in Section 6.2. The horizontal hydraulic conductivity for the overburden (Layer 2) and regolith (Layer 1) were uniformly set at $1x10^{-4}$ m/day and $1x10^{-3}$ m/day respectively.

For the base case model, a constant specific storage of $5x10^{-6}$ m^{-1} and Kh:Kv ratio of $1x10^{-3}$ were assumed (refer Section 6.6).

Modflow assumes no flow boundaries at the edges of the model domain. The proximity of the Tilbrook appraisal area to the model domain boundary is recognised. If the drawdown predictions propagate as far as the domain boundary, the magnitude of the predicted drawdown will increase due to the presence of the no flow boundary. Areas where geological layers pinched out (i.e., reduced in thickness to less than 1 m) were made inactive to represent areas of no flow. Recharge and evapotranspiration were not incorporated as these would not influence the calculation of water level drawdown.

Predictions of water level drawdown were undertaken with transient simulations from December 2008 through the end of July 2024 and incorporated all historical (TABLE 2) and forecast (FIGURE 3) water production. Water production was simulated using the Modflow WEL package and directly incorporated the actual or predicted water extraction rates. Production wells were assigned to their target formations. Horizontal wells were incorporated as line features.

Water level drawdown was calculated as the difference between the steady-state model hydraulic heads and the predicted hydraulic head at the timestep of interest from the transient simulations.

The simulations were run to 50 years following the end of production to assess post-appraisal pressure drawdown propagation and recovery.

TABLE 5 GROUNDWATER FLOW MODEL LAYERS AND HORIZONTAL HYDRAULIC CONDUCTIVITIES

Layer Number	Unit Name	Horizontal Hydraulic Conductivity (m/day)
1	Regolith	1×10^{-3}
2	Overburden	1×10^{-4}
3	Upper Goonyella	5×10^{-2} to 5×10^{-5}
4	Interburden	1×10^{-4}
5	P Seam	5×10^{-2} to 5×10^{-5}
6	Interburden	1×10^{-4}
7	Middle Goonyella	5×10^{-2} to 5×10^{-5}
8	Interburden	1×10^{-4}
9	Lower Goonyella A	5×10^{-2} to 5×10^{-5}
10	Interburden	1×10^{-4}
11	Lower Goonyella B	5×10^{-2} to 5×10^{-5}
12	Interburden	1×10^{-4}
13	Lower Goonyella C	5×10^{-2} to 5×10^{-5}
14	Basement/Interburden	1×10^{-4}

8.3 Predicted Magnitude and Extent of Groundwater Level Decline

Predictions of groundwater level drawdown are primarily influenced by the construction and parameterisation of the groundwater flow model and the footprint of production, and the amount of water extracted. Predictions were made of water level declines (drawdown) resulting from the historical and forecast exercise of underground water rights from all CSG appraisal activities across

ATP688P using the multi-layered numerical groundwater flow model as described in Section 8.2.. Water production for currently planned appraisal activities ceases at the end of July 2024.

The *Water Act 2000* identifies the bore trigger threshold for water level decline as 5 m for a consolidated aquifer and 2 m for an unconsolidated aquifer. Since the only unconsolidated aquifers within ATP688P are associated with the alluvium, the relevant bore trigger threshold is for a consolidated aquifer – 5 m. The area in which the water level is predicted to decline by more than the relevant bore trigger threshold within 3 years following the UWIR consultation day is termed the IAA, and the area in which the relevant bore trigger threshold is exceed at any time is termed the LTAA (DES, 2017).

A single IAA and LTAA has been defined for all layers constituting the Moranbah Coal Measures by using the maximum predicted drawdown for each model cell from Layers 3 to Layer 13 inclusive. This is the same approach as OGIA has implemented for defining the IAA and LTAA for the Walloon Coal Measures in the UWIR for the Surat CMA (OGIA, 2021a).

The mapped extents of the IAA and LTAA are presented as Figure 21 and Figure 23 respectively. Timeseries drawdown predictions each year applicable to this UWIR is included in Figure 22. The timing is benchmarked to the end of production testing at the end of July 2024.

Less than 5 m of drawdown is predicted in the overburden and regolith layers, therefore there is only an IAA and LTAA for the Moranbah Coal Measures.

8.4 Predictive Uncertainty

Due to inherent uncertainties in the construction of the groundwater flow model, there is associated uncertainty in the drawdown predictions. The impact of these uncertainties on the predicted drawdown was explored through a sensitivity analysis in which horizontal and vertical hydraulic conductivities, storage parameters and water extraction rates were varied one parameter at a time.

The sensitivity analyses performed are summarised in Table 6. A comparison of the sensitivity analyses and the base case predictive model is shown on Figure 24, which shows the extent of the 5 m predicted drawdown at any time (the equivalent of the LTAA). Figure 24 indicates that the base case model is generally conservative as the 5 m drawdown prediction of the base case encompasses the extent of most sensitivity analysis 5 m predicted drawdown. The exception to this is the analysis performed where the specific storage was halved, reducing it to 1×10^{-6} m^{-1}. This value of specific storage is at the lowest magnitude explored by Arrow (2022).

TABLE 6 PREDICTIVE GROUNDWATER FLOW MODEL SENSITIVITY ANALYSES

Case	Description	Adopted parameter values
Base Case	The predictive model	-
Kh_low	Horizontal hydraulic conductivity decreased	Base Case x 0.5
Kh_high	Horizontal hydraulic conductivity increased	Base Case x 2.0
Kv_high	Vertical hydraulic conductivity increased	Base Case x 10
Ss_low	Specific Storage decreased	Base Case x 0.5
Ss_high	Specific Storage increased	Base Case x 2
Q_low	Water production rates decreased	Base Case x 0.5

FIGURE 21 MAP OF THE EXTENT OF THE IAA

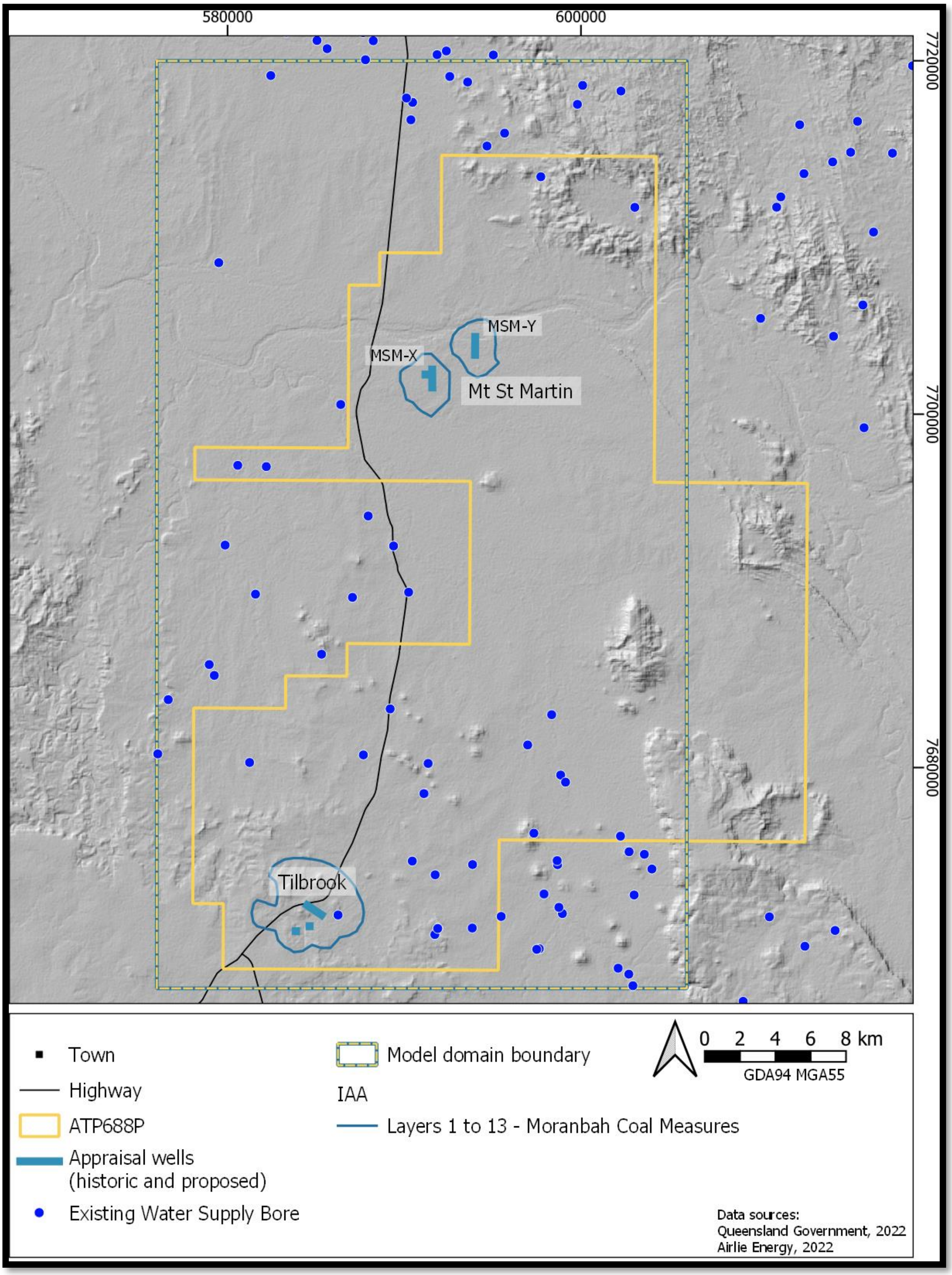


FIGURE 22 MAPPED DRAWDOWN EACH YEAR OF THIS UWIR

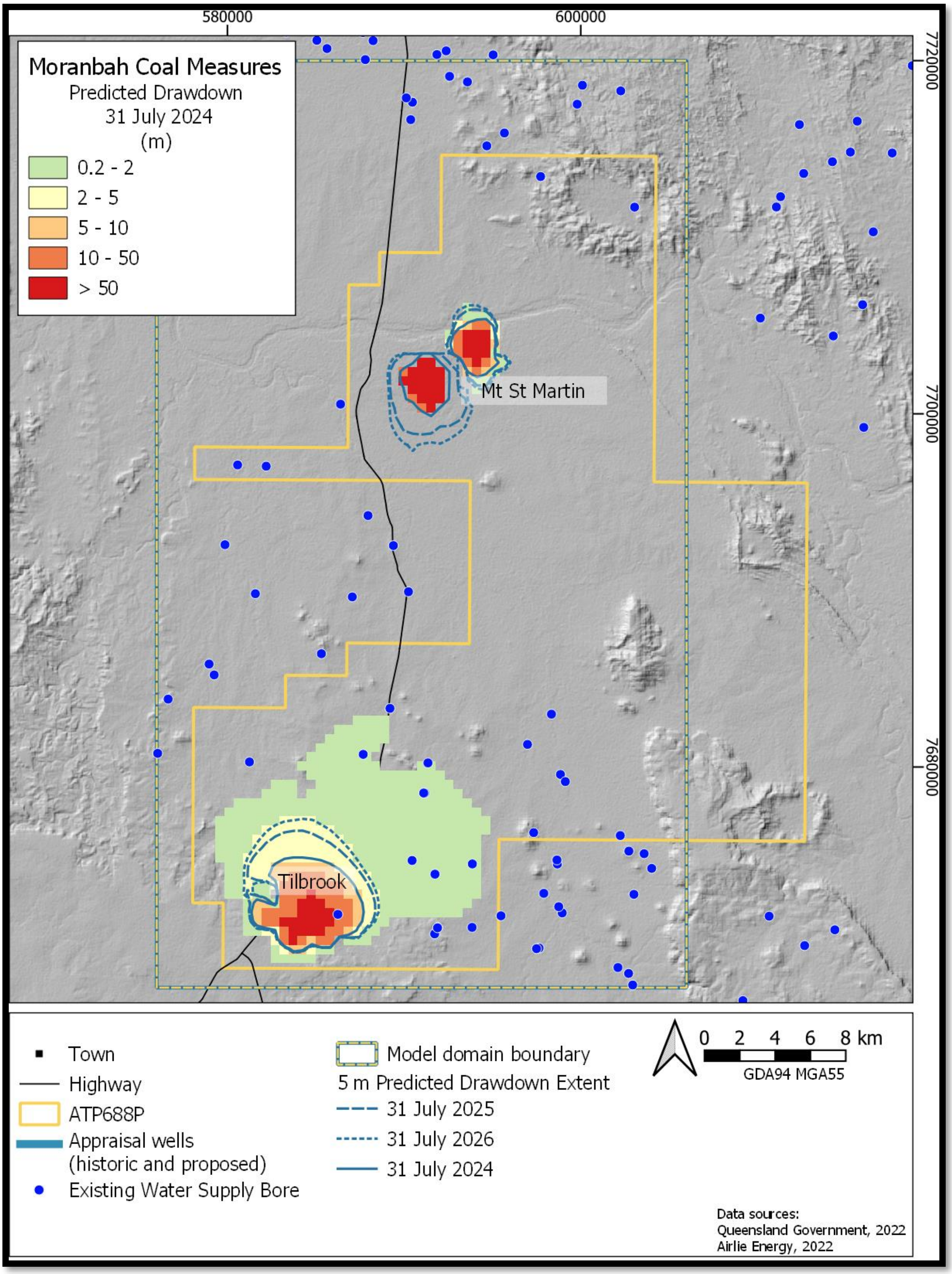


FIGURE 23 MAP OF THE EXTENT OF THE LTAA

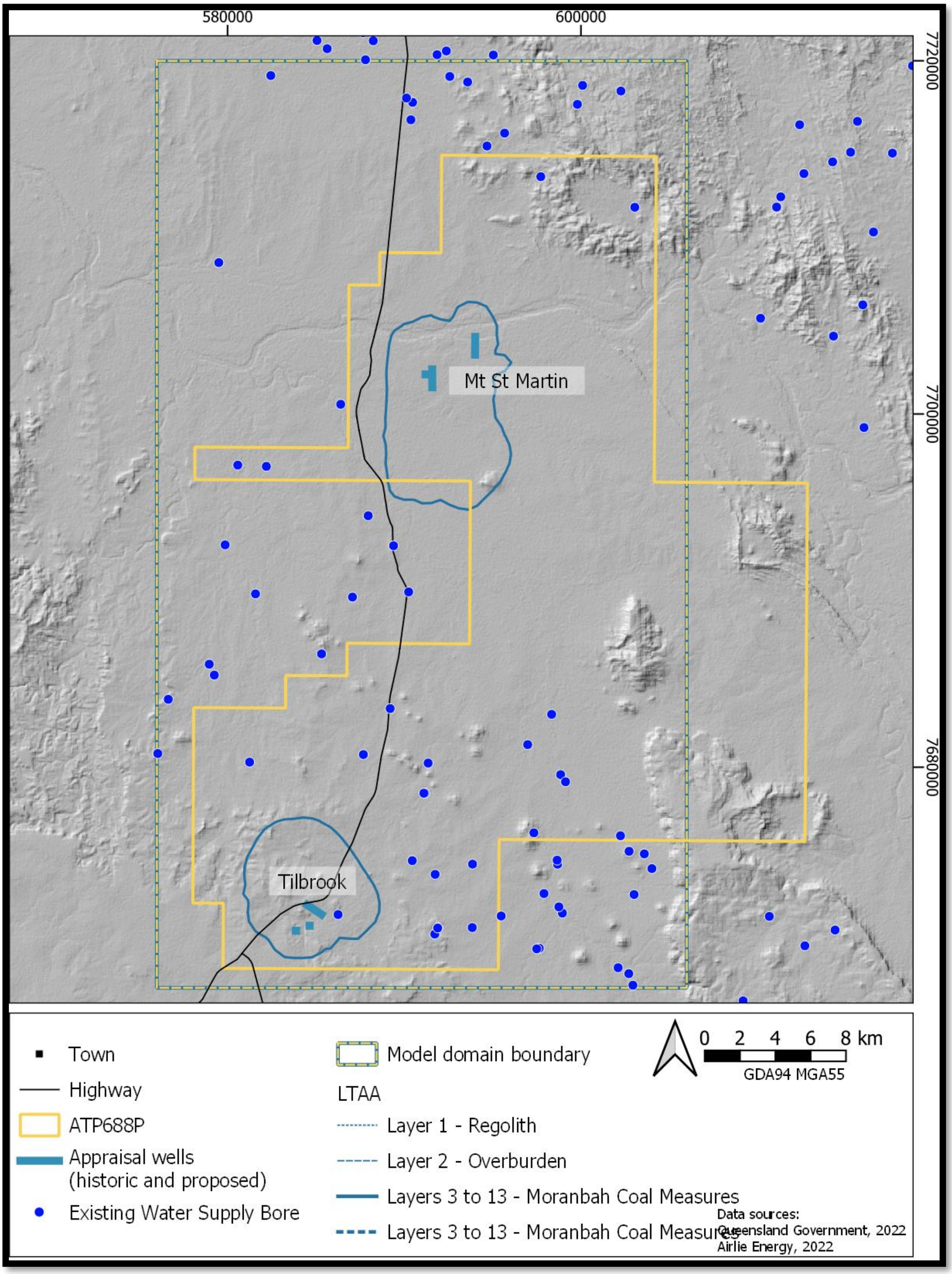
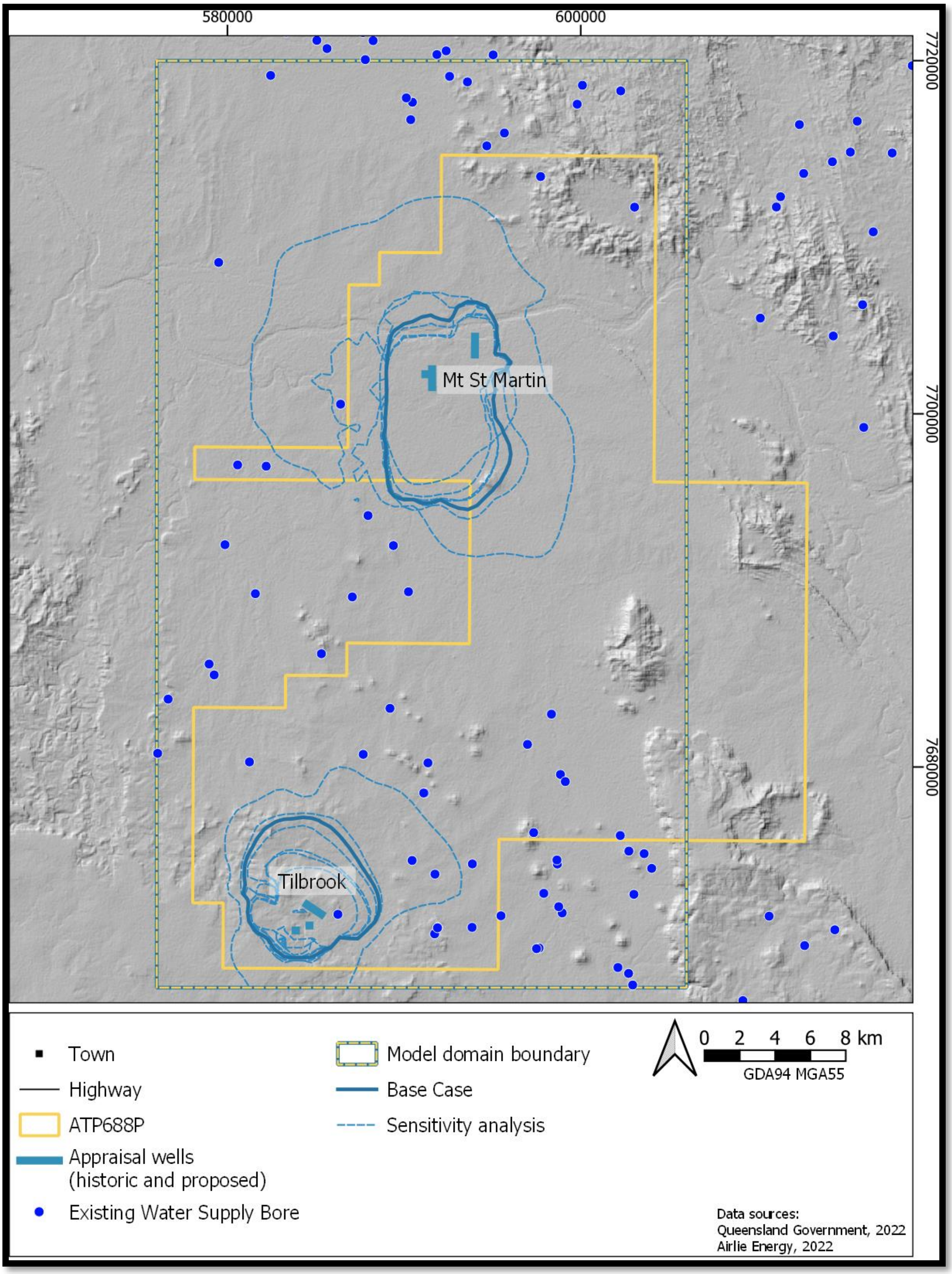


FIGURE 24 COMPARISOIN OF BASE CASE DRAWDOWN AND SENSITIVITIY ANALYSIS



8.5 Predicted Impacts to Environmental Values

8.5.1 Groundwater Bores

There are no active water supply bores identified that access the Moranbah Coal Measures within the extent of the IAA or LTAA (Figure 21 and Figure 23).

The only bore (RN25621) within the spatial extent of the IAA and LTAA accesses the Fort Cooper Coal Measures (Section 7.1). The Fort Cooper Coal Measures is represented within Layer 2 of the numerical groundwater flow model, for which the maximum predicted drawdown is 0.5 m, and no drawdown is predicted at the location of RN25621. There is no water license associated with the Lot/Plan on which RN25621 is located (State of Queensland, 2022).

The low specific storage sensitivity analysis results in the spatial extent of the 5 m drawdown extent encompassing an additional two active water supply bores (RN54108 and RN33215). According to their bore cards, these bores are both less than 60 m deep and are interpreted to be constructed in the Fort Cooper Coal Measures or shallower formations (model Layer 2), for which drawdown is not predicted to exceed 5 m.

8.5.2 Groundwater Dependent Ecosystems

The *Water Act 2000* defines a spring trigger threshold as a water level decline of 0.2 m. Since the *Water Act 2000* does not define a trigger threshold for terrestrial GDEs, the spring trigger threshold has been utilised.

Figure 25 presents the extent of the 0.2 m drawdown prediction in the Moranbah Coal Measures and the regolith at any time. Drawdown is not predicted to exceed 0.2 m in the next three years.

There are no springs within the extent of the 0.2 m drawdown contour extents.

The predicted drawdown in the regolith (Layer 1) is relevant to the prediction of potential impacts to terrestrial GDEs as it represents the formation that hosts the regional water table in the numerical groundwater flow model. Two small areas to the southwest and northwest of the Mt St Martin appraisal area are predicted to experience greater than 0.2 m of drawdown in the regolith. These are areas where the coal seams are modelled to sub-crop beneath the regolith.

The northwestern area where the adopted trigger threshold is exceeded is not mapped to host potential GDEs and regional ecosystem mapping identifies the entire area not to host remnant vegetation. The southwestern area underlies a small portion of low potential terrestrial GDE associated with the alluvial sediments adjacent to the drainage line. Regional ecosystem mapping identifies the area of potential terrestrial GDE to host Regional Ecosystems (RE) 11.3.1, 11.3.10 and 11.3.25.

Canopy trees will have the most developed and deepest root architecture and be more likely to be utilising groundwater than underlying shrub species (Barbeta et al, 2017). Regional ecosystem mapping (DES, Version 12.0) indicates that eucalypts are the dominant canopy species in the REs mapped, with other genera represented including acacia and casuarina.

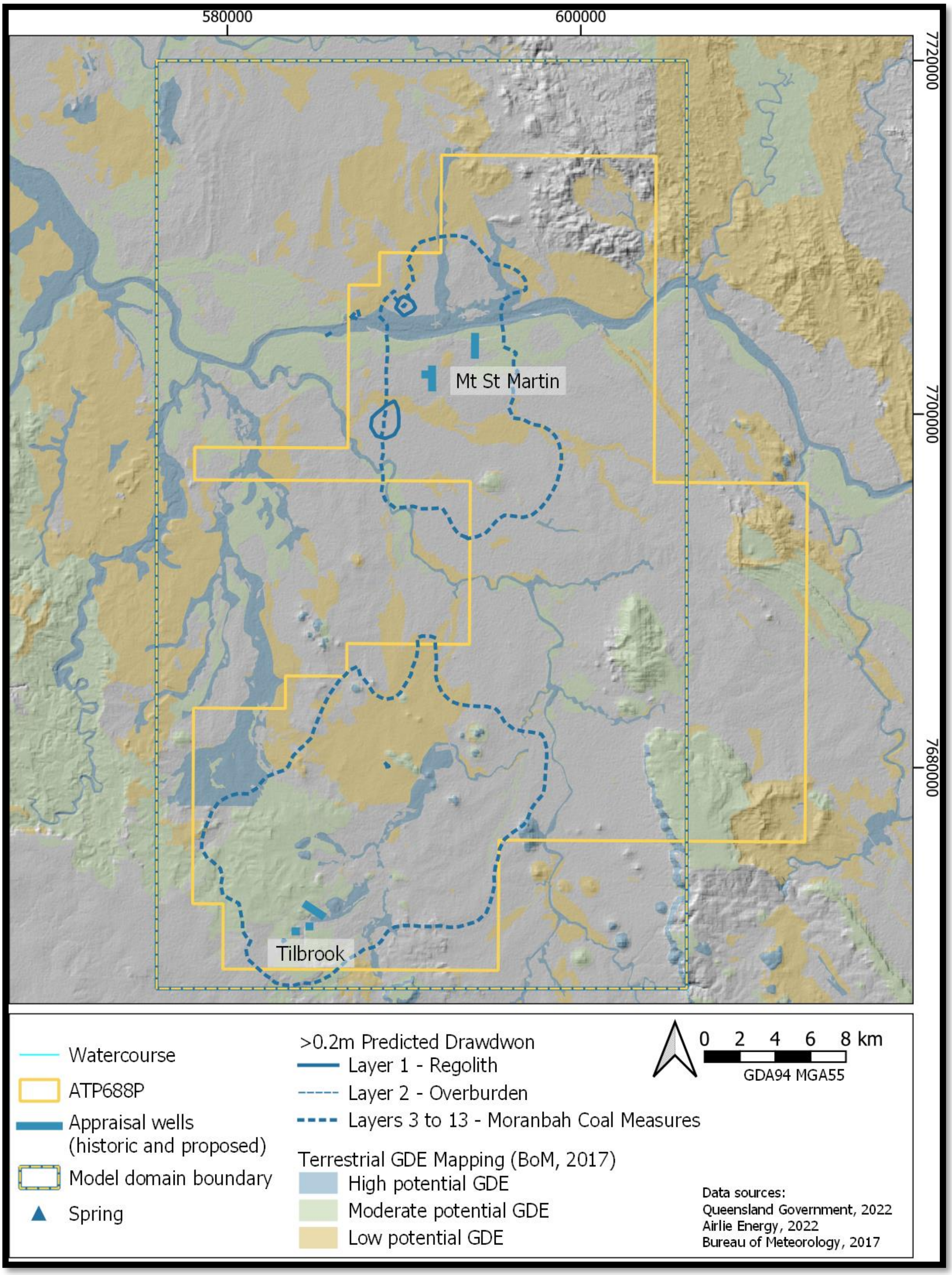
Cook et al. (2007) suggest that all eucalyptus species are potential users of groundwater. Their groundwater dependence likely varies from complete dependence (obligate phreatophyte) to occasional usage when groundwater is available within the tree root zone (facultative phreatophytes), to no groundwater use across any season. While rooting depths are not known for acacia species, they are not considered to be potentially groundwater dependent as they tend to have very shallow roots (Johnson et al, 2016). O'Grady et al. (2006) determined that river oak (a casuarina) mainly utilised river water when adjacent to a stream channel, which is its most common topographic position. There has been no demonstration that river oak has capacity to utilise deeper groundwater sources, however they may utilise shallow groundwater when alluvial sediments are saturated.

River red gum is a relatively well-studied eucalypt species known to have deep sinker roots, hypothesised to grow down towards zones of higher water supply (Bren et al., 1986). River red gum is adapted to arid and semi-arid environments and will go through alternate phases of shedding and regaining its crown, depending on the availability of water (Colloff, 2014). Trees less able to survive drought tend to die off, hence the genes that are associated with drought tolerance traits become more common in the remaining population. The species is considered opportunistic in its water use with the water requirements obtained from three main sources being groundwater, and soil moisture following rainfall, and river flooding (Thorburn et al., 1993; Mensforth et al., 1994; Holland et al., 2006; Doody et al., 2009). The species is able to survive in semi-arid areas where stands are intimately associated with the surface-flooding regime of watercourses (ANBG, 2004). River red gums are considered a facultative phreatophyte, shifting between a combination of surface soil moisture and groundwater during periods of high rainfall, then shifting to exclusive use of groundwater during drier periods. They are likely to achieve this shift through inactivation of surface roots during drier periods with increased reliance on deeper tap roots when surface water is unavailable. Doody et al. (2009) demonstrated that soil moisture alone can sustain the health of *Eucalyptus camaldulensis* through periods of drought for up to six years before significant decline in tree health is noted.

The maximum potential rooting depth of river red gum is subject to considerable conjecture in current literature, although it is widely accepted that the species has capacity to access deep groundwater sources (Eamus et al., 2006). Horner et al. (2009) found rooting depths at 12–15 mbgl based on observed mortality in plantation river red gum forests on the Murray River floodplain. Jones et al. (2020) found maximum rooting depths of 8.1 mbgl in river red gum in a broad study area across the Surat Basin. In conclusion, maximum rooting depth of river red gum is likely to be variable, dependent on-site geology and depth to saturation with the capillary fringe being the general depth at which root penetration will be arrested (Eamus et al 2006).

Based on the above, the eucalypts are the only canopy species that potentially utilise groundwater from the regional water table, with a maximum rooting depth of up to 15 mbgl. From the available water level data (FIGURE 9) and the SRTM DEM, the regional water table depth in the area where drawdown is predicted to exceed 0.2 m is estimated to be at approximately 7-10 mbgl. The maximum predicted drawdown in this area is 0.5 m, therefore the water table is predicted to remain within the root zone of the eucalypts. Other species may use shallow groundwater hosted within the alluvial sediments, however these aquifers are ephemeral, being present only after significant rainfall, and shallow and hydraulically disconnected from the regional water table, and therefore terrestrial GDEs sourcing wate from the alluvial aquifers will not be impacted.

FIGURE 25 MAP OF THE EXTENT OF THE PREDICTED DRAWDOWN EXCEEDING THE SPRING TRIGGER THRESHOLD



8.6 Predicted Impacts to Formation Integrity and Surface Subsidence

The extraction of water and gas from the subsurface will result in compaction of the strata from which they are produced. The magnitude and extent of the compaction are influenced by the magnitude and extent of the drawdown, the geomechanical properties of the coal, interburden and overburden, and the total thickness of the coal in which the drawdown occurs. It can be conservatively assumed that any compaction of the coal seams will directly translate to subsidence at the surface. OGIA (2021a) suggests that for hundreds of meters of drawdown of pressure in the coal seams, only a few centimetres of subsidence will occur at the surface. CSG companies operating in the Surat Basin predicted surface subsidence of 80 mm to 280 mm OGIA (2021a).

The LTAA (Figure 23) identifies the area in which predicted drawdown may exceed 5 m. Only a small portion of the LTAA will experience sufficient drawdown to induce compaction which on the assumption of hundreds of meters of drawdown is likely to be in the order of a few centimetres.

9. Monitoring, Management and Reporting

This section describes the water monitoring strategy (WMS), spring impact management strategy (SIMS) planned under this UWIR and the program for annual review of the accuracy of each map of the IAA and LTAA.

9.1 Water Monitoring Strategy

An underground water monitoring strategy is required for the IAA and the LTAA. IAAs and LTAAs have only been defined for the Moranbah Coal Measures as water levels are not predicted to decline in excess of the bore trigger threshold in the overlying formations.

The primary purpose of the monitoring is to provide information to improve the understanding of the groundwater system.

9.1.1 Monitoring Methodology

All water monitoring will continue to be undertaken in accordance with the *Queensland Monitoring and Sampling Manual* (DES, 2018).

The volume of water produced at each well will be constantly measured by individual electronic water flow meters installed in accordance with the manufacturer's specifications. The SCADA system will continuously record the data and calculate the total daily volume produced from each well.

Reservoir pressures in each well will be extrapolated from measured surface pressures at least monthly while the well is on production.

A sample for water quality analysis will be collected from each pilot/appraisal well. The samples will be collected from a valve on the wellhead, directly into laboratory supplied bottles.

Field parameters will be measured at the time of sampling using a calibrated field water meter and include:

- Electrical conductivity (EC)
- pH
- Temperature
-

Samples for laboratory analysis will be:

- Collected in new, laboratory supplied sample containers, with appropriate preservatives;
- Stored in a chilled esky or refrigerator prior to delivery to the laboratory;
- Submitted under Chain-of-Custody protocols; and
- Submitted to a laboratory accredited with the National Association of Testing Authorities (NATA) for the analyses to be conducted.

The analytical suite shown in Table 7 is based on the suite identified in the WMS (OGIA, 2021b) for the Surat CMA UWIR (OGIA, 2021a) and is considered appropriate to meet the purpose of the monitoring. Dissolved methane has been excluded from the OGIA (2021b) suite as methane concentrations are expected to be at saturation due to gas production.

TABLE 7 LABORATORY ANALYTICAL SUITE

Category	Parameters	
Physiochemical parameters	Electrical conductivity	
	Total dissolved solids	
	pH	
Major ions	*Cations*	*Anions*
	Calcium	Chloride
	Magnesium	Carbonate
	Sodium	Bicarbonate
	Potassium	Sulphate
Dissolved metals and minor/trace elements	Arsenic	Lead
	Barium	Manganese
	Boron	Mercury
	Cadmium	Nickel
	Chromium	Selenium
	Cobalt	Strontium
	Copper	Zinc
	Iron	
Other analytes	Fluoride	

9.1.2 Implementation of Strategy

Section 378(1)(d) requires a program for reporting to the office (OGIA) about the implementation of the WMS.

Data collected under the WMS will be compiled and provided to OGIA every 6 months. The delivery timing will correspond to the timing for the Surat CMA (OGIA, 2021a), i.e. by 1 April and 1 October of each year.

9.2 Spring Impact Mitigation Strategy

Since there are no springs located within the predicted extents of the exceedance of the spring trigger thresholds (0.2 m) a spring impact management strategy is not required.

9.3 Annual Review of the UWIR

An annual report will be prepared to provide an update on changes to circumstances that would impact on predictions reported in the UWIR, and to provide updates on the implementation of the WMS. An annual review will not be prepared when a revised UWIR is prepared, i.e. every third year.

A brief report will be prepared that includes a summary of the outcome of each review including a statement of whether there has been a material change in the information or predictions used to prepare the maps.

The annual review will also include a summary of the data collected under the WMS.

The annual reviews will be provided to the Chief Executive (DES) within 20 business days of the anniversary date of the approval of this UWIR.

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