August 31, 2021

Westside Corporation Ltd
17/300 Queen St
Brisbane, QLD
4000

Rob Ully
Senior Environmental Advisor

Dear Mr. Ully:

Mungi West / Mungi North
Underground Water Impact Report

KCB Australia Pty Ltd (KCB) is pleased to provide this Underground Water Impact Report of the Mungi West / Mungi North Project to Westside Corporation Limited. Should you have any queries regarding this document, please do not hesitate to contact the undersigned on cstrachotta@klohn.com or +61 447 485 835.

Yours truly,

KCB AUSTRALIA PTY LTD.

Chris Strachotta RPGeo
Principal Hydrogeologist

CS:MA

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1 INTRODUCTION

KCB Australia Pty Ltd (KCB) was commissioned by Westside Corporation Ltd (Westside) to prepare an Underground Water Impact Report (UWIR) for the Mungi North and Mungi West Project (the Project) within Petroleum Lease (PL) PL 1048 and PL 1049.

1.1 Project Overview

Petroleum Lease (PL) PL 1048 and PL 1049 (the Project) is located to the northwest of Moura in the southeastern portion of the Bowen Basin (Figure 1-1). The Project lies within the Fitzroy Basin surface water catchments. Directly adjacent to the Project, to the east and southeast, is Anglo American's Dawson Mining Complex (Dawson): an open cut and historic underground mine that commenced operations in the 1960s producing a mixture of coking, soft coking and thermal coal.

An existing CSG production area, identified as the Greater Meridian gas field, is located within the vicinity of the Project.

Gas production activities for the Project are planned to commence in March 2022. The Project will involve the progressive development of gas infrastructure including the following activities:

- 380 wellheads comprising of vertical wells, lateral wells and multi – lateral wells;
- Ancillary linear infrastructure including gas and water pipelines, access tracks, power lines, and communication lines;
- Water management infrastructure; and,
- Other ancillary activities and facilities to support gas field development.

Westside is the operator of PL 1048 and PL 1049. The permits are held by:

- Westside Mungi Pty Ltd;
- Harcourt (Queensland) LLC; and
- Mitsui E&P Australia Pty Ltd.

1.2 Background to the UWIR

The *Petroleum and Gas (Production and Safety) Act 2004* entitles the holder of a PL to take or interfere with underground water (i.e., groundwater) as part of approved CSG operations. This entitlement is termed the PL holder's 'underground water rights'.

Groundwater that is taken or interfered with while exercising the underground water rights is termed 'associated water'. The holder of the PL is entitled to use associated water for any purpose. In order to exercise the underground water rights for the project - the PL holder must:

- Obtain an Environmental Authority (EA) under the *Environmental Protection Act 1994* (EP Act); and,
- Comply with its reporting obligations under Chapter 3 of the *Water Act 2000* (Water Act). The administering authority for Chapter 3 of the Water Act is the Department of Environment and Science (DES). Lease holder obligations under Chapter 3 of the Water Act

include undertaking baseline assessments of the groundwater regime and water supply bores, preparing UWIRs to provide for ongoing assessment and reporting of groundwater take and (where necessary) entering into make good agreements with owners of affected water supply bores.

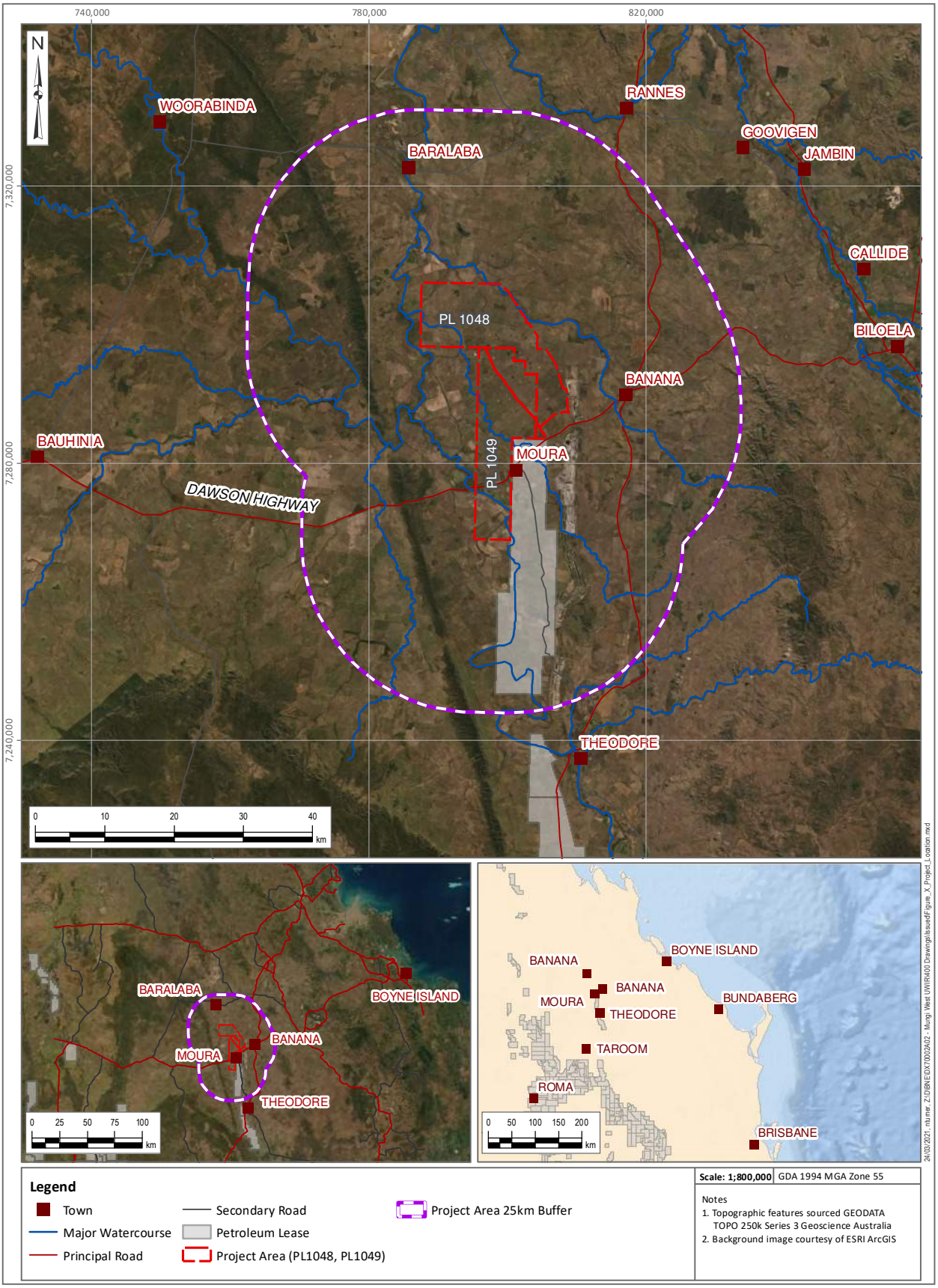

Figure 1-1 Project Location

This report has been prepared for submission to the Queensland Government, Department of Environment and Science (DES); and, is the first UWIR submitted for PL 1048 and PL 1049.

1.3 UWIR Scope and Structure

Chapter 3 of the *Water Act* requires that the proponent prepare an initial UWIR for the project. The main purpose of the UWIR is to describe the groundwater take due to CSG development (and any associated impacts) over a three-year period (the UWIR period).

This UWIR addresses the initial three years of the Project from the date that Westside exercises its underground water rights on the Project site. Westside's exercise of its underground water rights on the Project site is currently scheduled to commence in March 2022. The planned CSG activities during this UWIR period include CSG depressurisation in the southeast portion of PL 1048. Westside has not produced any groundwater or exercised its rights to take groundwater from PL 1048 or PL 1049 prior to this UWIR period.

The UWIR has been prepared in accordance with the UWIR content requirements described in Section 376 of the *Water Act* and the DES guideline Underground water impact reports and final reports (the UWIR guideline), where relevant. The requirements Section 376 of the *Water Act* are complimentary to the information requirements of the Section 126A and 227AA of the EP Act.

The specific scope of the UWIR includes:

- Presenting the relevant groundwater, geological and environmental information for the Project area;
- Undertaking a review of the Department of Regional Development, Manufacturing and Water's (DRDMW) Groundwater Database to identify relevant water supply bores within the Project area and its surrounds;
- Presenting the conceptual understanding of the groundwater regime within the Project site and its surrounds, based on historical groundwater studies and relevant public domain data;
- Develop a 3D numerical groundwater flow model for the Project to simulate existing conditions of the groundwater regime and provide predictions of the potential impact of the proposed CSG development;
- Using the 3D groundwater model to produce predictions of the Project groundwater effects during the UWIR period, including drawdown predictions for years 1, 2 and 3 of the UWIR period;
- Using water production "type curves" from comparable gas wells within the vicinity of the Project, produce water production volumes for years 1, 2 and 3 of the UWIR period;
- Assessing the groundwater impacts and developing feasible mitigation and management strategies in the event of potential adverse impacts being identified. Impacts assessed included:
    - Potential groundwater drawdown impacts on groundwater supply bores;
    - Potential groundwater drawdown impacts on the Dawson River and other surface water features;

- Potential groundwater drawdown impacts on Groundwater Dependent Ecosystems (GDEs);
- Potential cumulative drawdown impacts with adjacent resource activities, including existing coal seam gas and mining activities; and,
- Potential impacts on existing groundwater quality pre-mining as a result of the Project development.

The UWIR comprises the following sections:

- Section 1 – Introduction
- Section 2 – Regulatory Framework
- Section 3 – Project Setting
- Section 4 – Assessment Methodology
- Section 5 – Groundwater Regime
- Section 6 – Numerical Groundwater Model Summary
- Section 7 – Groundwater Impact Assessment
- Section 8 –Groundwater Monitoring Program
- Section 9 – UWIR Updates and Review

2 REGULATORY FRAMEWORK

2.1 Petroleum and Gas (Production and Safety) Act 2004

The *Petroleum and Gas (Production and Safety) Act 2004* is an Act relevant to exploring for, recovering and transporting by pipeline, petroleum and fuel gas, and ensuring the safe and efficient undertaking of those activities. The key purpose of this Act is to facilitate and regulate the undertaking of responsible petroleum activities and the development of a safe, efficient and viable petroleum and fuel gas industry.

This Act identifies underground water rights for petroleum tenures, and states that the holder of a petroleum tenure may take or interfere with underground water in the area of the tenure if the taking or interference happens during the course of, or results from, the carrying out of another authorised activity for the tenure.

The Act prescribes mandatory compliance with the Queensland Department of Resources (DoR), formerly the Department of Natural Resources and Mines (DNRME), '*Code of Practice for the construction and abandonment of coal seam gas and petroleum wells, and associated bores in Queensland Version 1'* (DNRME 2019). The purpose of this Code is to provide guidance that all petroleum wells, CSG wells and associated bores are constructed, maintained and abandoned to a minimum acceptable standard resulting in long-term well integrity, containment of petroleum and the protection of groundwater resources.

2.2 Water Act 2000

General Purpose of the Water Act

The *Water Act 2000* is an Act to provide for the sustainable management of water and the management of impacts on underground water, among other purposes. This Act provides a framework for:

- the sustainable management of Queensland's water resources by establishing a system for the planning, allocation and use of water;
- the sustainable and secure water supply and demand management for designated regions;
- the management of impacts on underground water caused by the exercise of underground water rights by the resource sector; and
- the effective operation of water authorities.

This Act covers water in a watercourse, lake or spring, underground water (or groundwater), overland flow water, or water that has been collected in a dam.

Water Act and CSG Related Activities

The *Water Act 2000* provides for the identification and management of potential impacts on underground water caused by the exercise of underground water rights by resource tenure holders, which are regulated under the *Petroleum and Gas (Production and Safety) Act 2004.* The Act also outlines the requirements for make good agreements, if required, associated with the impacts to underground water.

Chapter 3 of the *Water Act 2000* has a stated purpose to provide for the management of impacts on underground water caused by the exercise of underground water rights by resource tenure holders, which includes petroleum tenure holders. To achieve the stated purpose, a regulatory framework is provided which requires:

- Resource tenure holders monitor and assess the impacts of the exercise of underground water rights on water bores and to enter into make good agreements with the owners of the groundwater bores as necessary;
- The preparation of underground water impact reports (UWIR) that establish underground water obligations, including obligations to monitor and manage impacts on aquifers and springs; and
- Manage the cumulative impacts of the activities of two or more resource tenure holders' underground water rights on underground water.

Under this regulatory framework, where there is an area of concentrated development, a cumulative management area (CMA) can be declared. The Project is located beyond the northern extents of the Surat CMA, which was declared in 2011. Of relevance to this Project, UWIRs have been previously compiled for:

- ATP 564 (now ATP 2027) (CDM Smith 2016a);
- ATP 602 (CDM Smith 2016b); and,
- Meridian Gas Project – PL94 (CDM Smith 2019).

Trigger Thresholds

Under Section 362 of the *Water Act 2000*, a bore trigger threshold, for a consolidated aquifer, of 5 m applies (2 m for an unconsolidated aquifer). The 5 m threshold represents the maximum allowable groundwater level decline in a groundwater bore, due to petroleum tenure holder's activities, prior to triggering an investigation into the water level decline.

Under Section 379 of the *Water Act 2000* a spring trigger threshold for an aquifer applies. This includes vent springs / complexes and watercourse springs (i.e., gaining streams). This threshold value (0.2 m) represents the maximum allowable decline in the water level of an aquifer in connection with a spring, at the spring location, prior to triggering an investigation into the water level decline.

2.2.1 UWIR Requirements

Section 376 of the Water Act specifies the UWIR content requirements. Table 2-1 lists the specific content requirements and provides an explanation of where each requirement is addressed in this UWIR.

Table 2-1: UWIR Content Requirements

Water Act Section No.	Water Act Section Content	UWIR Cross Reference
376(1)(a)	An underground water impact report must include each of the following — 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 (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.	i) To date, Westside has not produced or taken groundwater due to the exercise of underground water rights on the project site. (ii) Section 7 describes the estimated groundwater take over the UWIR period.
376(1)(b)	For each aquifer affected, or likely to be affected, by the exercise of the relevant underground water rights: (i) a description of the aquifer; (ii) an analysis of the movement of underground water to and from the aquifer, including how the aquifer interacts with other aquifers; and (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); (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, (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.	(i) and (ii) Section 5 describes the groundwater regime in the relevant aquifers. (iii) To date, Westside has not produced or taken groundwater due to the exercise of underground water rights on the project site. (iv) Section 7 provides discussion on the predicted groundwater level drawdown associated with the proposed CSG development during the UWIR period. (v) Section 7 provides discussion on the predicted groundwater level drawdown associated with the proposed CSG development at any time during the development.

Water Act Section No.	Water Act Section Content	UWIR Cross Reference
376(1)(c)	A description of the methods and techniques used to obtain the information and predictions under paragraph (b).	Section 4 describes the UWIR methodology
376(1)(d)	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.	Section 5.10 describes the water bores identified from the DRDMW groundwater database.
376(1)(d,a)	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.	To date, Westside has not produced or taken groundwater due to the exercise of underground water rights on the Project site
376(1)(d,b)	An assessment of the likely impacts on environmental values that will occur, or are likely to occur, because of the exercise of underground water rights: i. during the period mentioned in paragraph (a)(ii); and, ii. over the projected life of the resource tenure.	Section 7 presents an assessment of potential groundwater impacts due to CSG development.
376(1)(e)	A program for: i. conducting an annual review of the accuracy of each map prepared under paragraph (b)(iv) and (v); and, 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.	Section 9 describes the UWIR review and reporting process for the affected aquifers.
376(1)(f)	A water monitoring strategy.	Section 8 describes the groundwater monitoring program.
376(1)(g)	A spring impact management strategy.	There are no springs within the Project site or its surrounds. Hence, a strategy for spring management is not required.
376(1)(h)	If the responsible entity is the office: i. a proposed responsible tenure holder for each report obligation mentioned in the report; and, 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.
376(1)(i)	The information or matters prescribed under a regulation.	No other relevant information or matters have been prescribed under a regulation.
376(2)	However, if the underground water impact report does not show any predicted water level decline in any area of an affected aquifer by more than the bore trigger threshold during the period mentioned in subsection (1)(b)(iv) or at any time as mentioned in subsection (1)(b)(v), the report does not have to include the program mentioned in subsection (1)(e).	Section 9 describes the UWIR review and reporting process for the affected aquifers.

Section 378 of the Water Act lists the content requirements for the water monitoring strategy. Table 2-2 lists the specific content requirements and provides an explanation of where each requirement is addressed in this UWIR.

Table 2-2 UWIR Water Monitoring Strategy Content Requirements

Water Act Section No.	Water Act Section Content	UWIR Cross Reference
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; b) the rationale for the strategy; c) a timetable for implementing the strategy; d) a program for reporting to the office about the implementation of the strategy.	Section 8 describes the groundwater monitoring program.
378(2)	The strategy for monitoring mentioned in subsection (1)(a) must include: a) the parameters to be measured; b) the locations for taking the measurements; and, c) the frequency of the measurements.	Section 8 describes the groundwater monitoring program.
378(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 resource tenure; but b) within the area shown on the map prepared under section 376(b)(v).	Section 5.10 describes the water bores identified from the DRDMW groundwater database.
378(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.

2.3 Environmental Protection Act 1994

The *Environmental Protection Act 1994* (State of Queensland 2021) is an Act with the objective to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (ecologically sustainable development).

This Act states that 'to carry out an environmentally relevant activity (ERA) an environmental authority (EA) is required'. A resource activity, specifically a petroleum activity, is defined as an ERA.

2.3.1 Environmental Authority EA0002230

Westside currently holds an Environmental Authority (EA) (EA0002230) authorising petroleum activity within PL 1048 and PL 1049. EA (EA0002230) authorises the construction and operation of up to 401 production wells and other ancillary activities to support gas field development across PL 1048 and PL 1049.

Under the *Environmental Protection Act 1994*, streamlined model conditions for petroleum activities have been developed for incorporation into EA's. These are provided in a guideline published by the State of Queensland Department of Science and Environment (DES) (2016c). The streamlined conditions are based on acceptable management approaches and constraints to protect environmental values.

3 PROJECT SETTING

3.1 Project Location and Land Use

The Project area is located in Central Queensland and covers a total area of ~378 km^2, comprising PL 1048 and PL 1049. The southeastern extent of the Project area is located less than 2 km from Moura, while the far western extent is located 8 km east of Banana.

Dominant land use within the vicinity of the Project is grazing native vegetation. Other land use types surrounding the Project area include cropping, irrigated cropping, coal mining and production native forests. Figure 3-1 presents the mapped land use distribution within the vicinity of the Project area.

The Project is situated directly north of an existing petroleum lease held by Westside entities and Mitsui E&P Australia Pty Ltd (PL 94). Dawson Mine, operated by Anglo American Coal, is located to the west of the Project.

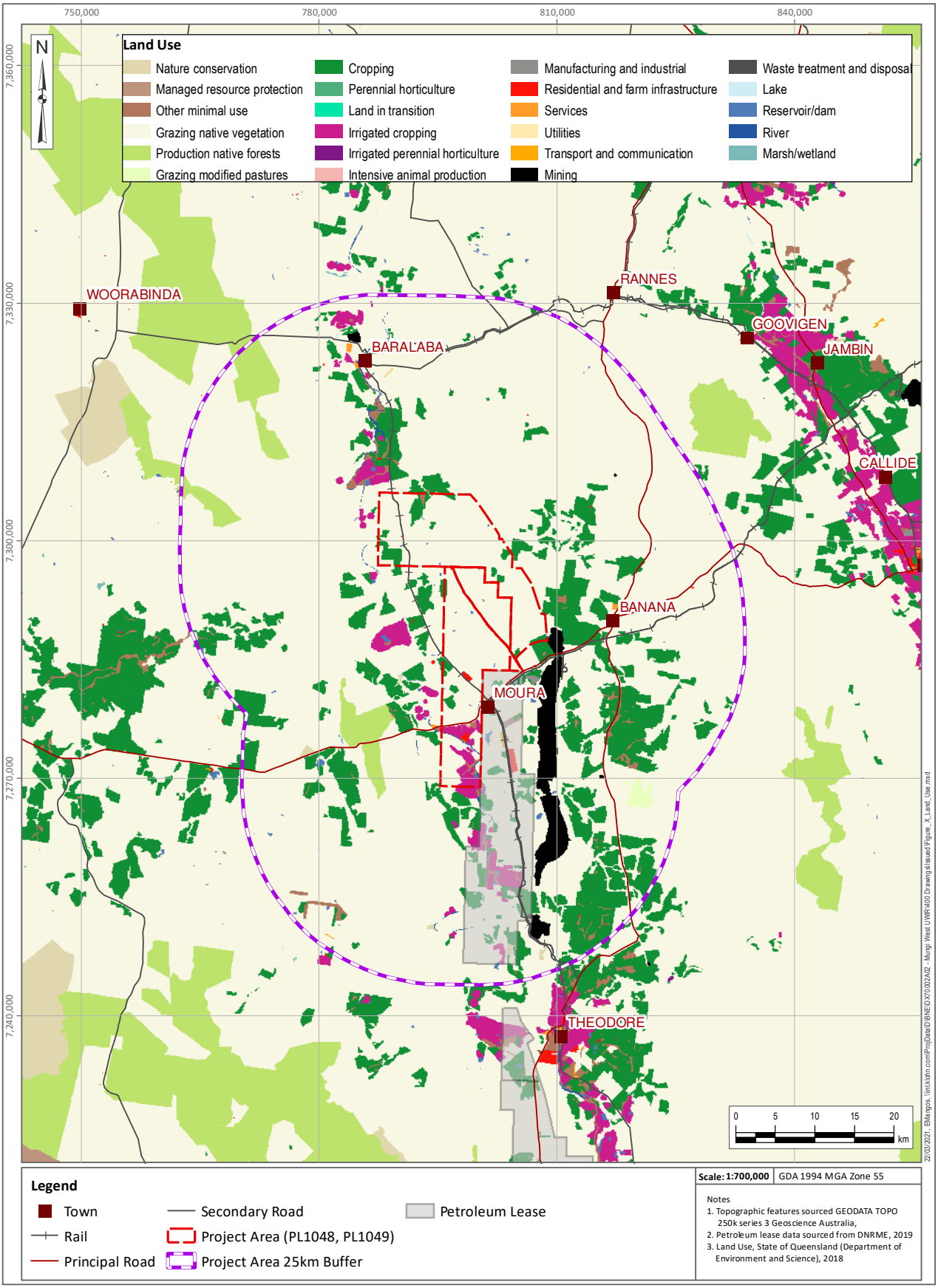

Figure 3-1 Project Development Area Current Land Use

3.2 Topography and Drainage

The Project area is generally undulating and is situated between two topographic highs. It is bordered by the Dawson Ranges and the Banana Ranges, located ~15 km west and ~30 km east of the Project area respectively. Both of those topographic highs trend in a north-south direction (Figure 3-2).

The Project area is located in the Lower Dawson Sub-Basin, part of the Fitzroy Basin (State of Queensland 2013). The Fitzroy River Basin is the second largest externally drained basin in Australia and the largest on the eastern coast of the continent. Covering an area of 150,000 km^2, the basin contains several significant tributaries, including the Nogoa, Comet, Mackenzie and Dawson Rivers. The basin discharges into the Coral Sea, east of Rockhampton.

The Dawson River drainage sub basin is 565 km^2 (DES 2019). The Lower Dawson catchment is bounded by the Shotover Ranges (URS 2014), ~120 km to the northwest of the Project Area. The catchment consists of an extensive network of watercourses that are ephemeral. The Dawson River is a perennial watercourse due to inflow from groundwater springs throughout the year (URS 2014), although there are sections of ephemeral flow (DNRME 2018).

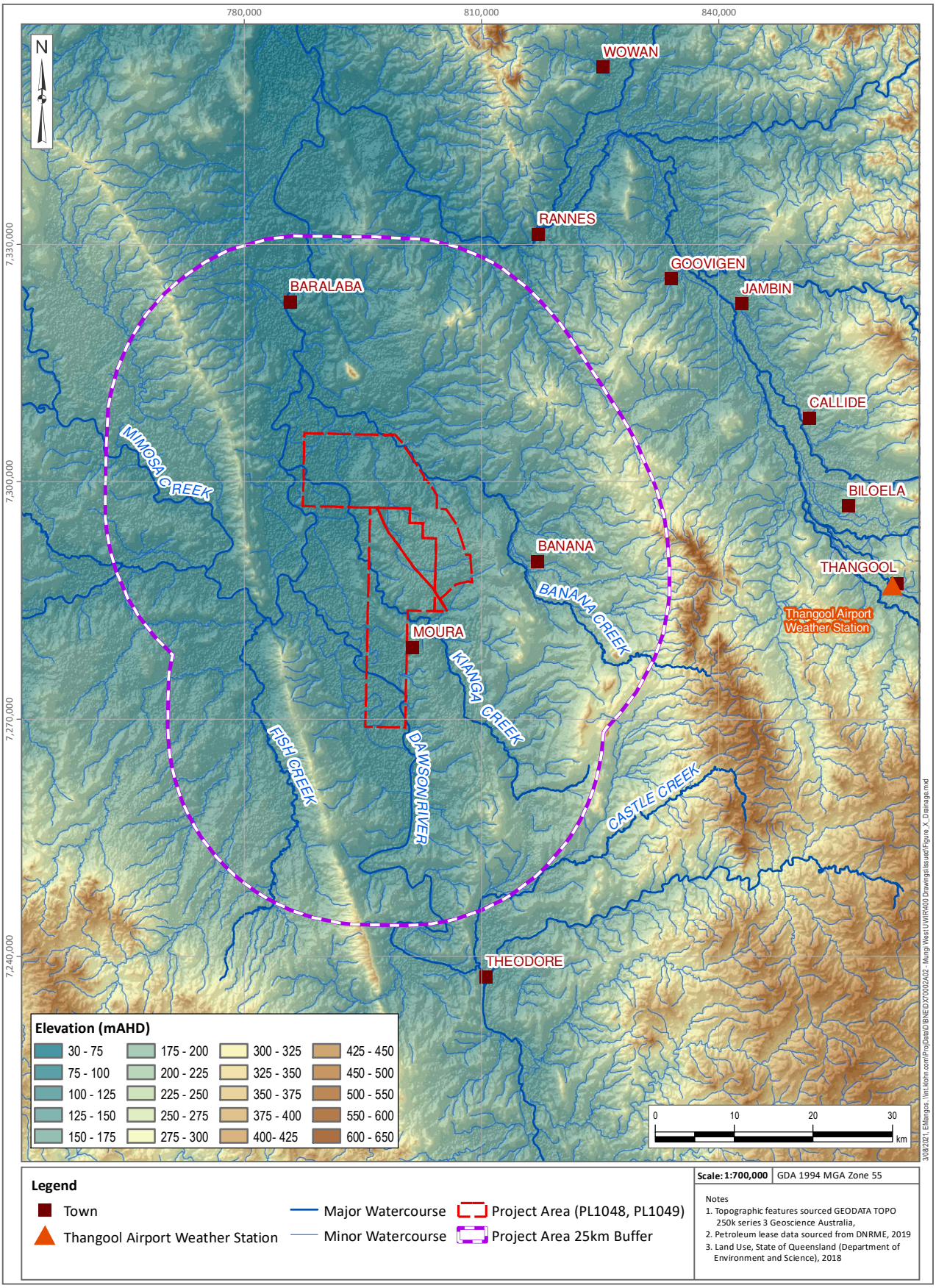

Figure 3-2 Project Site Topography and Drainage

3.3 Climate

The climate of the Project Area is classified as subtropical with a moderately dry winter, based on the modified Köppen classification system (BOM 2016). Climate statistics sourced from the Bureau of Meteorology (BOM) are presented in Table 3-1 for the climate station Thangool Airport (39089), situated 55 km east of the Project area. The locations of the stations are provided in Figure 3-2.

Table 3-1 Climate statistics for Thangool Airport, Site Number 39089 (BOM 2021b)

Thangool Aiport (39089)				
Statistic Element	**Mean maximum temperature (°C)**	**Mean minimum temperature (°C)**	**Mean rainfall (mm)**	**Mean daily evaporation (mm)**
Period of Record	1992-2021	1992-2021	1929-2021	1997-2009
January	33.8	19.7	95.2	7.4
February	33.1	19.9	94.3	6.6
March	32.0	18.0	63.6	6.4
April	29.6	14.1	33.5	5.1
May	26.2	10.0	37.9	4.0
June	23.4	7.1	31.5	2.9
July	23.3	5.7	27.4	3.1
August	25.0	6.3	23.1	4.0
September	28.2	9.9	24.9	5.5
October	30.5	13.5	56.9	6.7
November	32.0	16.3	74.2	6.8
December	33.2	18.7	92.7	7.4
Annual	29.2	13.3	659.8	5.5

Mean maximum temperature ranges between 33.8°C in the summer months and 23.3°C in the winter months. Mean minimum temperature ranges between 19.7°C in the summer months and 5.7°C in the winter months. The highest rainfall occurs during December to February, with the lowest rainfall occurring between April to September.

Evaporation data shows a mean daily evaporation to range between 2.9 mm to 7.4 mm. The highest evaporation occurs during the summer months (November to January; 6.8 mm to 7.4 mm), while the lowest evaporation occurs during the winter months (May to August; 2.9 mm to 4 mm).

Figure 3-3 presents daily rainfall between 1929 and 2021 for the Thangool Airport rainfall station, and a rainfall excess / deficit trend for the same period. Rainfall excess / deficit trends present a running deviation of long-term actual rainfall against the average. This provides seasonal-scale identification of trends (wet / dry) and longer term (e.g., decadal) deviation from average conditions. These trends result in a natural tempering of peaks for rainfall events, and therefore support the correlation of rainfall events to aquifer responses.

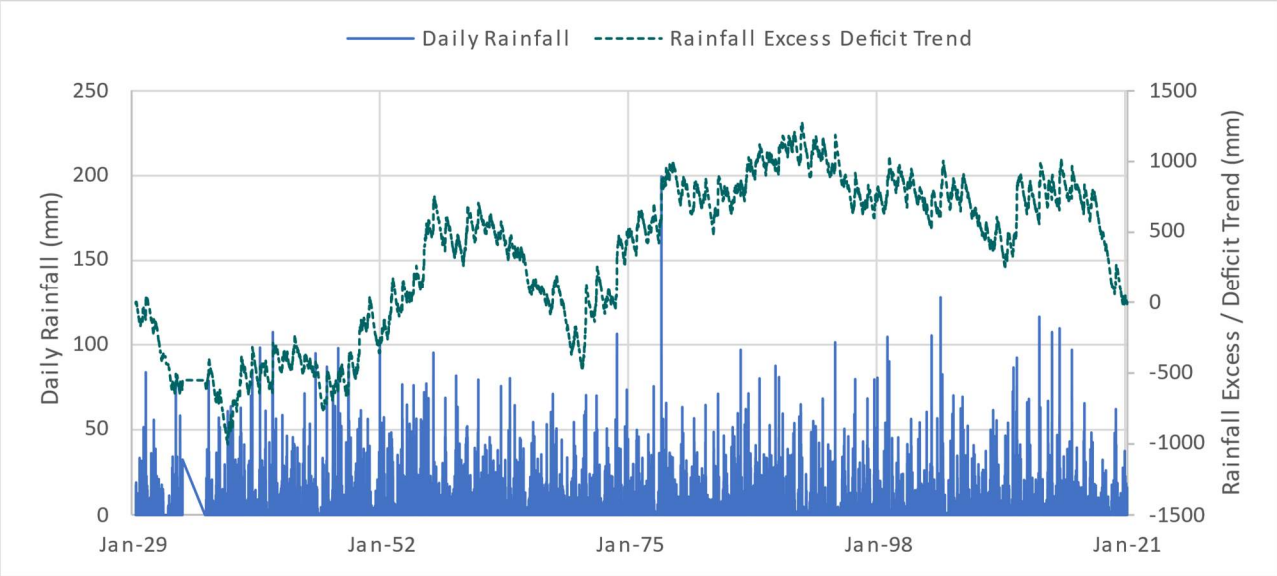

Figure 3-3 Daily Rainfall and Rainfall Excess / Deficit Trend (Thangool Airport) (BOM 2021a)

Observations from the rainfall / excess deficit trend include:

- The overall rainfall trend is characterised by the cyclic nature of the wet and dry seasons, with annual fluctuations of ~80 mm evident across the record.
- Large rainfall events were recorded in 1978 and 2003 where more than 120 mm was recorded in a day. The highest rainfall was recorded in 1978 at 200 mm.
- The overall rainfall excess/deficit trend is a general increase between 1929 and 1957. This is followed by a short decrease until 1970. After 1970, the rainfall excess/deficit trend increases until 1980.
- The rainfall excess/deficit trend is relatively stable from 1980 to 2016. After 2016, the rainfall excess/deficit trend decreases.

4 ASSESSMENT METHODOLOGY

This section describes the UWIR methodology, including the desktop study of relevant groundwater bores, geological and environmental information, and groundwater monitoring data. It also provides an overview of the numerical groundwater modelling method. A detailed description of the numerical groundwater modelling method is provided in Section 6.

4.1 Information and Data Sources

A preliminary desktop assessment utilised data and information provided by Westside, the DRDMW Office of Groundwater Impact Assessment (OGIA) and publicly available reports and data. Primary data and information utilised in this assessment includes:

Datasets:

- Registered bore data from the DRDMW Groundwater Database (GWDB) (DRDMW 2021)
- Queensland Spring Register, published by the Queensland Herbarium (Queensland Herbarium 2018)
- Potential Groundwater Dependent Ecosystem (GDE) mapping published by the DES (DES 2018b)
- The Queensland Spatial Catalogue (QSpatial), via Queensland Globe – comprising records of petroleum and coal seam gas (CSG) exploration, production and monitoring wells
- Groundwater monitoring records (levels and quality) provided by Westside
- Aquifer attribution dataset for third party groundwater bores, provided by OGIA
- Geological model from Westside of the Project area localised geological regime
- Regional geological layers and associated hydraulic parameters from OGIA

Reports:

- Greater Meridian Field Groundwater Assessment (KCB 2020)
- Updated Geology and Geological Model for the Surat Cumulative Management Area (OGIA 2019a)
- Meridian Gas Project – PL94 Underground Water Impact Report (CDM Smith 2019)
- Underground Water Investigation Report for ATP769 Paranui Pilot Project (AGE 2018)
- Meridian Gas Project – PL94 Underground Water Impact Report (CDM Smith 2016c)

OGIA's provision of interpretive data was subjected to a limitation that the quality of data, from the Project area and surrounds, may not be at the same standard in comparison to other areas of the Surat CMA as the Project area is outside of the main CSG developments within the Surat CMA – reflecting the corresponding level of effort applied by OGIA in data acquisition and interpretation.

4.2 Assessment Methodology

This assessment has been completed to assess potential impacts on the groundwater system from the proposed CSG development of PL 1048 and PL 1049 for the UWIR period (Immediately Affected Areas (IAA)) and for the proposed overall development (Long Term Affected Areas (LTAA)).

All relevant data (as identified in Section 4.1) was collated and analysed to develop a conceptual understanding of the groundwater regime, including the key geology, groundwater flow and groundwater quality characteristics. This conceptualisation served as the basis for the development and simulation of the numerical groundwater model, which was used to undertake the prediction of potential impacts to the groundwater regime. Details of the numerical groundwater model are provided in the following section.

4.2.1 Numerical Groundwater Modelling

A 3D numerical groundwater flow model was developed to predict the extents of depressurisation and the associated impacts on the groundwater regime and the surrounding environment. The groundwater model for the project was developed using the MODFLOW-USG platform. MODFLOW is the most widely used groundwater modelling software in Australia and is considered to be the industry standard. A detailed description of the groundwater model is provided in Section 6.

The groundwater model was constructed using a detailed geological model developed by Westside, which was further enhanced by inclusion of bore logs from groundwater monitoring bores and CSG production wells installed within the Project site and its surrounds, and all published lithological logs within the model extents. Geological data compiled from the public domain, and provided by OGIA, was incorporated with the local Project data provided by Westside to allow construction of the model to the adopted extents. The model was calibrated to existing groundwater levels using reliable measurements from local and regional bores within the model domain.

Once calibrated, the model was used to predict the groundwater response to the project, including changes in groundwater levels as a result of the proposed CSG development. The groundwater model allowed the impacts of the existing approved CSG operations and adjacent Dawson Mining complex to be distinguished from those of the Project.

The groundwater model has specifically been used to predict the magnitude and extent of groundwater depressurisation; and these predictions have been used to identify the IAA and LTAA for the UWIR. Those predictions have also been used to assess the impacts of the Project on groundwater users and the sensitive environmental features.

5 GROUNDWATER REGIME

5.1 Geological Setting

The regional geology of the Project area comprises sediments from the Early Permian to middle Triassic age Bowen Basin. The Bowen Basin is an elongated, north-south trending basin extending over 160,000 km^2 from central Queensland to the New South Wales border. Deposition is predominantly within two south–southeast trending troughs, the Taroom Trough to the east and the Denison Trough to the west, which are separated by the Comet Ridge (OGIA 2019b). The Project area is located on the southeastern portion of the Bowen Basin, on the northeastern limb of the Taroom Trough and lies to the west of the Auburn Arch (OGIA 2019a).

Regionally, the Bowen Basin, comprises thick successions of shallow marine and non-marine sediments and volcanics, deposited in a foreland basin in the Late Permian (R. Korsch and Totterdell 2009b). The southern Queensland and northernmost New South Wales portion of the basin is overlain by up to 2.5 km of Early Jurassic to Early Cretaceous Surat Basin sedimentary sequences (R. Korsch and Totterdell 2009b). In the vicinity of PL 1048 and PL 1049, sediments from the Surat Basin have been eroded and the Bowen Basin units reside under Cenozoic cover.

Prior to the formation of the Bowen Basin, the basement rocks derived from magmatic origin were deposited during the Carboniferous – early Permian. The volcanic arc known as the Connor –

Auburn Province is a linear magmatic belt comprising two sub-provinces: The Auburn to the south and Connor to the north. The sub-provinces are separated by the Gogango Thrust zone which comprises strongly deformed Permian sediments (P. M. Green et al. 1997; Withnall and Cranfield 2013). A change in geochemical patterns and bimodal volcanism suggests a period of extensional tectonics, lending to the initiation of deposition within the Bowen Basin (Withnall and Cranfield 2013). The Camboon Volcanics overlies Carboniferous volcanics along the western edge of the Auburn Arch and form the basal unit of the Taroom Trough (P. Green et al. 1997).

The Bowen Basin began as an extensive north–south trending back-arc basin to the west of the continental Camboon Volcanic Arc (Connor – Auburn Province) (P. M. Green et al. 1997). The period of extension on the western margin of the Bowen Basin produced a series of half-grabens, such as the Denison Trough, in which fluvial and lacustrine sediments were deposited in (Dickins and Malone 1973). In the east of the Bowen Basin: volcanics were also deposited during that time, whilst a thick succession of coals and non-marine sediments were deposited in the west of the Bowen Basin (Geoscience Australia 2019a; P. M. Green et al. 1997)

Sedimentation in the Bowen Basin ceased in Middle to Late Triassic by the Goondiwindi event which caused regional compression and significant extension and thrust faults in the Bowen Basin strata. This was followed by widespread erosion prior to the deposition of the Surat Basin sediments (OGIA 2019a).

A large intracratonic sag developed following the extended period of erosion and shallow platform basins including the Surat Basin, amongst others, formed as a result. Sedimentation in the Surat Basin was predominately focused within the Mimosa Syncline, which unconfomrably overlies the Permian strata deposited in the Taroom Trough. Sedimentation occurred between the Triassic to Middle Cretaceous, which coincided with a compressional event, causing the uplift and erosion of the Bowen and Surat Basins and their related volcanic arcs (P. M. Green et al. 1997).

Cenozoic sedimentary deposits overlay the Bowen Basin units regionally, formed through subsidence-related faulting and erosion in conjunction with fluvial sedimentary depositional processes (R. J. Korsch et al. 2009). Crustal thinning caused by extensional tectonic events resulted in magma upwelling and intermittent volcanism, expressed as basaltic lava flows as well as interbedded tuff and volcanolithic fragments within the Cenozoic sedimentary sequences (R. Korsch and Totterdell 2009a).

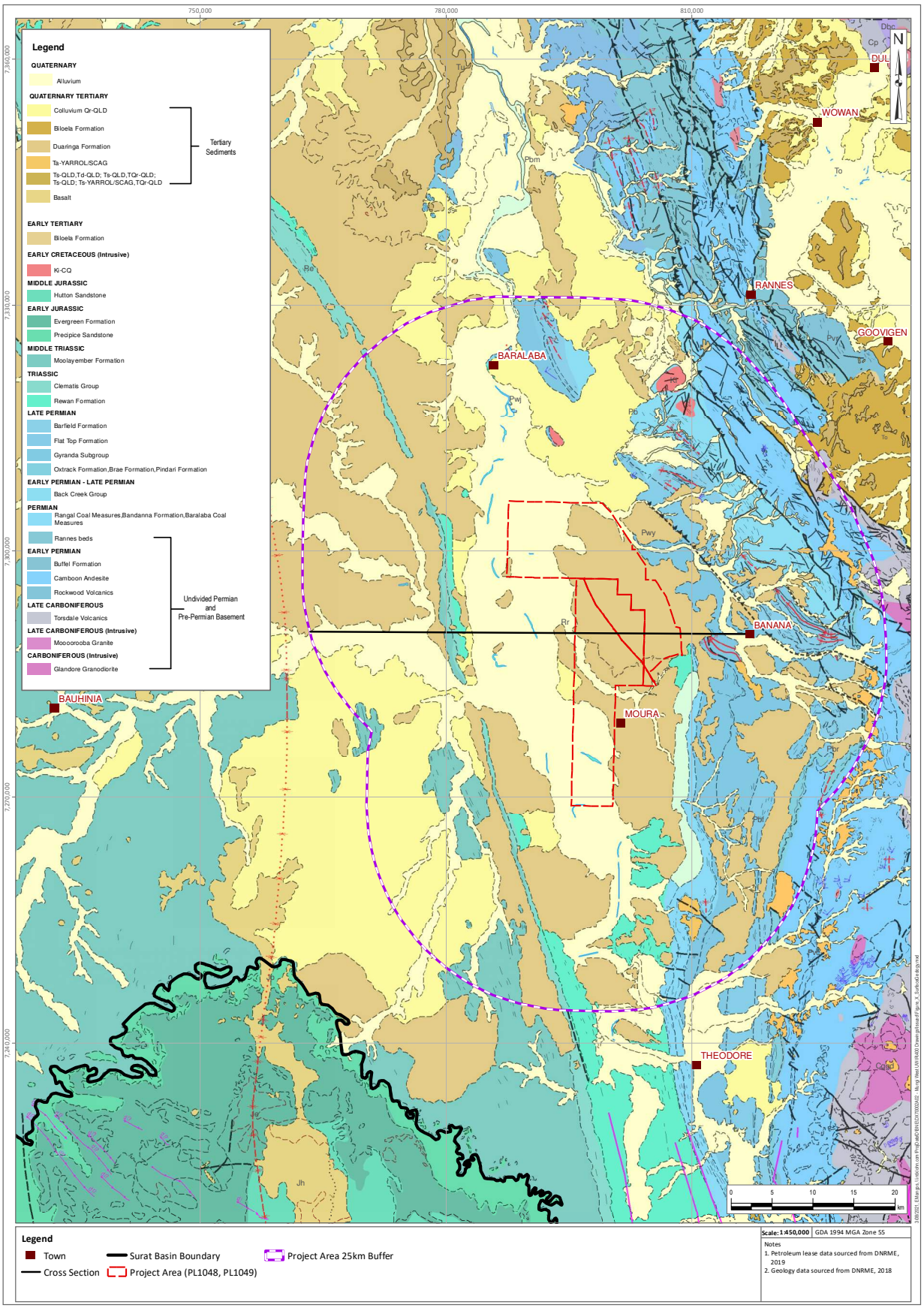

Figure 5-1 Surface Geology within the Vicinity of the Project Site

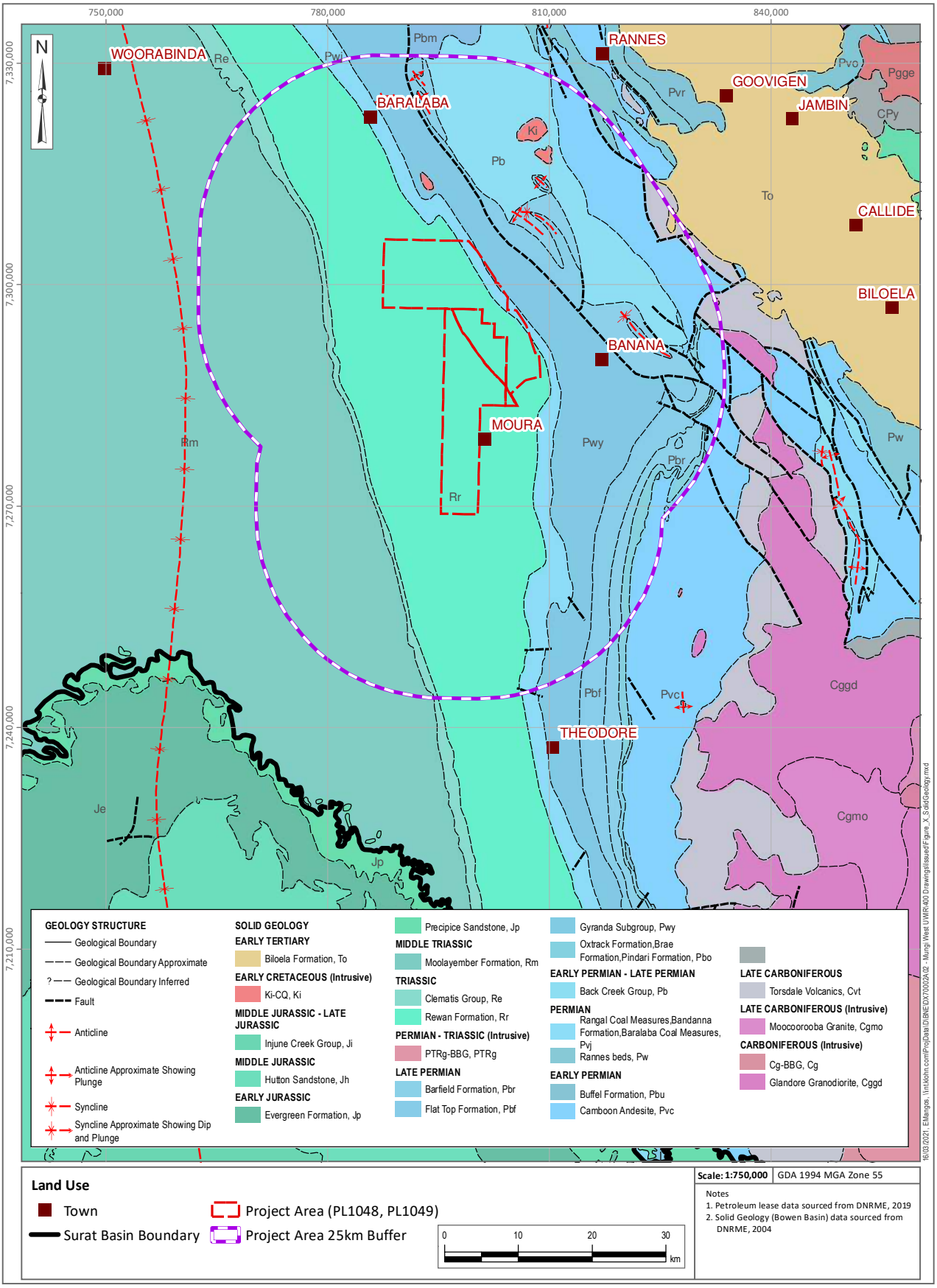

Figure 5-2 Solid Geology within the Vicinity of the Project Site

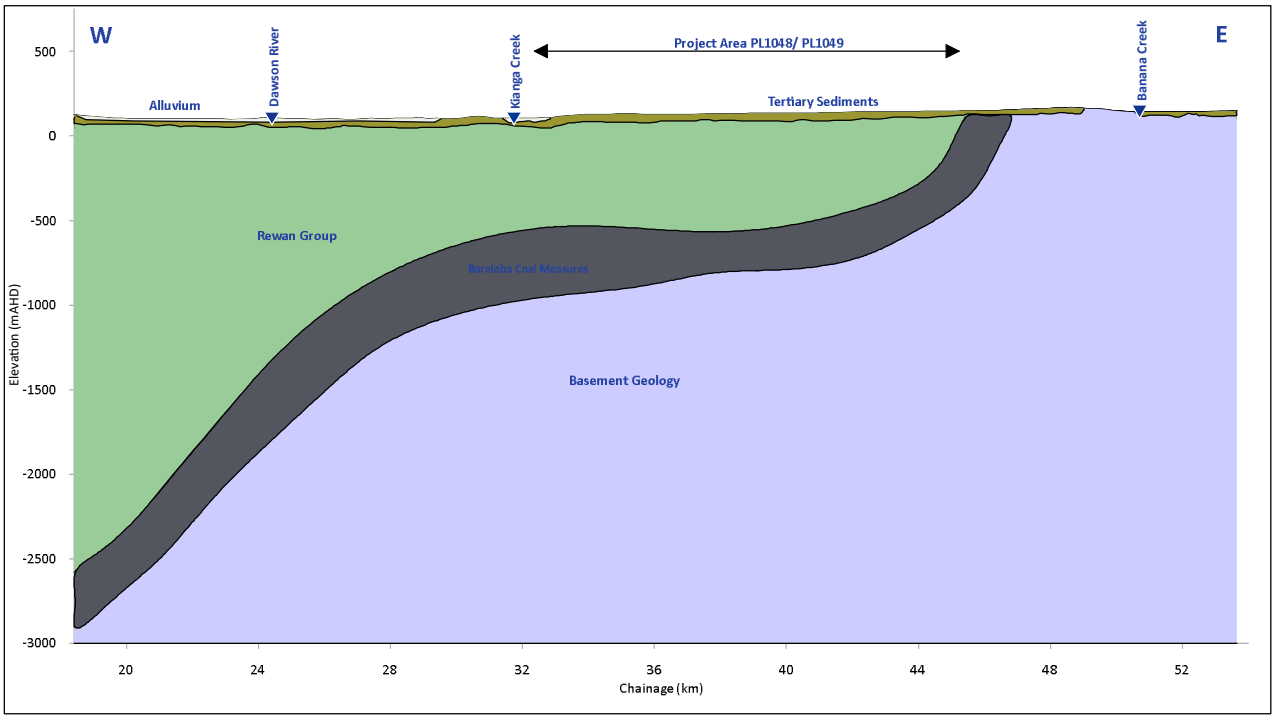

Figure 5-3 West – East Conceptual Geological Cross-section across the Project Area

5.1.1 Structural Elements

The Project area is located at the northeastern boundary of the Taroom Trough, on the eastern limb of the Mimosa syncline. The Project area is located west of the Auburn Arch which is intersected by a series of northeasterly faults (in Dickins and Malone 1973).

Regionally, the Bowen Basin has experienced a mixture of thrust faults, volcanic activity, extensional fault systems and reactivation of structures which creates a structurally complex basin (OGIA 2019a).

The main structural feature located in the southern part of the Bowen Basin is the Mimosa Syncline, located ~45 km west of the Project area. The axis of the Mimosa Syncline follows that of the Taroom Trough and developed and filled with sediment in the Triassic. (Dickins and Malone 1973). To the northeast of the Project area, discontinuous northwest – southeast trending faults occur. Phases of deformation occurred throughout history resulting in the reactivation of historic structures as well as the creation of new structural elements. During the Middle Cretaceous, a compressional event caused the uplift and erosion of the Bowen and Surat Basin and their associated volcanic arcs (Elliott 1994 in (P. Green et al. 1997). Further deformation occurred during the Late Cretaceous and Tertiary as a result of epeirogenic movements as well as larger divergent plate motion related to the break-up of Gondwana (Exon 1976; P. Green et al. 1997).

Further discussion related to the structural elements directly within the Project area is included in Section 0.

5.2 Regional Hydrostratigraphy

Stratigraphic units of relevance to the project include:

- Quaternary alluvial deposits located along the Dawson River and major tributaries;
- Surficial Cenozoic deposits;
- Jurassic sediments of the Boxvale Member, Evergreen Formation and Precipice Sandstone;
- Early to Middle Triassic sediments of the Clematis Group and Moolayember Formation;
- Early Triassic sediments of the Rewan Group; and
- Late Permian sediments of the Baralaba Coal measures.
- Early Permian basement geology.

5.2.1 Quaternary

Alluvium

The Quaternary alluvium deposits comprise unconsolidated alluvium associated with existing river and creek systems located within the Project area. Major alluvium deposits occur within and to the west of the Project area and correspond with the location of the Dawson River, which crosses the Project area in the south of PL 1049. Smaller alluvial deposits associated with Kianga Creek cross the Project area through PL 1049 (Figure 5-1). Other alluvial deposits extend from the northeast and east of the Project Area and correspond with the location of Banana Creek.

The alluvium consists of fine to coarse grained gravels and channel sands interbedded with clays. The formation overlies Tertiary deposits, Cenozoic-age sediments and Triassic to Permian units. The alluvium varies in thickness and lateral extent.

5.2.2 Tertiary Sediments

The alluvium deposits are underlain by Tertiary-Quaternary colluvium consisting of clay, silt, sands, and gravel (DNRME 2018). This colluvium unit is not observed within the Project area, however, it does dominate the surface geology 25 km west of the Project area near the Dawson Ranges.

The Duaringa Formation unconformably overlies the Permian units of the Bowen Basin and is the majority of the surface geology throughout the Project area. This unit comprises mudstone, sandstone, conglomerate, siltstone, shale, lignite and basalt (Murray and Cranfield 1989).

Published geological mapping have identified lithological similarities between the Tertiary-Quaternary colluvium and the Duaringa Formation; with the contacts between these units being frequently indistinguishable. These units are therefore considered to form a single unit, and hereafter referred to as the Tertiary sediments.

5.2.3 Jurassic Deposits

Jurassic deposits are related to the Surat Basin and unconformably overlie the Permian strata of the Bowen Basin. The Jurassic units comprise Boxvale Sandstone Member, Evergreen Formation and the Precipice Sandstone. The units are located to the southeast of the Project Area, where the Surat Basin overlaps the Bowen Basin.

Boxvale Sandstone Member

The Upper Jurassic unit in the vicinity of the Project area is known as the Boxvale Sandstone Member, comprising fine to coarse grained quartzose sandstone with carbonaceous siltstone, shale and coal interbeds. The sediments are interpreted to be deposited in shallow non-marine environment where sand was reworked and sorted, with periods of sea inundation. The Boxvale Sandstone Member lies conformably on the Evergreen Formation.

Evergreen Formation

The Evergreen Formation comprises chemically weathered sandstone overlain by carbonaceous mudstone, siltstone and minor coal (Geoscience Australia 2019). The lower part of the formation was likely laid down in an estuarine or lacustrine setting, with periodic marine inundation.

Precipice Sandstone

The Precipice Sandstone is the oldest unit within the Jurassic Sequence situated in the Project area. It was formed by folding and subsequent erosion of pre-existing units (such as the Clematis Sandstone) during the late Triassic; creating the unconformity between the Triassic and Jurassic sequences (Martin et al. 2018).

The Precipice Sandstone consists of quartz sandstone with common cross-bedding and cut and fill structures; attributed to deposition in a fluviatile environment (La Croix et al. 2020). Evidence of marine influence throughout sedimentation has been reported (Martin et al. 2018). Deposits are laterally extensive across the Bowen Basin, indicating vast distances of sediment transport (Martin et al. 2018) . The unit is considered a major aquifer (OGIA 2019b) and outcrops to the west of the Dawson Ridge southeast of the Project area.

5.2.4 Triassic Deposits

The Triassic sequence can be subdivided into three recognisable units; the Moolayember Formation, the Clematis Sandstone and the Rewan Group.

Moolayember Formation

The Middle to Upper Triassic Moolayember Formation is the youngest unit in the Bowen Basin and comprises interbedded mudstones, lithic, medium to coarse-grained sandstone, carbonaceous shales, siltstones, and conglomerates (Green 1997).

The lower part of the Moolayember Formation was deposited in a lacustrine depositional environment that grades upwards into an alluvial plain with alluvial fans on the eastern margin (Golin and Smyth 1986). The thickness of this formation varies from 200 m on the Springsure Shelf to nearly 1,500 m in the centre of the Taroom Trough (Radke et al. 2000). The Moolayember

Formation is characterised as a tight aquitard (OGIA 2019b). The formation outcrops to the southeast of the Project area.

Clematis Group

The Lower to Middle Triassic Clematis Group (formally, Clematis Sandstone) comprises medium to coarse – grained, cross-bedded, quartzose to sub-labile and micaeous sandstone; siltstone and thin beds of mudstone, deposited in fluvial environment. The Clematis Group includes two geological formations within the Denison Trough: the Expedition Sandstone (a quartzose sandstone, conglomerate, siltstone and mudstone package) and the Glenidal Formation (thinly bedded, very fine to medium-grained sandstone with common siltstones and mudstones), which overlies the Early Triassic Rewan Group (Brakel et al. 2009). The Expedition Sandstone is equivalent to the Showgrounds Sandstone in the Taroom Trough (Hoffmann, Green, and Gray 1997).

The Clematis Group forms the Dawson Range which outcrops to the west of the Project area.

The Clematis Group is considered to be a major aquifer of the Great Artesian Basin (GAB). The Clematis Group is separated from the Baralaba Formation (targets for CSG production) by a thick sequence of the Rewan Group aquitard.

Rewan Group

The Rewan Group is described as containing thick-bedded, fine to medium-grained, commonly micaceous, and feldspathic sandstones. However, near the top of the unit, thin, medium-coarse grained, poorly sorted sandstones were observed (Olgers et al. 1966). Overall, the Rewan Group is dominated by reddish-brown to greenish-grey siltstones and mudstones. This is similar to observations recorded in the Paranui 10 well, drilled within Westside's existing PCA196 license, west of PL 94. In this well, the Rewan Group was described as containing mostly greenish-grey siltstone with thin beds of fine to medium-grained quartz-lithic sandstone Figure 5-4. Sandstones were observed to have low to medium visible porosity and low permeability. 60-70 degree fractures were present through lower part of the section with multiple healed and carbonate-filled fractures, however, these are likely to have been developed as a result of the core drilling process.

Figure 5-4 Drillcore from Paranui 10 Well showing Rewan Group Core

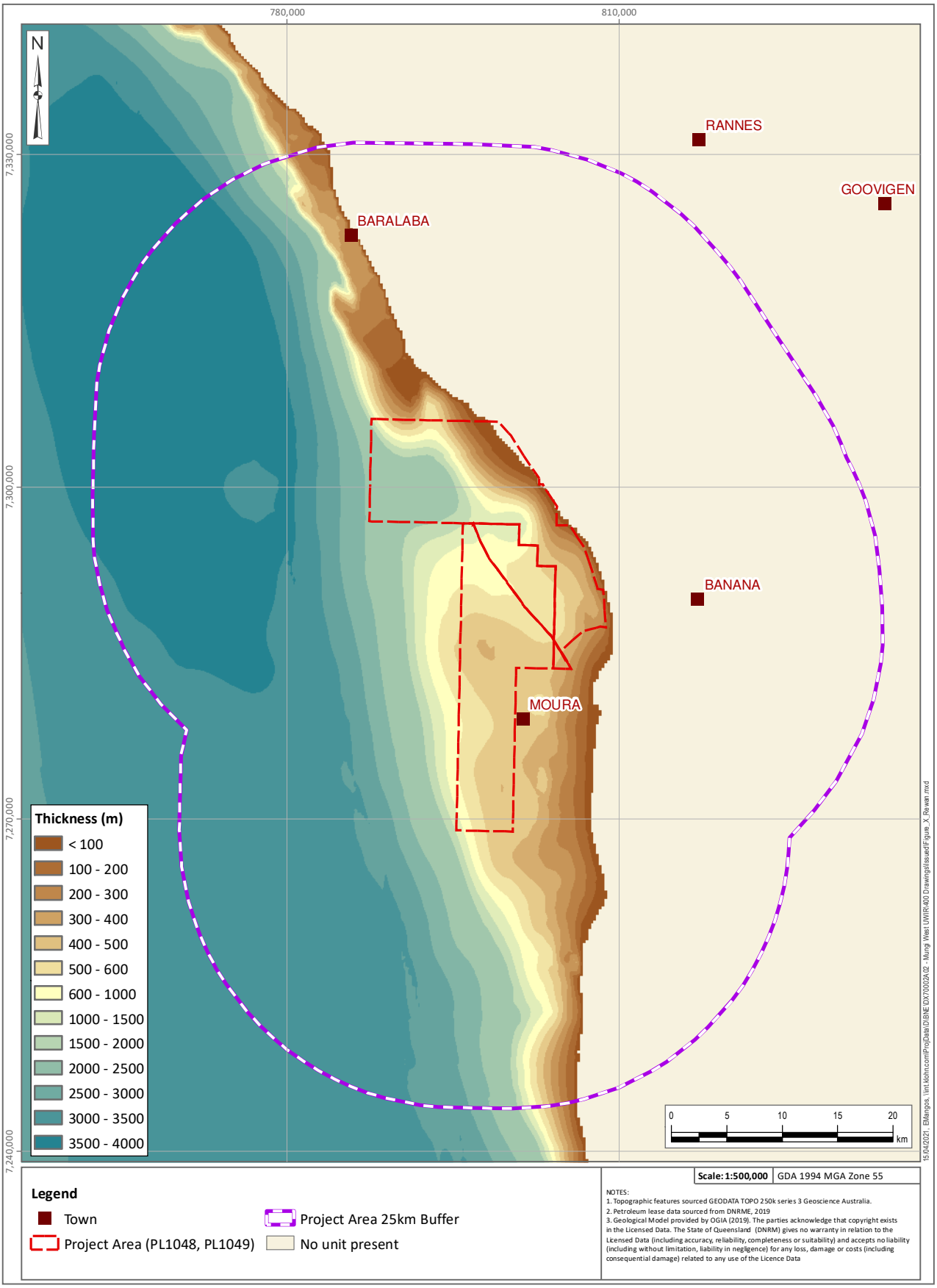

Figure 5-5 Rewan Group Isopach (sourced from OGIA 2019b)

5.2.5 Permian Units

Baralaba Coal Measures

The Late Permian Baralaba Coal Measures is part of a larger group known as the Blackwater Group. The Baralaba Coal Measures forms part of the upper units, comprising economical coal seams interbedded with calcareous mudstone, siltstone and shales (CDM, 2019). The Baralaba Coal Measures were deposited in paludal and lacustrine environments. Whilst, the lower part comprises carbonaceous shale, limestones, coal and sandstone, laid down during the transition from marine to freshwater sedimentation. The Baralaba Coal Measures correlates with the Banadanna Formation located in the southwestern Bowen Basin and the Rangal Coal Measures located in southeastern Bowen Basin and northern Bowen Basin (Ayaz et al. 2016).

The Baralaba Coal Measures comprises the target coal seams, which are interbedded with sandstone, siltstone and shales that occur as interburden or overburden relative to the coal seams. The fine-grained shale and siltstone are observed as having low permeability and are interpreted to function as aquitards. In comparison, the target coal seams generally have a higher permeability.

The Baralaba Coal Measures outcrop to the east of the Project area and dips to the west / northwest (CDM, 2019). The Baralaba Coal Measures are considered as an interbedded aquitard (OGIA 2019b).

Kaloola Member

The Kaloola Member (equivalent to the Burngrove Formation) comprises mudstone, siltstone, sandstone, conglomerate and minor coal (Geoscience Australia 2019) and is the basal sub-unit of the Baralaba Coal Measures.

The Kaloola Member outcrops to the east of the Project Area, immediately east of the Dawson Mine. This unit is considered an interbedded aquitard.

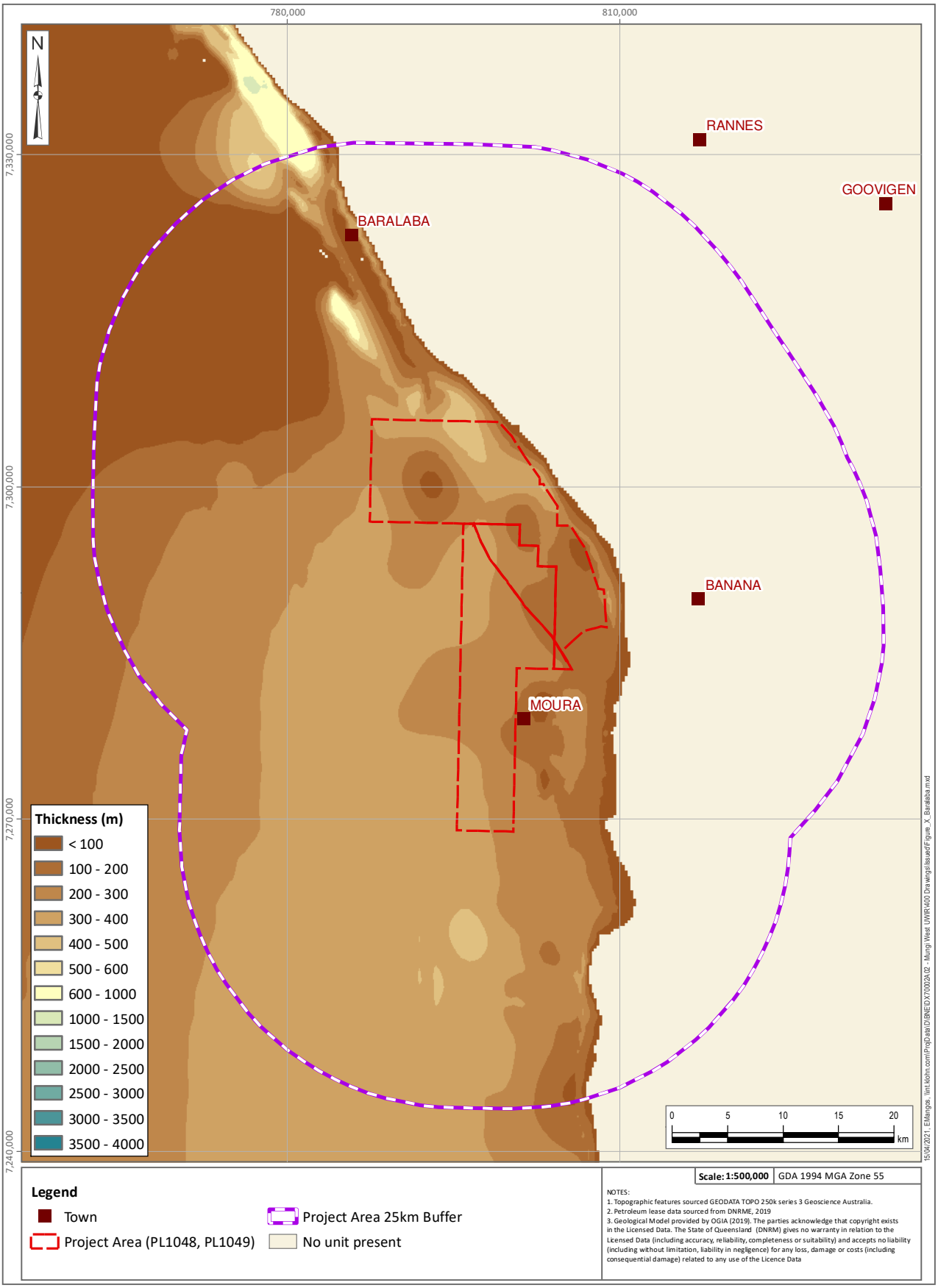

Figure 5-6 Baralaba Coal Measures Isopach (sourced from OGIA 2019b)

5.2.6 Undivided Permian – Carboniferous Units

The basement geology, interpreted for the Project area, encompasses Upper Permian, Lower Permian and Upper Devonian-age units, broadly identified as any stratigraphic unit underlying the Baralaba Coal Measures. This group includes the Gyranda Subgroup, Back Creek Group and Camboon Volcanics. The units have been combined for the purpose of the geological model and the relevance to the Project and purpose of the hydrogeological model as designed by KCB.

Generally, the Back Creek Group comprises sandstone, siltstone and carbonaceous shale, which unconformably overlie the Camboon Volcanics. Units of the Back Creek Group; Flat Top, Barfield Formation and Oxtrack Formations (OGIA 2019a); outcrop to the east of the Project area. The Camboon Volcanics comprise basaltic to andesitic composition volcanic rocks that outcrop to the east of the Project area.

In general, the basement geology is not considered as an aquifer due to confinement beneath the Rewan Group and the Baralaba Coal Measure. The “Undivided Permian Group” forms the base of the geological model.

5.3 Local Hydrogeology

The Project area is directly underlain by Quaternary alluvium associated with the Dawson River and the broader deposits of Tertiary sediments. Beneath the Quaternary and Tertiary surficial geology, the unconformably underlying Triassic (Moolyamber Formation, Clematis Group, Rewan Group) and Permian (Baralaba Coal Measures, Kaloola Member, Back Creek Group) sedimentary units are gently dipping towards the west in the vicinity of the Project area. As a result of the dipping units, the Rewan Group outcrops within and to the east of the Project area, while the Baralaba Coal Measures outcrop to the east of the Project area, in the vicinity of the Dawson Mining complex Figure 5-2.

As discussed previously, the mapped alluvium in the Project area is associated predominantly with the Dawson River, Kianga Creek, Banana Creek, and associated contributing water courses. A review of available data from the GWDB ‘stratigraphy table’ (DNRME 2019a) indicates the alluvium associated with these systems is up to ~20 m thick.

Isopachs for the Rewan Group and Baralaba Formation are presented in Figure 5-5 and Figure 5-6, respectively. The Rewan Group aquitard is present across the Project area but does not extend east of the tenure due to formation outcropping in that area. The Rewan Group thickness beneath the Project area increases east to west from <100 m in the east to ~2,500 m in the northwest corner. The Baralaba Coal Measures are <100 m to 500 m thick beneath the Project area. Individual coal seams within the coal measure are reported to be up to 6 m thick.

5.3.1 Local Structure

The Project area is located on the eastern limb of the Mimosa Syncline, the central axis of which is located ~30 km west of the Project area. A series of compressional events to the east of the Project area resulted in multiple northwest-southeast trending faults. Historical reports note reverse faulting in the Moura area (Chong 1968). Between those major disturbance zones, minor normal faults have been identified in bore holes (Taylor 1971).

2D seismic were acquired across PL 94 (directly south of the Project area) to support CSG development activities (KCB 2020). Observations from seismic surveys show few large-scale faults interpreted within the Baralaba Coal Measures and even fewer which extend into the overlying Rewan Group. No faults extending more than 30 m were observed above the youngest target coal seam of the Baralaba Coal Measures, illustrating that faults do not extend to the top of Rewan Group and adjacent to overlying surficial hydrostratigraphic units. The seismic character of the Rewan Group is generally low reflectivity, indicating more homogenous lithologies, which supports the mudstone/siltstone dominant lithologies identified from the drill core obtained from within the vicinity of the Project area.

5.4 Aquifer / Aquitard Hydraulic Properties

OGIA (2019b) present a range of hydraulic conductivity values, which have been estimated from core, drill stem tests (DSTs) and pumping tests. The data was compiled as part of the 2016 UWIR (OGIA 2016a). Table 5-1 presents a range of hydraulic conductivities estimated from core DSTs and pumping tests (OGIA 2019b).

Table 5-1 Horizontal Hydraulic Conductivity Ranges (after OGIA 2016b)

Source	Statistic	Hydrostratigraphic Unit Hydraulic Conductivity (m/day)					
		Alluvium	Moolayember Formation	Clematis Group	Rewan Group	Lower Permian	Basement
Core	10th Percentile		2.90×10^{-6}	2.0×10^{-6}	5.4×10^{-7}	3.2×10^{-6}	8.5×10^{-7}
	Median		1.44×10^{-4}	1.6×10^{-4}	4.0×10^{-5}	1.4×10^{-5}	3.3×10^{-4}
	90th Percentile		7.21×10^{-2}	0.2	0.1	2.2×10^{-4}	0.4
DST	10th Percentile		9.18×10^{-5}	6.7×10^{-5}	1.7×10^{-5}	8.3×10^{-5}	7.2×10^{-4}
	Median		1.52×10^{-3}	2.3×10^{-3}	4.2×10^{-4}	1.2×10^{-4}	7.2×10^{-4}
	90th Percentile		2.13×10^{-1}	0.6	0.03	1.2×10^{-3}	7.2×10^{-4}
Pumping Test	10th Percentile	2.44	2.16×10^{-2}	0.1	-	-	-
	Median	1.63×10^{1}	4.32×10^{-1}	0.4	-	-	-
	90th Percentile	1.16×10^{2}	5.33	15.2	-	-	-

Data reproduced from OGIA (2016a). Converted from millidarcies using the reported conversion factor of 1.27×10^{-3}.

DST and pumping tests have been referenced in the Hydrogeological Conceptualisation Report for the Surat Cumulative Management Area (OGIA 2016a) that are within the vicinity of the Project Area, and across different hydrostratigraphic units. A summary of these tests is provided as follows:

- Moolayember Formation
  - DST – two tests; 1.27×10^{-2} to 1.27 m/day
  - Pumping test – two tests; 1.27×10^{-2} to 0.127 m/day
- Clematis Group
  - DST – two tests; 1.27×10^{-2} to 0.127 m/day

- Rewan Group
  - DST – six tests; 1.27 x 10^{-5} to 1.27 x 10^{-3} m/day

Site-specific data is also available for the Baralaba Coal Measure, from 83 DSTs undertaken in wells within the Project Area. A statistical summary of this data is presented in Table 5-2. Additional testing of the Baralaba Coal Measures permeability will be undertaken as CSG production wells are drilled.

Table 5-2 Site-Specific Baralaba Horizontal Hydraulic Conductivity Statistics

Statistic	Hydraulic Conductivity – Site-Specific DST (m/day)
10th Percentile	6.35 x 10^{-5}
90th Percentile	7.64 x 10^{-3}
Median	4.57 x 10^{-4}
Geomean	5.32 x 10^{-4}

5.5 Groundwater Recharge

Key processes of recharge include localised recharge, preferential pathway flow, and diffuse recharge:

- Localised recharge occurs beneath drainage features including rivers, and free-draining unconsolidated sedimentary cover, such as alluvium.
- Preferential pathway flow arises from changes in permeability within aquifers and in overlying regolith, providing conduits for water to infiltrate. Zones of higher permeability may include fissures, faults, joints, tree roots and high-permeability beds within individual formations and along bedding planes (Kellett et al. 2003; Suckow et al. 2016). This mechanism is considered the dominant recharge process in the GAB (Kellett et al. 2003).
- Diffuse recharge is the process by which rainfall infiltrates directly into outcropping hydrostratigraphic units. This is expected to occur within all outcrop areas and therefore this process applies to the largest spatial extent (Kellett et al. 2003).

Recharge in the Project area will occur as diffuse recharge with rainfall infiltration occurring at outcropping aquifers. Estimates of long-term average recharge rates have been made by OGIA as part of the 2016 UWIR (OGIA 2019b) using chloride mass balance recharge estimation method. For the units outcropping within the vicinity of the Project Area, the following recharge rates were estimated by OGIA:

- Alluvium – 6.8 mm/year
- Moolayember Formation (outcrops to southwest) – 2.5 mm/year
- Clematis Group (outcrops to southwest) – 26.9 mm/year
- Rewan Group (outcrops to south-southwest and within Project Area) – 1.2 mm/year
- Baralaba Coal Measures (outcrops to east) – 5.0 mm/year
- Older Permian Units (outcrops to east) – 6.8 mm/year

Recharge into the alluvium associated with the Dawson River is anticipated to occur during high flow periods, following significant rainfall events, although insufficient data is available to quantify the recharge. Recharge from the alluvium into the units underlying may also occur. Further discussion on groundwater–surface water interaction in the Project Area is provided in Section 5.8.

5.6 Groundwater Level and Flow

A total of 45 groundwater bores are registered on the GWDB with water level readings in a 25 km radius of the Project area (Figure 5-7). The majority of these bores are dedicated groundwater monitoring bores associated with the coal mining activities to the east of the Project area.

The following section provides a summary of the available groundwater monitoring data. Table 5-3 presents the number of groundwater monitoring bores within a 25 km radius of the Project area for each monitored hydrostratigraphic unit.

Table 5-3 Summary of Registered Groundwater Bores within 25 km of the Project Area with Groundwater Level Monitoring Records

Hydrostratigraphic Unit	No. of Bores
Alluvium	18
Tertiary Sediments	1
Moolayember Formation	4
Clematis Sandstone	1
Rewan Group	5
Baralaba Coal Measures	12
Undivided Permian / Basement	4

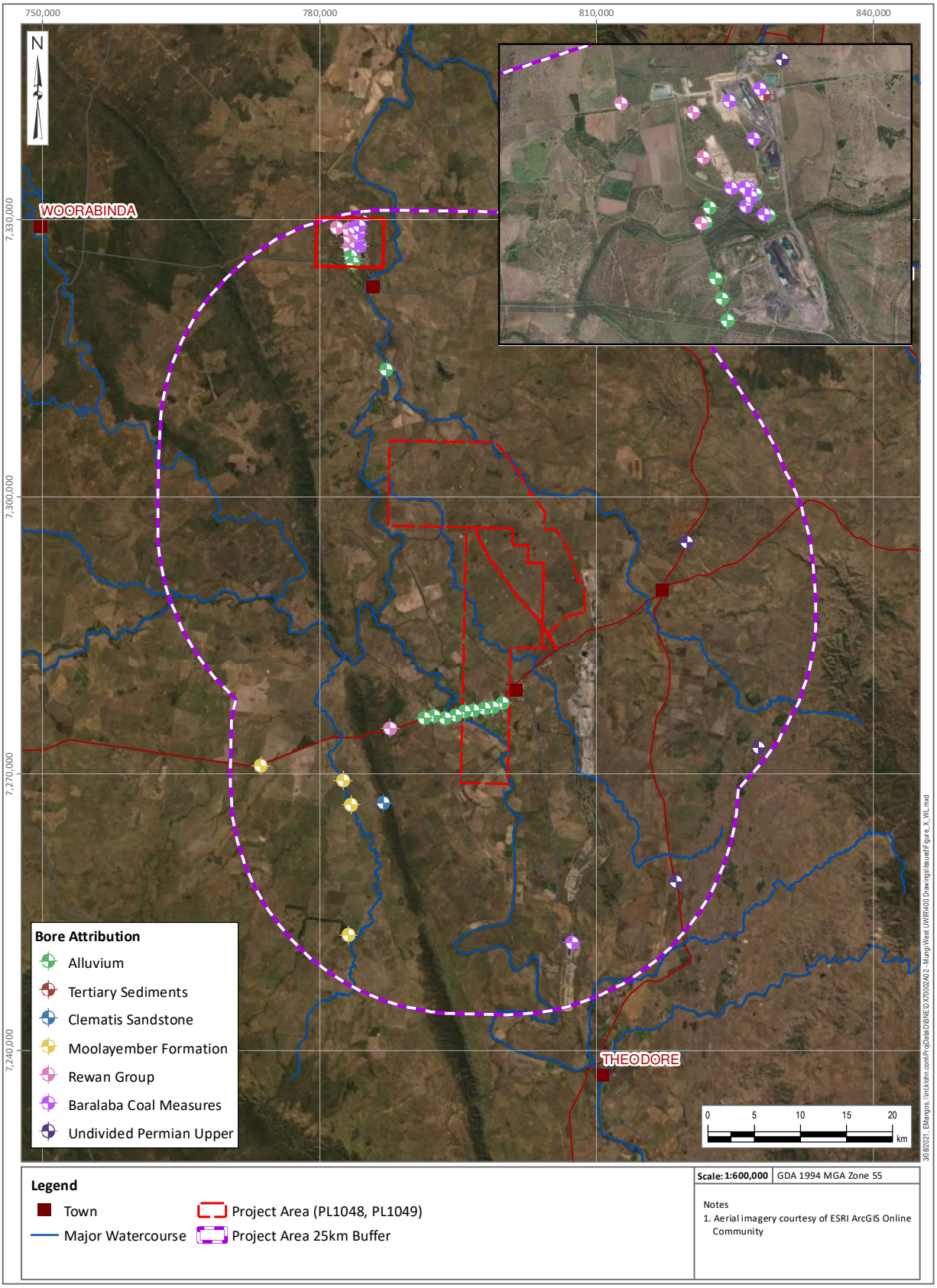

Figure 5-7 Location of Groundwater Bores with Groundwater Level Data in the Vicinity of the Project

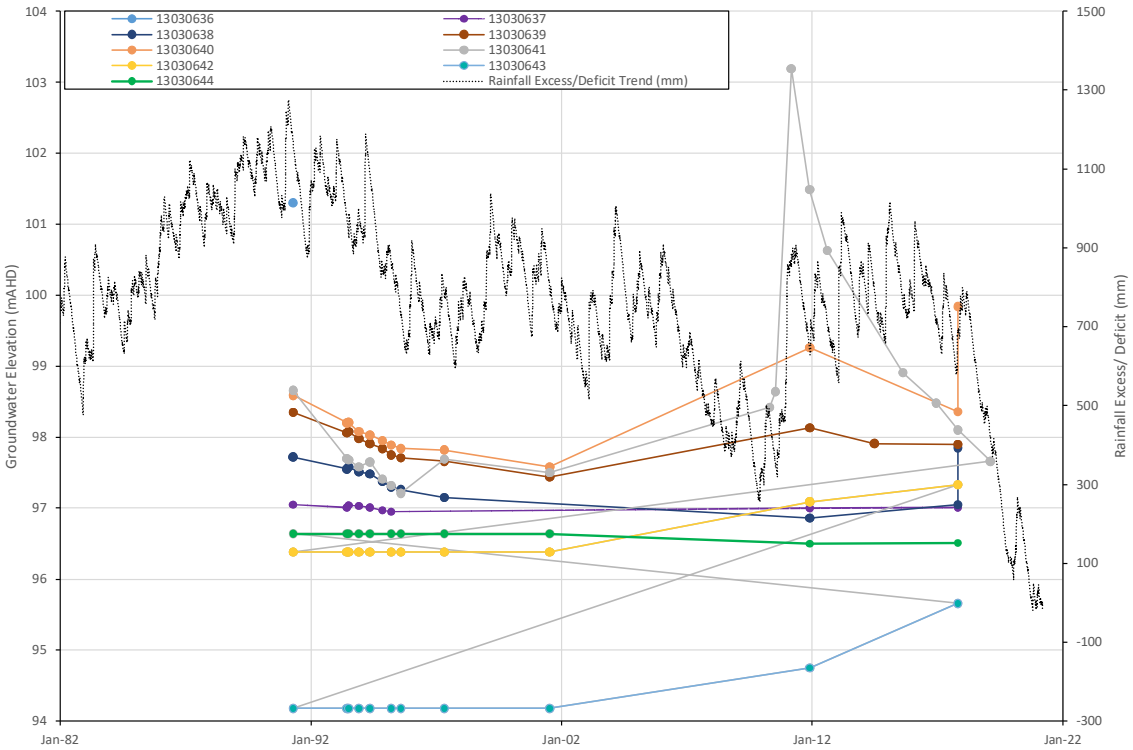

Figure 5-8 Alluvium Groundwater Elevation Hydrographs – Upstream Dawson River

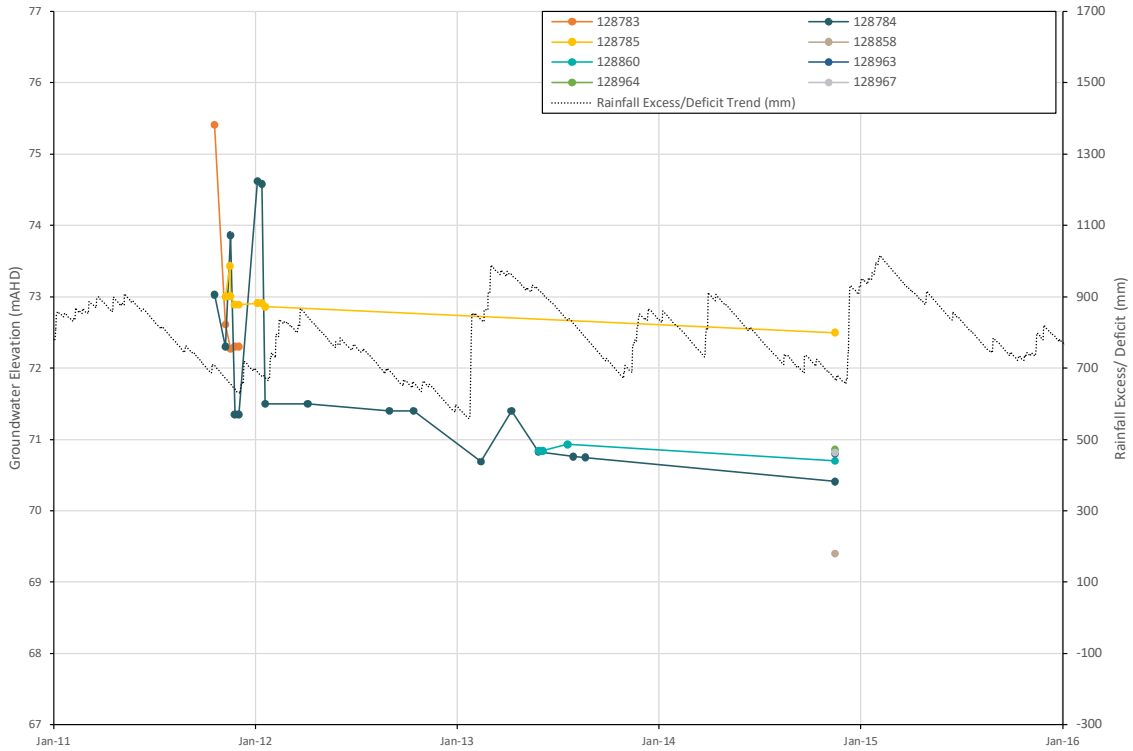

Figure 5-9 Alluvium Groundwater Elevation Hydrographs – Downstream Dawson River

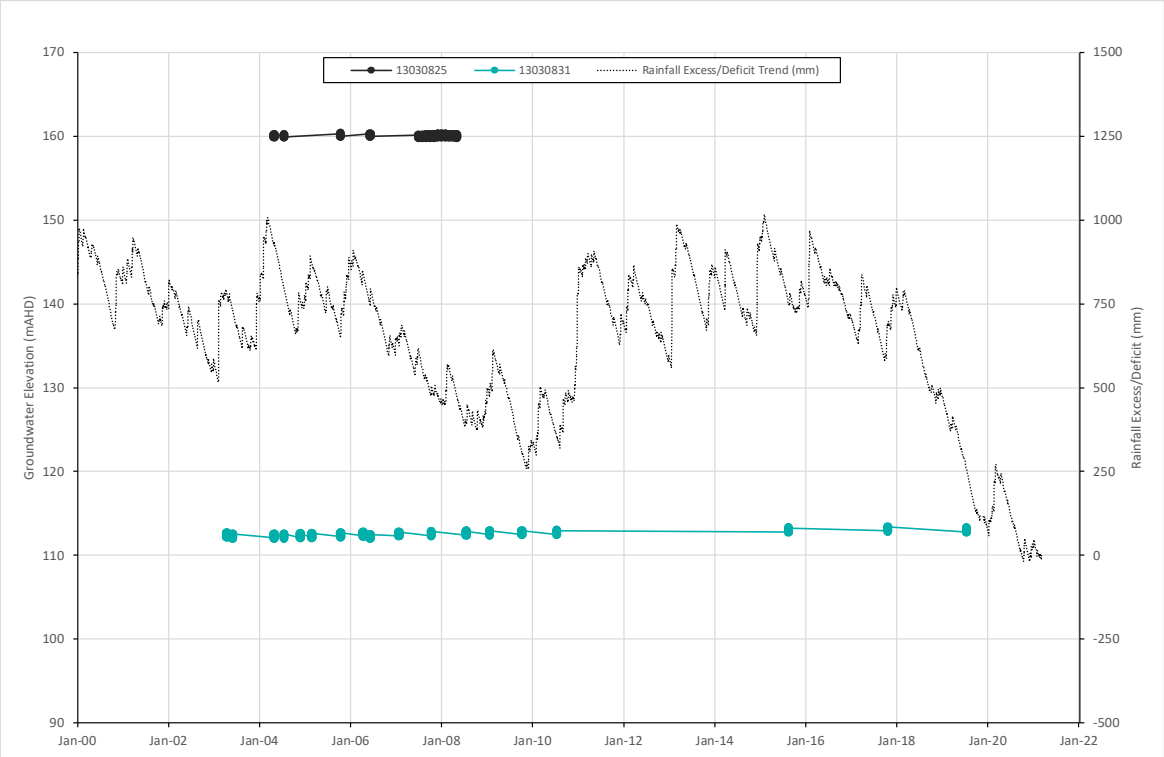

Figure 5-10 Moolayember Groundwater Elevation Hydrographs

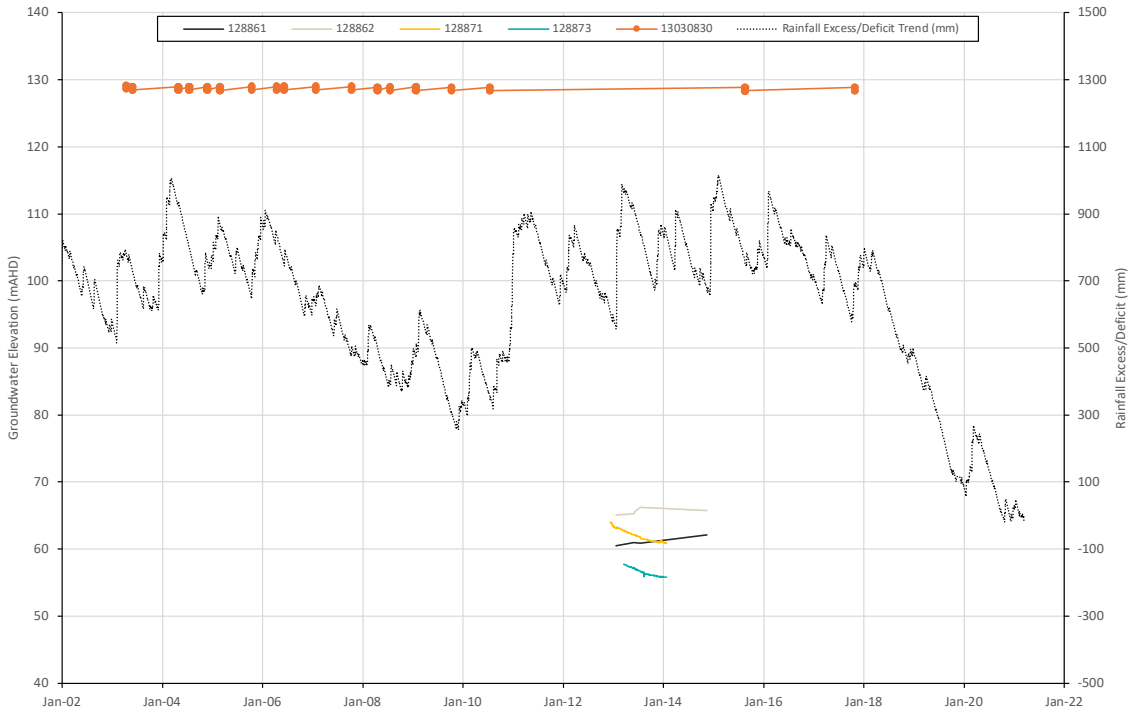

Figure 5-11 Rewan Group Groundwater Elevation Hydrographs

5.7 Groundwater Chemistry

Groundwater chemistry within the Bowen Basin has been considered using information reported by OGIA (2019b) and data sourced from the GWDB. Table 5-4 presents a summary of regional groundwater chemistry from OGIA (2019b) for formations present within the Project area.

Table 5-4 Surat CMA Groundwater Chemistry Summary (sourced from (OGIA 2019b))

Analyte	Percentile	Alluvium	Evergreen Formation	Precipice Sandstone	Moolayember Formation	Clematis Sandstone	Rewan Group	Undivided Permian Upper
Ca	25th	30	5	1.1	13.5	9.4	27.4	31.5
	50th	46	20	2.7	27	23.5	80.6	61.8
	75th	76.8	52	7	89.3	39	281	84.3
Mg	25th	22	1	0.3	4.9	5.3	51.3	36.3
	50th	40	8.7	1	21.5	14	71.8	52.2
	75th	80	22	1.7	81.3	39	200.9	85.1
Na	25th	100	33	31	118.8	31.5	252	143.3
	50th	205	87	45	384	76	706	372
	75th	500	356	75.3	1123.8	120	2326.3	628
K	25th	0.05	0.05	2	0.05	8	0.05	1.25
	50th	1	2	2	1.03	12	1	2.5
	75th	3	5	3	5.75	16	8.25	5.5
Alkalinity	25th	308	122	73.8	150	120	143.3	474.3
	50th	403	195	112	282	322.5	342	722
	75th	511.7	478	172	460.8	465	381.8	890.8
Cl	25th	84	25	10	98.5	34.3	272.5	137.3
	50th	250	54	16	444.5	50	1141	342.5
	75th	780	310	44.4	1654.8	68.5	4215	595.3
SO_4	25th	5	0.1	0.1	0.1	2	1	0.1
	50th	15	8.1	1	4.9	5.5	25.9	16
	75th	70	24.5	2	24	16.8	164.9	85
F	25th	0.1	0.1	0.1	0.1	0.1	0.16	0.22
	50th	0.2	0.2	0.2	0.3	0.17	0.3	0.35
	75th	0.3	0.42	0.5	0.59	0.23	0.45	0.62
TDS	25th	649	223.1	128.4	537.5	227.1	1138.7	1244.2
	50th	1064	411.1	184.1	1401.5	522.4	2648	1770.1
	75th	2016	1458.1	302.9	3657.1	745.4	7009	2342.4
pH	25th	7.6	7.2	7	7.5	7.1	7.4	7.9
	50th	7.9	7.6	7.3	7.9	7.8	7.4	8
	75th	8.2	8.2	8	8.2	8	7.6	8.1
SAR	25th	2.9	1.7	3	5	1.7	5.8	3.4
	50th	5.4	6.4	7.8	13.2	2.3	17	7.9
	75th	11.9	12.5	10.7	26.1	3.9	28.5	14.9

Further groundwater chemistry has been sourced from the GWDB, for bores within 25 km of the Project area. The location of the bores with groundwater chemistry and the OGIA aquifer attribution (OGIA) is shown in Figure 5-12.

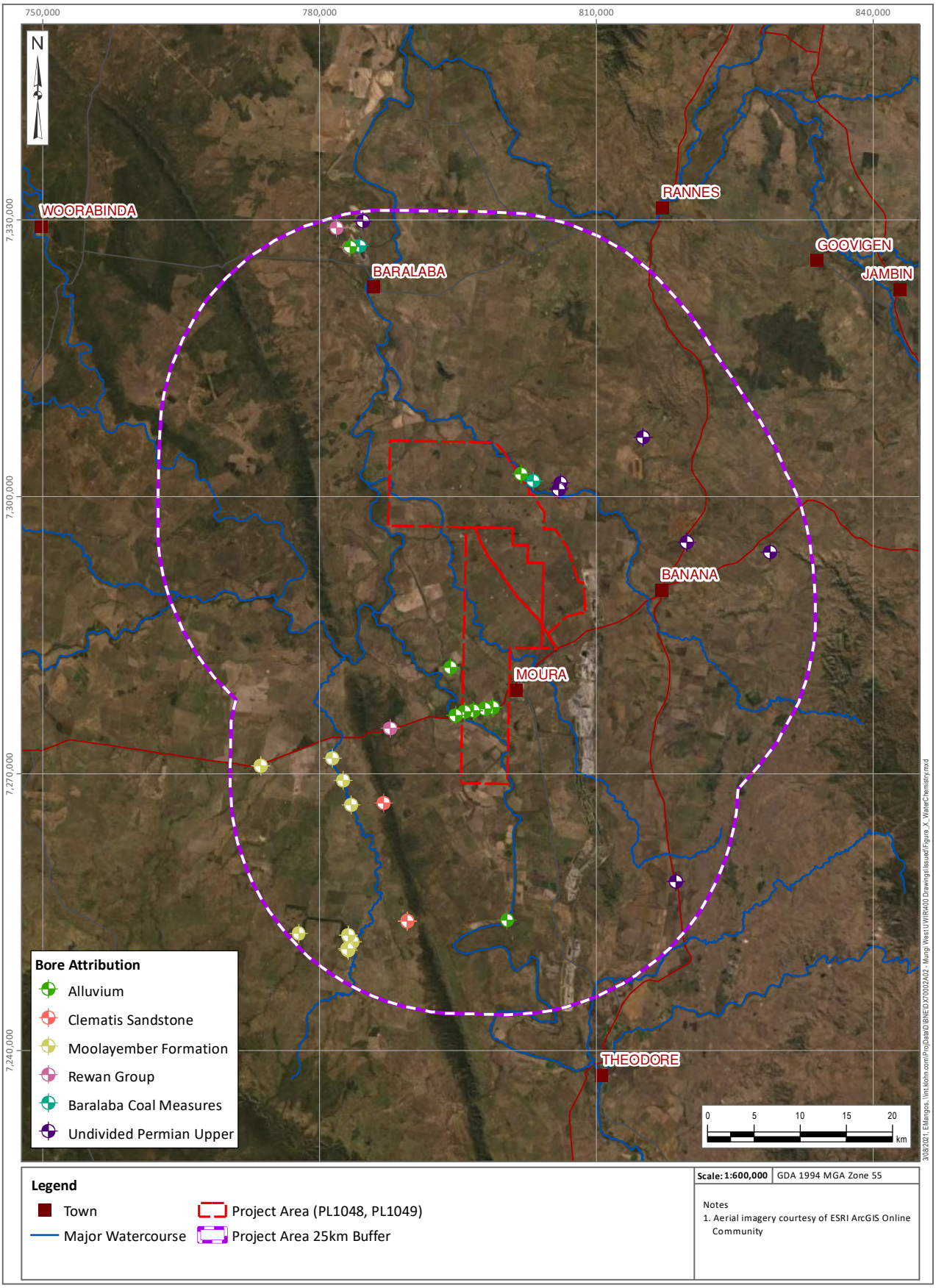

Figure 5-12 Current GWDB Bores with Chemistry Data within 25 km of the Project Area

A review of the water quality data was undertaken prior to data analysis, which identified / addressed any anomalies or gaps in the data set. Bores screened with the undivided Permian have been omitted from the Piper and Durov plots below due to the depth range in which the unit occurs, potential impacts from nearby mining operations, and the location of the bores to the east of the Project area interpreted to be beyond the extent of potential impacts from the proposed development.

Figure 5-13 to Figure 5-17 present Piper and Durov diagrams for each hydrostratigraphic unit. The following observations are made for the local hydrochemistry:

- The majority of groundwater samples have been collected from the alluvium, with 14 samples collected from bores within 25 km of the Project area. The groundwater samples from these bores vary between sodium- chloride and sodium- bicarbonate dominated. Salinity levels from the alluvium groundwater samples indicate that the water quality is predominantly fresh (Figure 5-13).
- Moolayember Formation water quality for this Project area is based on 11 samples collected from within 25 km of the Project area. Similar to alluvium, the Moolayember Formation varies between sodium-chloride and sodium-bicarbonate dominated. TDS concentrations indicate that the water quality is fresh (Figure 5-14).
- The Clematis Group water quality is based on seven groundwater samples. Water quality results from these samples indicate that the water is fresh. The limited groundwater samples prevent the identification of the dominant ionic constituents of the water (Figure 5-15).
- The Rewan Group water quality characteristics is based on four water quality samples. The water quality results indicate that the Rewan Group groundwater is sodium-chloride dominated and is saline (Figure 5-16).
- Water quality analysis of the Baralaba Coal Measures are based 3 sample results from the GWDB. The location of the bores, where samples were collected are to the north to the Project area. The water quality results indicate that the groundwater is sodium-chloride to bicarbonate dominated, with a quality ranging from fresh to brackish.

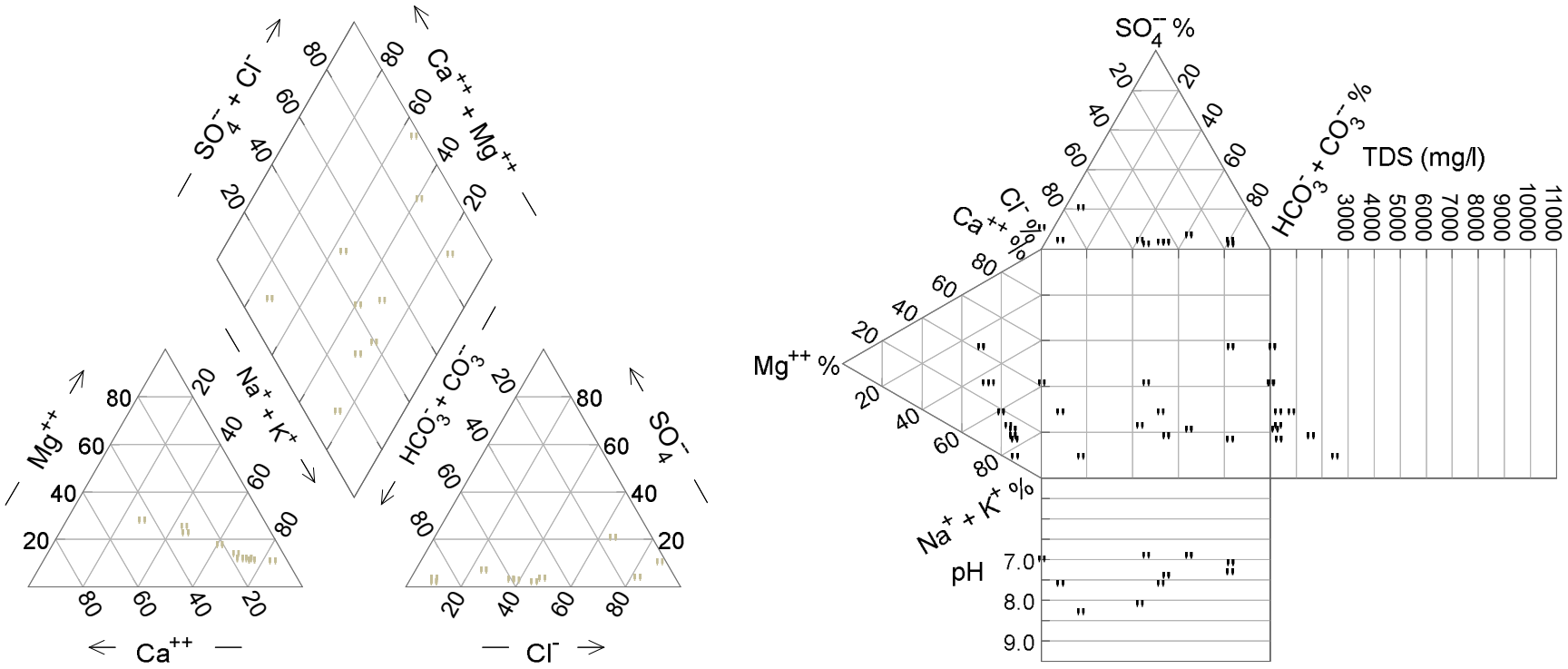

Figure 5-13 Piper and Durov Diagram – Alluvium

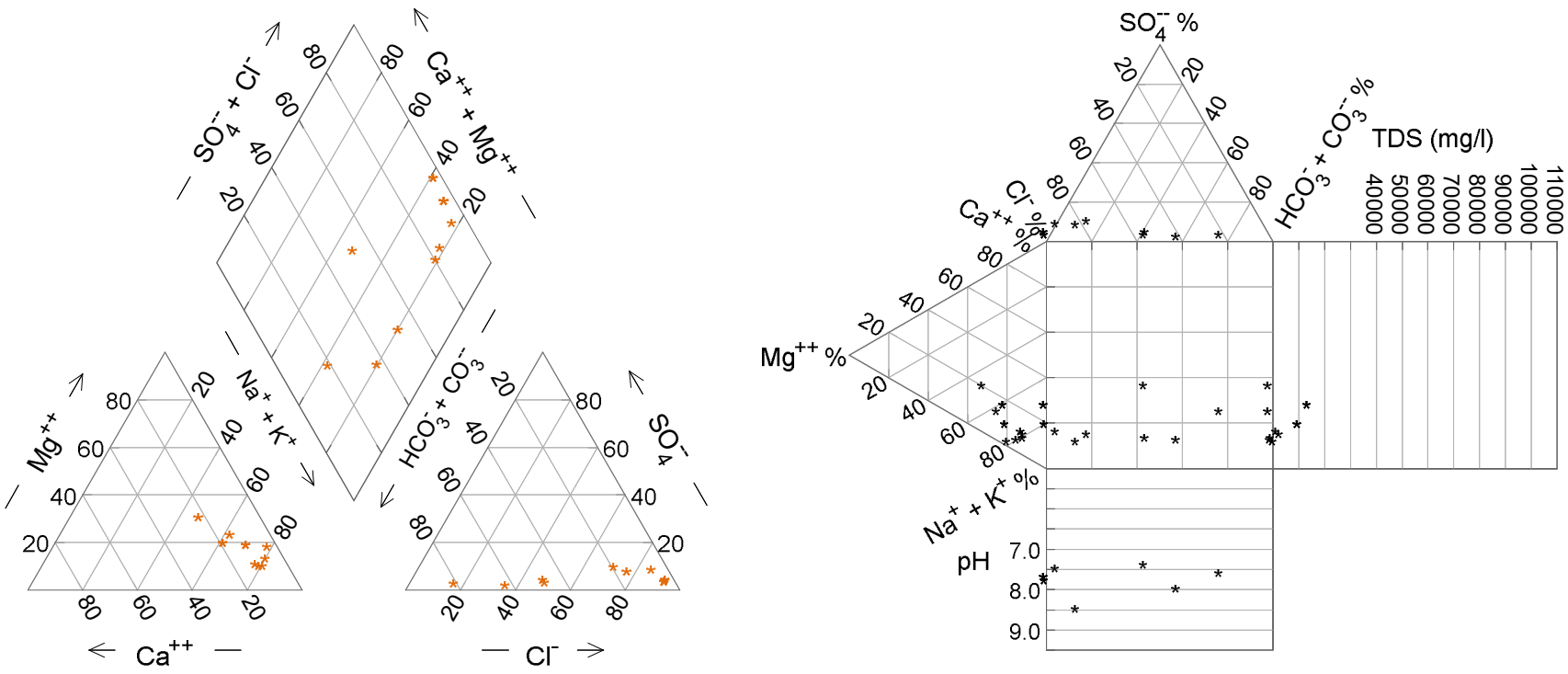

Figure 5-14 Piper and Durov Diagram – Moolayember Formation

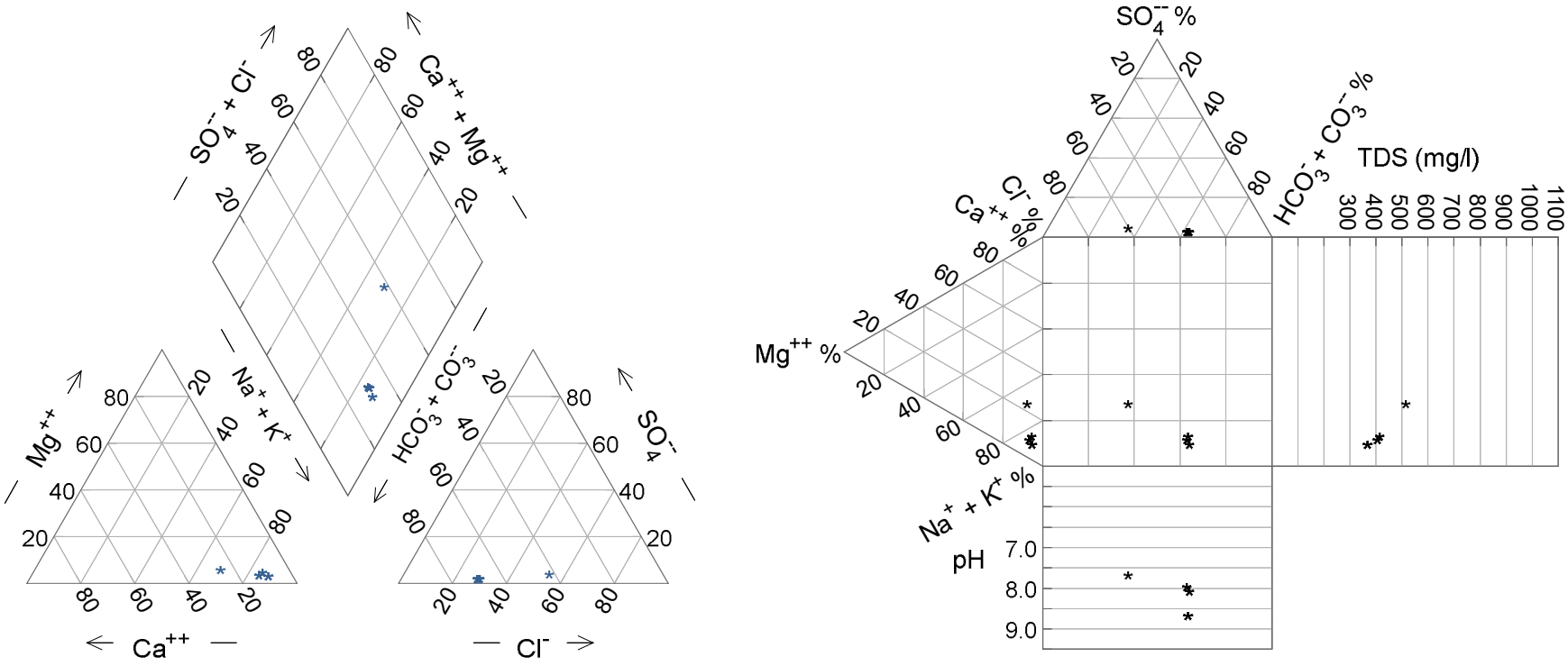

Figure 5-15 Piper and Durov Diagram – Clematis Group

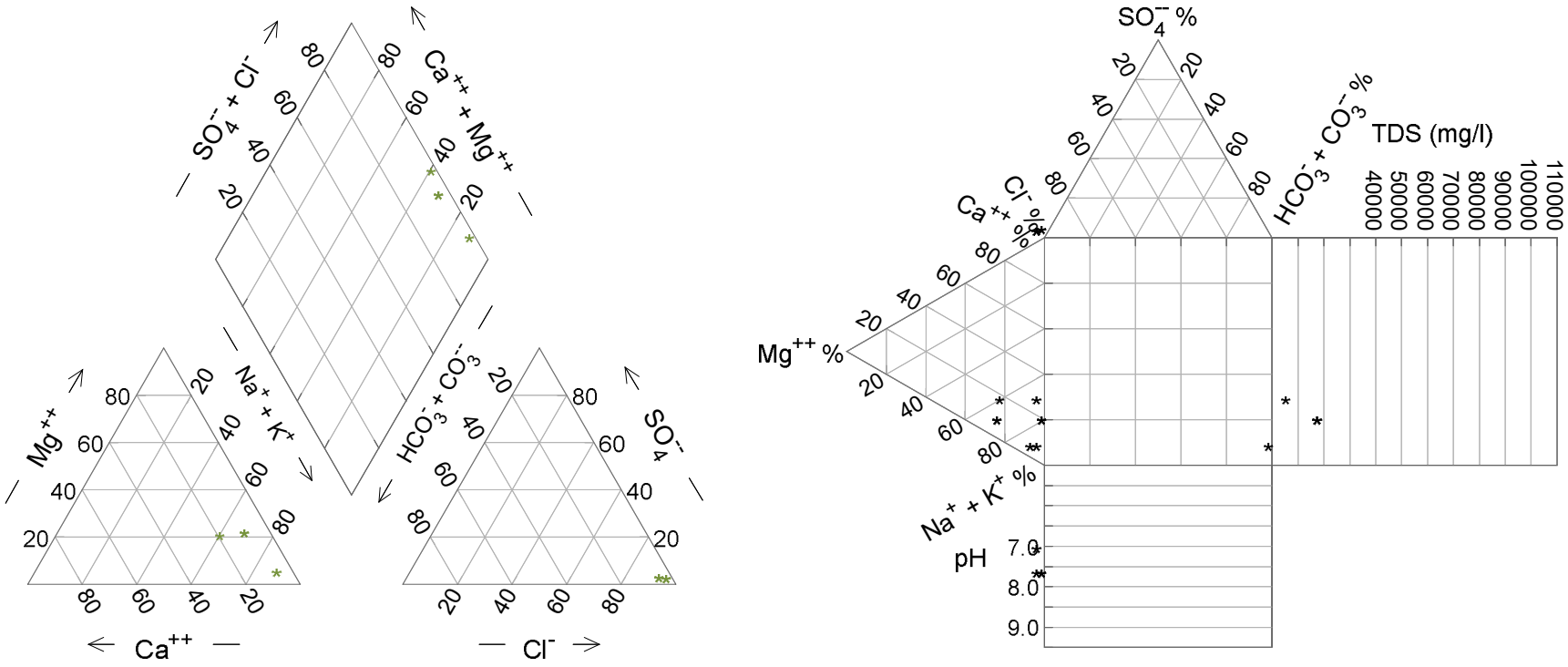

Figure 5-16 Piper and Durov Diagram – Rewan Group

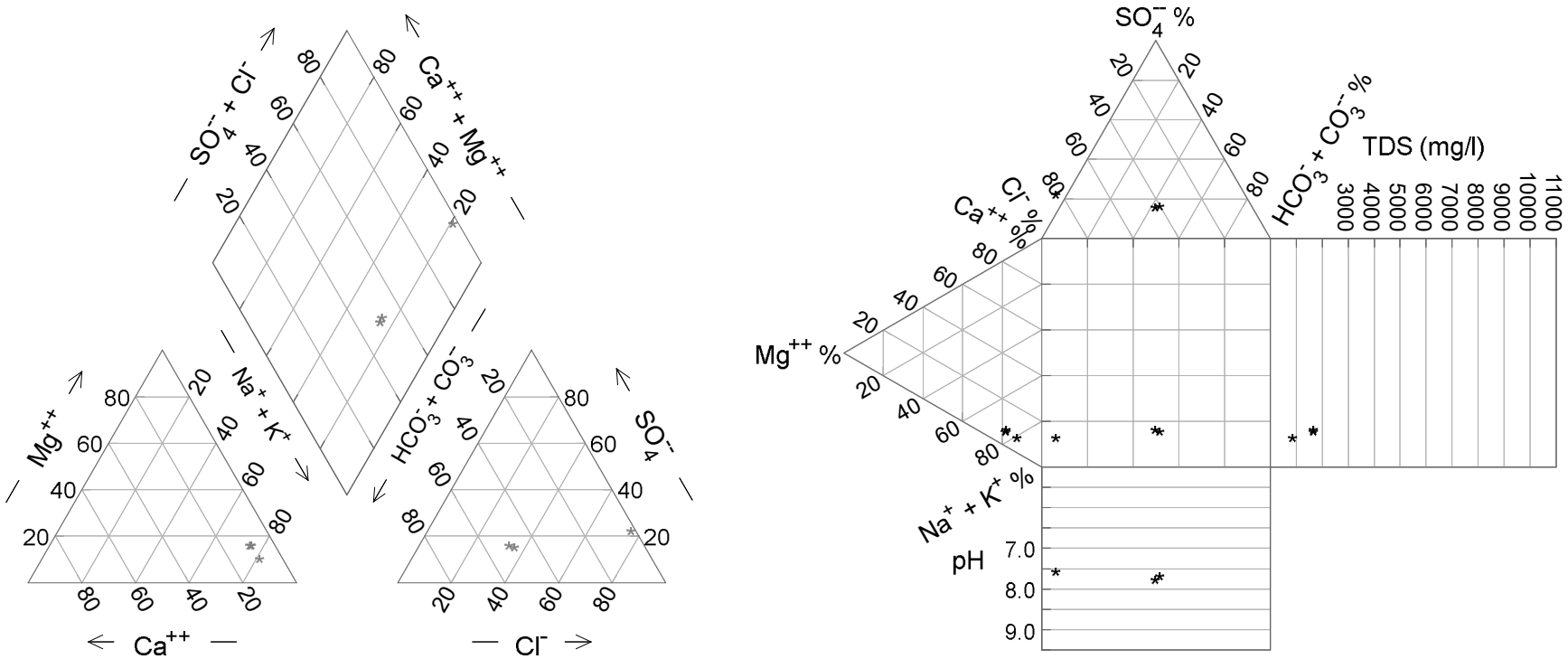

Figure 5-17 Piper and Durov Diagram – Baralaba Coal Measures

5.8 Groundwater-Surface Water Interactions

Groundwater-surface water interaction within the Project area may occur as a result of two key processes:

- Recharge of aquifers as leakage from watercourses; and,
- Discharge of groundwater to watercourses as baseflow.

Recharge to groundwater systems from watercourses may occur across the Project area, however this only occurs when there are conditions of sufficient saturation in the alluvium and associated hydraulic head to allow water to infiltrate into the underlying aquifers. This is likely for the majority of the ephemeral watercourses across the Project area where flow is only observed during and following rainfall event. The exception to this is the Dawson River where surface water flow is perennial.

Alluvial aquifers deposited by fluvial processes in river channels or floodplains are found along the Dawson River, and associated tributaries. Based on the information from the surface water flow gauges, and groundwater level data from the alluvium (Figure 5-8), there is limited potential for baseflow from the groundwater system to contribute to the Dawson River within the vicinity of the Project area. This is supported by the comparison between groundwater levels in the alluvium monitoring bore (RN 13030385 – assessed as part of the Greater Meridian Field Groundwater Assessment (KCB 2020)) immediately upstream of the surface water gauging station on the Dawson River at Woodleigh (130317B). Perennial surface water flow in the Dawson River, through the Project area, is a result of groundwater baseflow contribution up-catchment of the Project area.

Groundwater levels recorded in monitoring bore 13030385, over the duration of the surface water gauging records that correlated with the groundwater level monitoring records (October 1985 to May 2012), indicate that groundwater levels gradually rose from 120.62 mAHD to 126.2 mAHD throughout the recorded period. In comparison, the recorded river elevation at the Dawson River at Woodleigh gauging station fluctuated from 126.254 mAHD to 144.509 mAHD, with a median of 126.808 mAHD. This indicates that the river levels were always higher than the recorded groundwater levels in the alluvium.

As a result, the elevation of the Dawson River at Woodleigh is higher than the groundwater level at 13030385, and considering that the monitoring bore is approximately 10 km upstream in the Dawson River alluvium, there is limited connection between groundwater and surface water within the vicinity of the Project Area.

5.9 Groundwater Dependent Ecosystem

Potential groundwater dependent ecosystems (GDEs) have been mapped in the vicinity of the Project by the DES (DES 2018). GDEs are defined in water-related responses to coal seam gas extraction and coal mining (DoEE 2015) 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 GDE are* (Eamus et al. 2006)*:*

- *ecosystems dependent on surface expression of groundwater*
- *ecosystems dependent on subsurface presence of groundwater,*
- *subterranean ecosystems.'*

OGIA (2019b) provides further terminology relating to surface expression GDE's, which include spring vents / complexes:

- Spring vents are described as a single location in the landscape where groundwater discharges at the surface. A spring vent can be mounded or flat and can also present as wetland vegetation, with no visible water at the location of the spring.
- A spring complex is a group of spring vents located close to each other. The spring vents are located in the same surface geology and share the same source aquifer and landscape position. No adjacent pair of spring vents in the complex is more than 10 km apart.
- A watercourse spring is a section of a watercourse where groundwater from an aquifer enters the stream through the streambed. This includes waterholes and flowing sections of streams dependent on groundwater. This type of spring is also referred to as a baseflow-fed section of a watercourse.

Potential terrestrial GDEs, are mapped as present in the vicinity of the Project and are discussed in the following section. Spring complexes were identified ~65 km west and northwest of the Project area.

5.9.1 Spring Complexes

Spring complexes, as recorded in the Queensland spring database (Queensland Herbarium 2018), are presented in Figure 5-18. The majority of spring complexes are located over 60 km west of the Project area, while other spring complexes are located over 40 km to the southwest of the Project area.

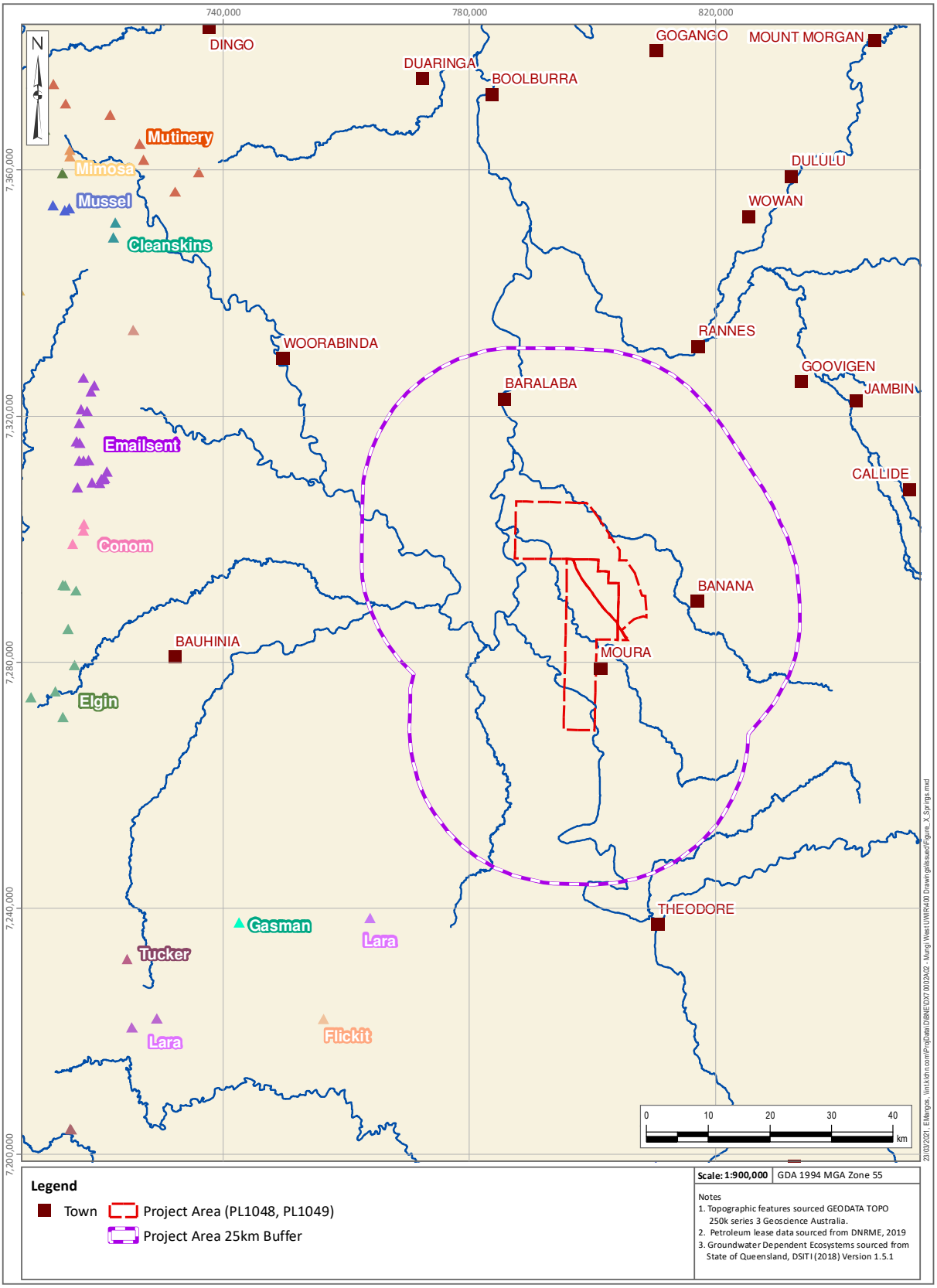

Figure 5-18 Location of Spring Vents / Complexes in the Vicinity of the Project Site

5.9.2 Potential Terrestrial GDEs

The distribution of potential GDEs, as mapped by DES (2018b), within the vicinity of the Project area is presented in Figure 5-19. The potential GDEs are generally located in the vicinity of watercourses, such as the Dawson River and associated tributaries (Fish Creek / Zamia Creek). The majority of potential GDEs are mapped as being 'low confidence' and are all derived from satellite or regional ecosystem mapping, rather than assigned based on known groundwater dependence.

Figure 5-20 presents the potential terrestrial GDEs using the GDE mapping rule sets as defined by the Queensland Government (2017) in 'Groundwater dependent ecosystem mapping rulesets for the Comet, Dawson and Mackenzie River Catchments'. The rule set occurring in the vicinity of the Project include:

- SURAT_RS_01A: Quaternary alluvial aquifers overlying sandstone ranges with fresh, intermittent groundwater connectivity regime
- SURAT_RS_01C: Quaternary alluvial aquifers with fresh, intermittent groundwater connectivity regime
- SURAT_RS_01D: Quaternary alluvial aquifers with fluctuating, intermittent groundwater connectivity regime and neutral pH
- SURAT_RS_02A: Permeable rock aquifers (basalts) greater than or equal to 100 ha in size with fresh, intermittent groundwater connectivity regime
- SURAT_RS_02B: Permeable rock aquifers (basalts) less than 100 ha in size with fresh, episodic groundwater connectivity regime
- SURAT_RS_03A: Permeable consolidated sedimentary rock aquifers with fresh, intermittent groundwater connectivity regime
- SURAT_RS_05: Permeable old loamy or sandy plain aquifers with fresh, intermittent groundwater connectivity regime
- SURAT_RS_07: Fractured rock aquifers (igneous rocks) with fresh, intermittent groundwater connectivity regime

Further discussion of the potential terrestrial GDEs, in the context of impacts, is provided in Section 7.5.

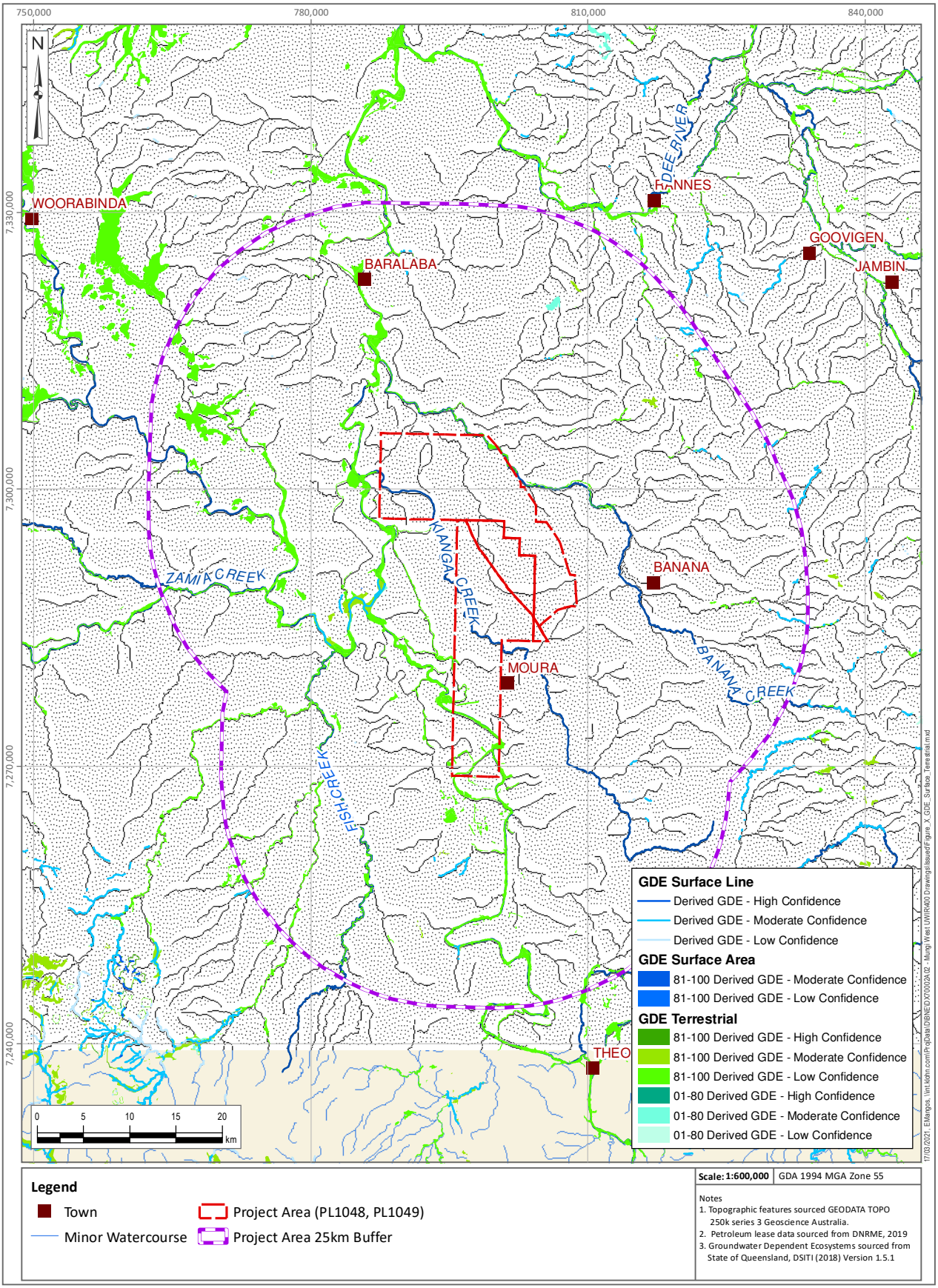

Figure 5-19 Location of Potential Terrestrial GDEs in the Vicinity of the Project Site

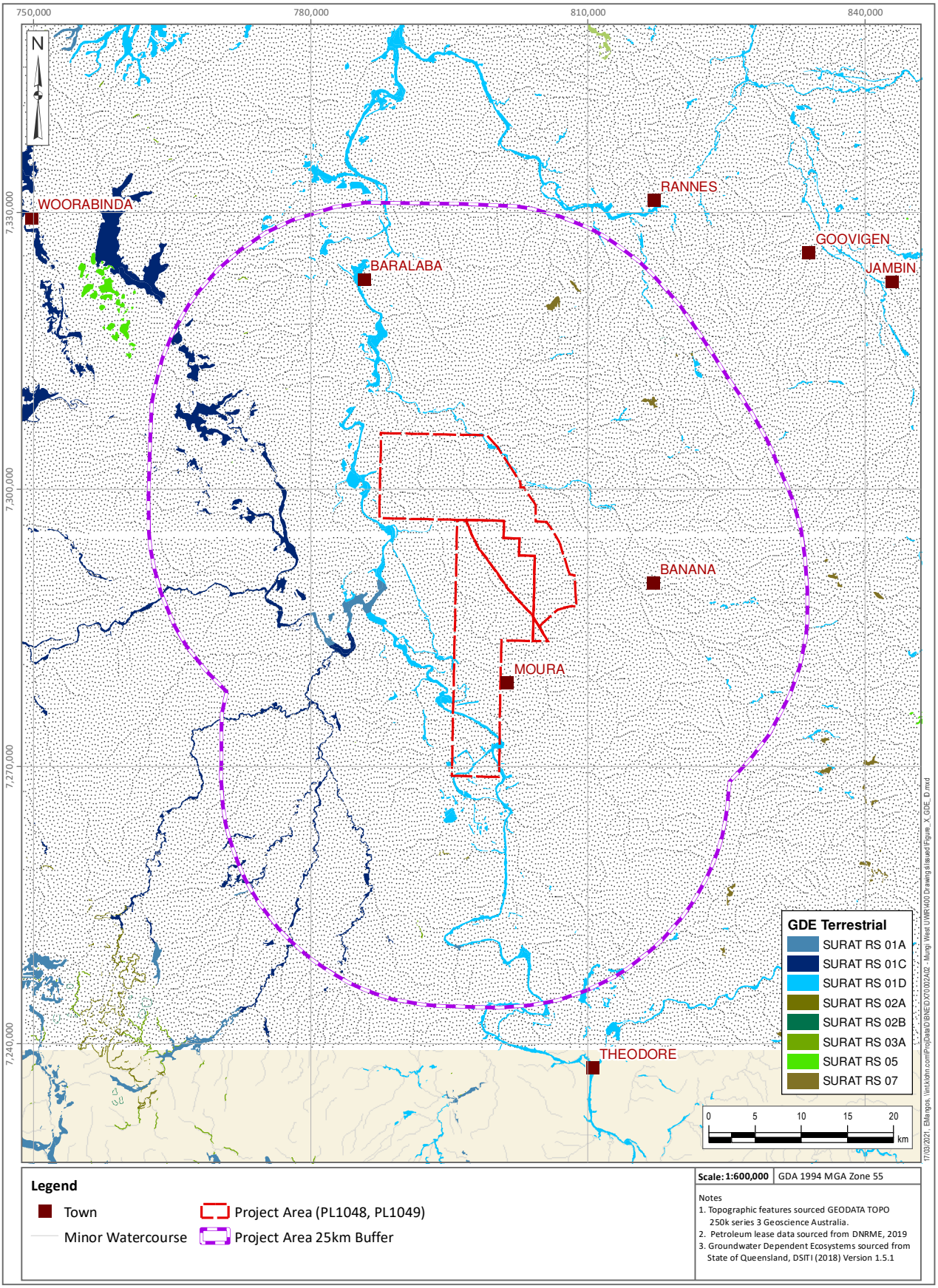

Figure 5-20 Potential Terrestrial GDEs by Rule Set

5.10 Third-Party Groundwater Users

5.10.1 Registered Groundwater Bores

Within the vicinity of the Project Area (within PL 1048, PL 1049 and a 25 km buffer outside), there are 380 registered groundwater bores recorded in the GWDB, as of July 2021 (DRDMW 2021). Of these registered bores, 340 are existing bores or abandoned but usable; the remaining bores are abandoned or decommissioned. A summary of registered bores is presented in Table 5-5 along with their type and status, as derived from the GWDB. Bores abandoned and destroyed have not been presented in the associated figures.

Table 5-5 Summarised Bore Type and Condition within a 25 km radius of Project Area

Type	Abandoned and Destroyed (AD)	Abandoned but useable (AU)	Existing (EX)	Total
Condition Unknown (AB)	0	0	89	89
Controlled Flow (AF)	0	34	3	3
Sub-artesian Facility (SW)	40	0	214	288
Total	**40**	**34**	**306**	**380**

Other groundwater bores may also be present within the Project area that are not registered in the GWDB (e.g. installed prior to the requirement to register water bores with the DRDMW). It is not known how many unregistered bores may exist; however, these bores may be identified during future bore baseline assessments. The data from baseline assessments is provided to OGIA and DRDMW for incorporation into future updates to the GWDB.

5.10.2 Bore Baseline Assessment

Under the *Water Act 2000*, petroleum tenure holders are required to undertake baseline assessments of water bores prior to commencement of production. Baseline assessments are undertaken in accordance with the 'Baseline Assessment Guideline' (DES 2017a), to obtain information such as:

- Bore status;
- Type and purpose;
- Information related to construction of the bore; and
- Bore equipment.

Baseline assessments for bores located within the Project Area were undertaken as part of the Mungi West CSG EA Application Groundwater Assessment (SLR Consulting Australia Pty Ltd 2019), which were completed in accordance with *Water Act 2000* requirements. A summary of the groundwater bores within the Project Area for which baseline assessment have been undertaken are provided in Table 5-6. Figure 5-21 presents the locations of the bores where baseline assessments were completed / attempted.

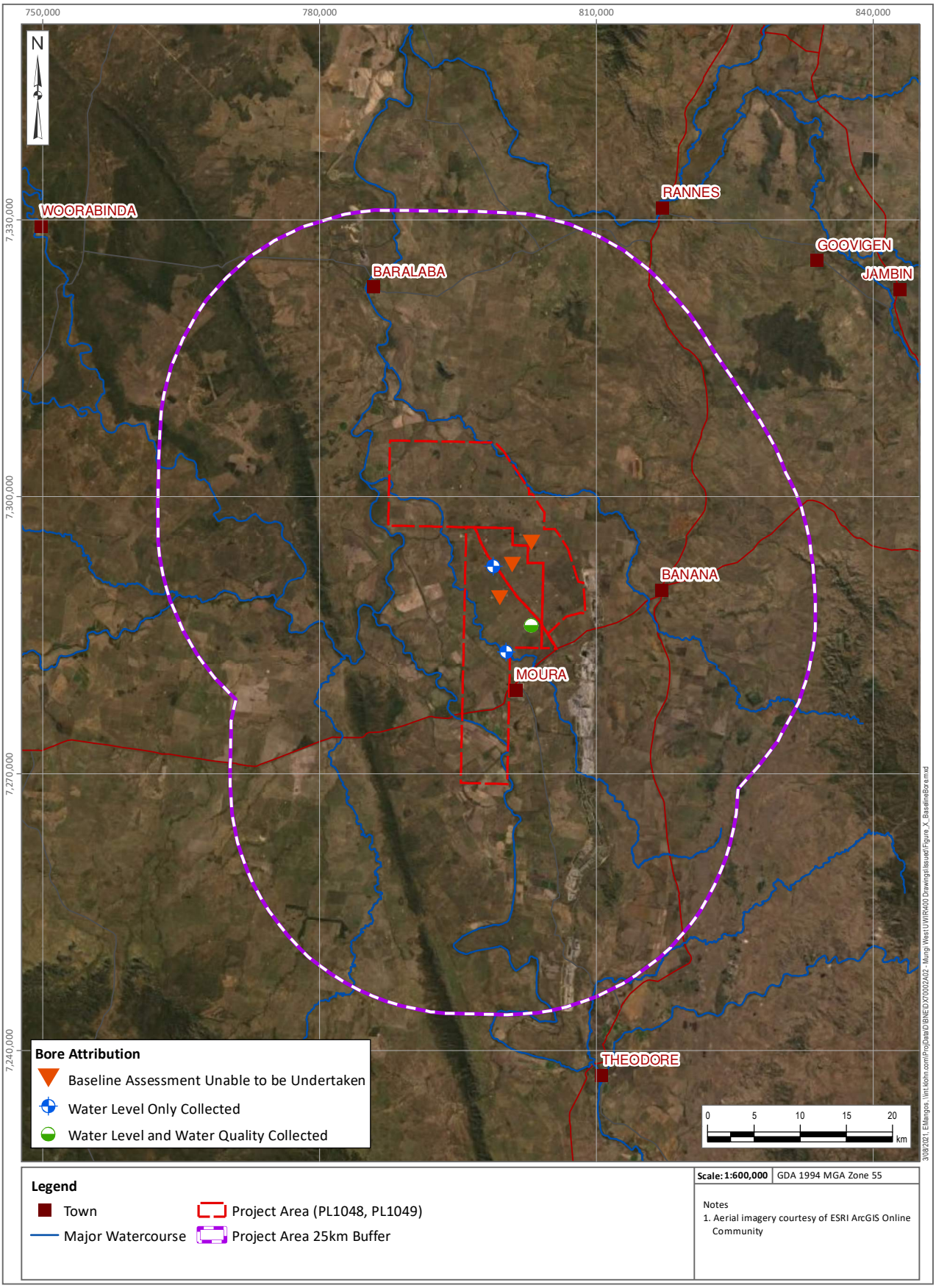

Figure 5-21 Locations of Completed / Attempted Bore Baseline Assessments

Table 5-6 Summary of Completed / Attempted Bore Baseline Assessments

Bore ID / Local Name	Easting	Northing	Landholder	Static Water Level Monitoring	Groundwater Quality Analysis
Unknown Bore 1	798810	7292497	2SP128480	YES	X
Unknown Bore 2	800910	7292622	2SP128480	X	X
128580	802998	7294999	2FN197	YES	X
128574 (missing)	799547	7289008	20FN208	X	X
128576	800242	7283198	6FN180	YES	X
128577	802990	7286080	6FN180	YES	YES

* Coordinates in GDA94, Zone 55.

5.10.3 Groundwater Use and Purpose

Groundwater is used for various purposes in the vicinity of the Project Area including Stock and Domestic; irrigation; Town Water Supplies; and industrial / mining purposes.

A summary of the estimated purpose for bores located within the 25 km buffer of the Project area is shown in Figure 5-22. Groundwater abstraction for water supply is the dominant water use purpose within the vicinity of the Project, with 127 bores considered as potential water supply bores (Total of water supply plus irrigation, stock and “unknown”).

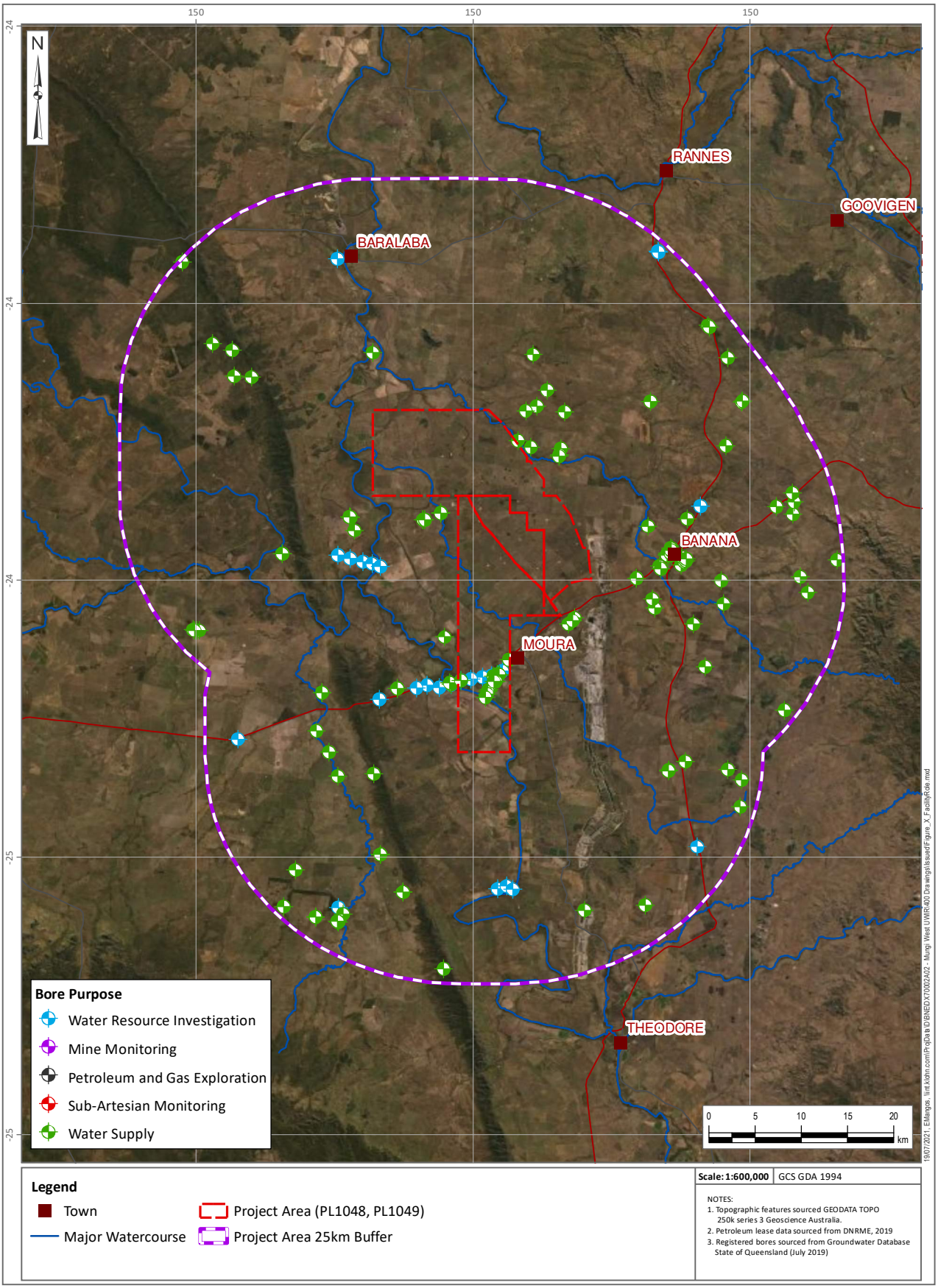

Figure 5-22 Estimated Bore Purpose (provided by OGIA)

5.11 Conceptual Model Summary

This section summarises the information of the previous section in terms of conceptual models for the hydrogeological systems and identifies the water dependent assets for consideration in the impact assessment. A summary of the conceptual model is as follows:

- The target for gas production for the Project is the Baralaba Coal Measures, which occurs beneath PL 1048 and Pl 1049, from <100 m in the east of the tenure to more than 2,500 m in the west.
- Geology within the Project area comprises Quaternary-aged alluvium associated with watercourses (predominately Dawson River), with Tertiary sediments covering the majority of the area beyond the extents of the alluvium adjacent to the creeks. The Rewan Group aquitard sub-crops directly beneath the Cenozoic cover within the Project area, and to the south of the Project; and outcrops in areas where the Cenozoic cover has eroded away. The Baralaba Coal Measures underlie the Rewan Group and outcrop to the east of the Project area. The outcrop of these coal measures coincides with the location of the Dawson Coal Mine Complex. Undivided Permian bedrock underlie the Baralaba Coal Measures and outcrop to the east of the Project.
- The Baralaba Coal Measures comprises the target coal seams, which are interbedded with sandstone, siltstone and shales that occur as interburden or overburden relative to the coal seams. The fine-grained shale and siltstone are observed as having low permeability and are interpreted to function as aquitards. In comparison, the target coal seams generally have a higher permeability.
- Localised faulting has been identified within the Project area and is associated with the Baralaba Coal Measures. However, detailed mapping of these fault structures have identified the faults to be limited to the coal measures and partially into the lower portions of the Rewan Group. The faults are not observed through the Rewan Group and into the overlying Cenozoic cover; and therefore, are not considered to be a conduit for groundwater flow or a concern for the proposed Project development.
- There is a significant thickness of the Rewan Group aquitard within the vicinity of the Project Area (~500 m thickness in the south of the Project Area, to ~2,500 m in the northwest of the Project area) which separates the Clematis Sandstone and Cenozoic cover from the Baralaba Coal Measures.
- The watercourses within the Project area are characteristically ephemeral and typically only flow during significant rainfall events. The exception to this is the Dawson River, which is interpreted to receive groundwater baseflow up-catchment of the Project area.
- Potential terrestrial GDEs associated with the watercourses, if groundwater dependant (or at least in part), would likely be sourcing groundwater from the alluvium associated with the Dawson River and key associated tributaries.

- Spring complexes are present to the southwest, west, and northwest of the Project and are predominantly associated with the Precipice Sandstone, with a few associated with the Hutton Sandstone and the Clematis Sandstone. The mapped spring complexes are beyond the 25 km buffer of the Project and are not considered to be a concern for this Project development.
- The majority of the groundwater-source for water supply in the vicinity of the Project area is predominately associated with the alluvium and Undivided Permian/Basement Rock.

6 NUMERICAL GROUNDWATER MODEL SUMMARY

A calibrated groundwater flow model was previously developed for the Project area and surrounds, as part of the Greater Meridian Field Groundwater Assessment (KCB 2020) to assess the potential impacts of CSG development on the local and regional groundwater systems. The domain for the previously developed groundwater model includes PL 1048 and PL 1049, and therefore was able to be adopted to undertake this assessment.

6.1 Model Design, Domain and Calibration

6.1.1 Model Code Selection

MODFLOW-USG is an “unstructured grid” version of MODFLOW that can use an irregular grid structure with arbitrary cell/node connections. This enables focused grid refinement to occur in areas where detail is important, without the need for continuation of grid refinement to the extremes of the model domain. It also facilitates implementation of pinching-out layers and/or layer discontinuities within the modelled domain. This can greatly reduce the number of grid cells within the model domain and thus greatly reduce model runtimes. In addition, MODFLOW-USG implements an “upstream weighting” formulation of the groundwater flow equation that allows cells to dewater and re-saturate easily.

For these reasons, MODFLOW-USG was selected for this assessment.

6.1.2 Model Processing and Discretisation

Algomesh was used to develop an unstructured grid based on Voronoi polygons and to calculate cell connectivities along with geometries of connected cell interfaces necessary for execution of the MODLOW-USG model. In doing so, grid mesh refinement was focused around:

1. The Quaternary alluvium;
2. Major surface water drainage lines; and
3. The development areas – CSG development and Dawson Mining Complex.

The maximum allowable grid cell edge length was limited to 1,000 m and the minimum allowable internal angle in any single cell was set to 32 degrees. The minimum allowable cell thickness was set at 0.2 m thereby instructing Algomesh to pinch-out cells that have thicknesses less than this. In the vicinity of the CSG development area, a combination of a structured grid and unstructured grid was adopted to allow easier representation of the open-pit developments to the east of the Project area and the proposed CSG wellfield development (i.e. project development and potential

future development) over time, respectively. The resulting grid cell mesh developed from these settings is shown in Figure 6-1 In representing the hydrostratigraphic units in the vicinity of the Project area, a total of 11 model layers were used and these are discussed further Section 6.1.3. The model grid comprises 98,903 active cells.

The transient period used for model calibration consists of monthly time-steps with quarterly stress periods over the period October 1990 to June 2019 and a combination of quarterly and annual stress periods were used in the predictive runs to simulate operational development and post-development groundwater level recovery.

6.1.3 Model Layers

The hydrostratigraphy of the project area was represented using 11 model layers. The uppermost surface is defined by project-specific LiDAR data, for the localised Project area, combined with public domain SRTM data for the wider model domain. Table 6-1 presents the model layers and the primary geological units that are represented by each.

Table 6-1 Summary of Model Layers

Model Layer	Hydrogeological Unit	Geological Age
1	Alluvium	Quaternary
2	Tertiary Sediments	Quaternary-Tertiary
3	Tertiary Basalt	Tertiary
4	Boxvale Sandstone	Jurassic
5	Evergreen Formation	
6	Precipice Sandstone	
7	Moolayember Formation	Triassic
8	Clematis Group	
9	Rewan Group	
10	Baralaba Coal Measures	Permian
11	Undivided Basement Units	Permian and older

The surfaces of these layer were derived from the following sources:

1. Geological surface contours in the Project area provided by the proponent from the geological block model, which include:
   - top of the Rewan Group;
   - top of the Baralaba Coal Measures; and,
   - base of the Baralaba Coal Measures.
2. Geological surface contours across the extent of the model domain from the geological model of the Surat Cumulative Management Area (CMA) developed by the Office of Groundwater Impact Assessment (OGIA) (OGIA 2019a). The adopted surface contours represent the majority of the regional groundwater model domain and were incorporated with the local surface contours from the proponent provided geological block model. OGIA's provision of interpretive data was subjected to a limitation that the quality of data, from the Project area and surrounds, may not be at the same standard in comparison to other areas of the Surat CMA as the Project area is outside of the main CSG developments

within the Surat CMA – reflecting the corresponding level of effort applied by OGIA in data acquisition and interpretation.

3. Publicly available groundwater bore records from the DRDMW GWDB which supported the definition of the alluvium layer (Layer 1).
4. Map products from the Bowen Basin Supermodel 2000 (Esterle et al. 2002).

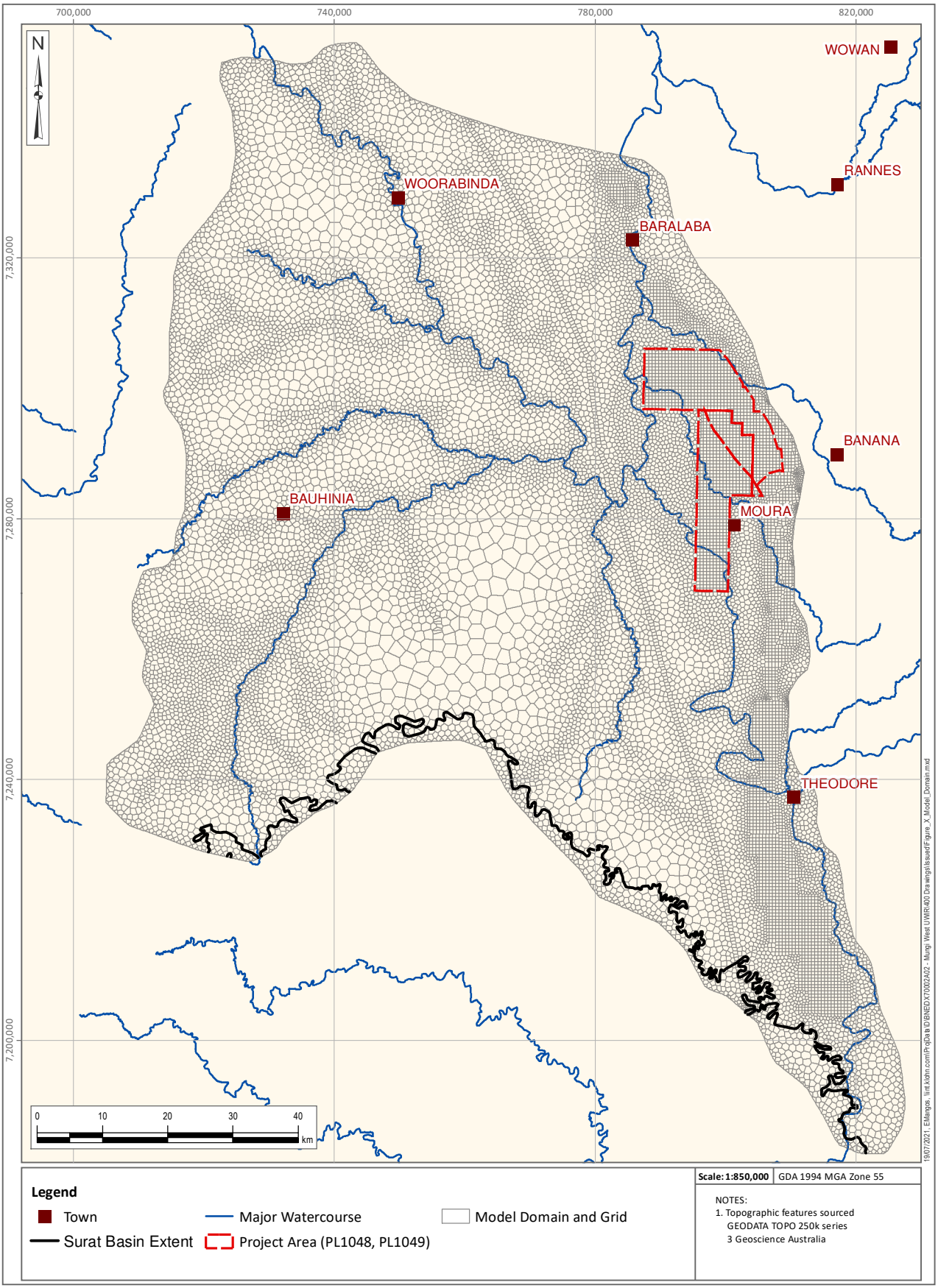

Figure 6-1 Groundwater Model Domain

6.1.3.1 Model Layer Assumptions

A key assumption that was adopted in the development of the numerical model domain was the simulation of the Baralaba Coal Measures as a single model layer. Section 5.2.5 identify the Baralaba Coal Measures as a series of interbedded sedimentary strata comprising the target coal seams and interbeds of sandstones, siltstones and shales; however, these discrete interbeds have not been simulated in the model domain.

The simulation of the Baralaba Coal Measures as a single model layer is considered conservative as the simulation of the gas development activities (i.e. depressurisation of the target coal seam), will be directly from the representative layer (Layer 9). This would result in the immediate propagation of drawdown into the overlying strata. If the lower permeability interburden and overburden strata of the Baralaba Coal Measures where included in the model, this would result in a more subdued drawdown response in the overlying strata. Therefore, the simulation of the Baralaba Coal Measures as a single model layer is considered a conservative assumption and is appropriate for this assessment.

6.1.4 Model Boundary Conditions

Boundary conditions are necessary for solution of the 3D groundwater flow equation that is implemented by MODFLOW-USG. They also provide a means by which auxiliary groundwater fluxes and stresses can be specified within the model. The following boundary conditions have been adopted in the model:

- Rainfall Recharge was applied in zones based on the extents of outcropping geological units, using the RCH package of MODFLOW. Recharge has been applied as the fraction of rainfall that passes through the unsaturated zone and arrives at the groundwater surface. Within the model recharge has been applied as a percentage of rainfall. Three recharge zones are defined, each of which has a unique recharge rate that reflects the hydraulic characteristics of the strata through which it infiltrates. The percentage of rainfall that enters the model as recharge in each zone was adjusted during calibration. The zones are defined by the extents/outcrop of alluvium; Tertiary sediments and Tertiary basalt; and, Jurassic sediments, Triassic sediment, Permian sediments and undivided basement units; and are shown in Figure 6-2.
- Evapotranspiration can be a significant component of the water budget for the groundwater system. In the model, it has been implemented using the EVT package in MODFLOW. A uniform extinction depth has been applied across the domain and set at 1.5 m below the natural surface, below which evaporative losses from the groundwater surface are zero. Where the groundwater elevation is above this level, water is removed from the system at a maximum rate of 584 mm/annum. This value is approximately 34% of the average areal potential evapotranspiration of the project area (Bureau of Meteorology 2020). The scale-back was necessary to achieve numerical stability and model calibration.

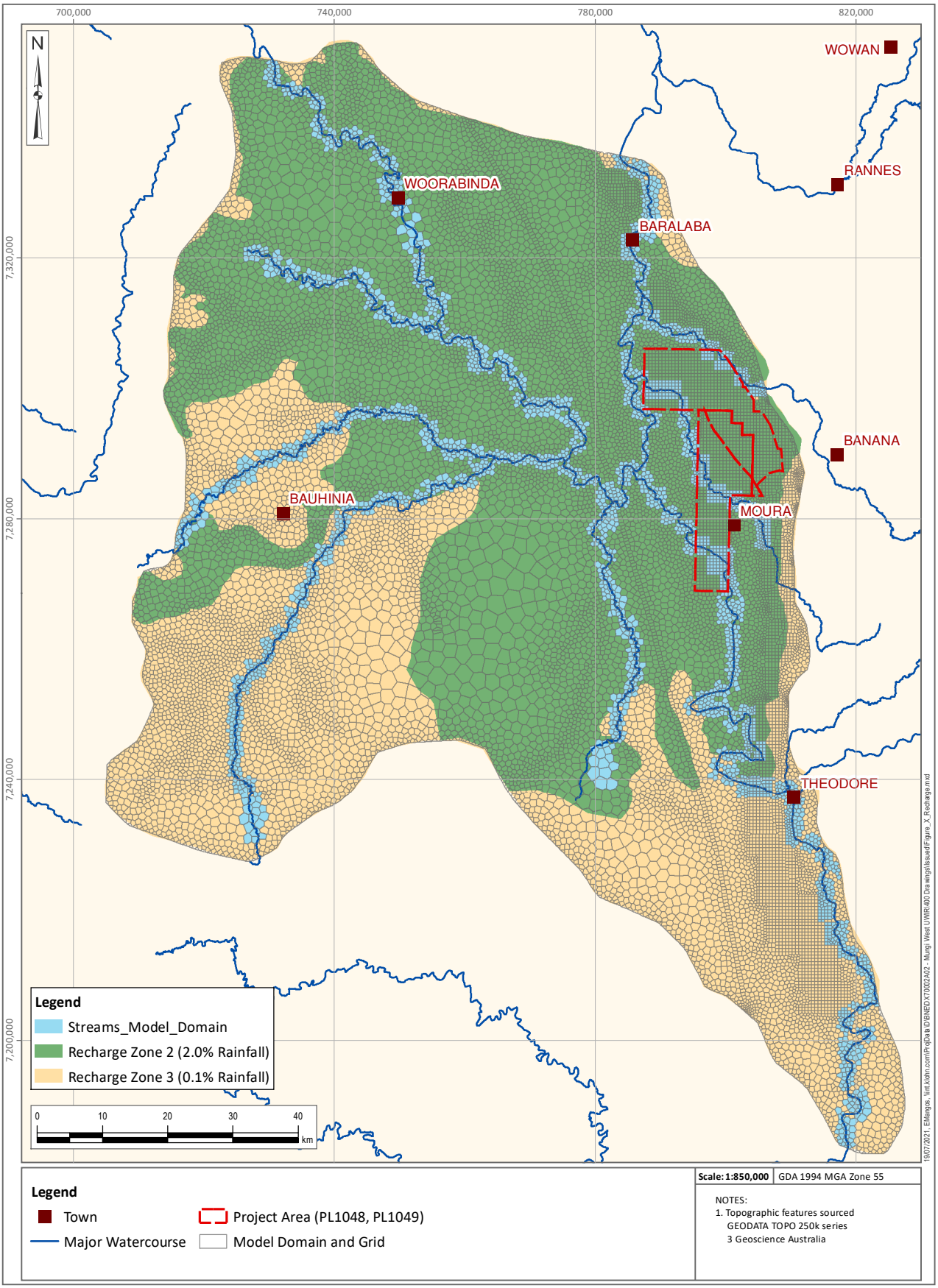

Figure 6-2 Recharge Zones Applied in the Groundwater Model

- General head boundary cells (GHB package) were implemented around the perimeter of the model domain. These GHBs are applied to all layers where that layer is present at the boundary. Use of this boundary type allows for the regional groundwater flow system to be better replicated in the semi-regional model domain. Conductance values applied to the GHB cells were calculated to be consistent with hydraulic conductivity values for each hydrostratigraphic unit and the average cross-sectional area of the boundary cells. A reference head for these cells was calculated as 15 m below ground surface. This boundary is sufficiently distant from the Project area to not materially influence model performance.
- The major water courses in the model domain are represented using the MODFLOW Streams package (STR7). This boundary type is appropriate where stream flows are intermittent or variable; as is the case in this project area. The package also allows for head-dependent surface water/groundwater exchanges to take place. This package calculates a stream stage height through application of Mannings' equation. Streambed conductances for three main water courses were calculated using properties and geometries presented in Table 6-2. Estimates of stream flows used as input in this package, were calculated from data recorded at stream gauge stations along the Dawson River at Bindaree (130374A) and Woodleigh (1303178B).
- Drains cells (DRN package) have been used to simulate existing open-cut mining activities in the vicinity of the project area. For open-cut mining, drains are placed in all layers above and including the target extraction layer (Layer 10), where the open pit extents are located. Reference heads for the Drain cells were specified as the bottom of the target seam while conductances were refined during calibration.
- Coal seam gas extraction, both existing and proposed (as part of the predictive simulation), is simulated using Drain cells (DRN package). At the location of each CSG production well, targeting the Baralaba Coal Measures (Layer 10), Drains have been activated to represent well production. The reference head for these Drains are set at 30 m above the top of the Baralaba Coal Measures. This reference head simulates the partial depressurisation of the target seam to an elevation that is considered optimal for CSG extraction. Drain conductance values for these cells were refined as part of the calibration process.
- The default, no flow boundary condition is applied to the base of the model which is located approximately 500 m below the base of the Baralaba Coal Measures, in the Undivided Basement Units.

Table 6-2 Summary Stream Bed Properties

Stream Segment	Stream Bed Vertical Hydraulic Conductivity (m/day)	Stream width (m)	Streambed thickness (m)
Dawson River	1.25	45.5	10
Fish Creek	1.25	10.5	5
Mimosa Creek	1.25	15.5	3

6.1.5 Model Calibration

Model calibration was performed to adjust model parameter values so that the model can better replicate historical observations of the system state. The outcome of the calibration process also provides the initial conditions for transient predictive simulations used to assess potential impacts of the project on the groundwater regime.

6.1.5.1 Calibration Approach

Calibration on this model focused on parameter estimation over the period from October 1990 to June 2019, which correlates with existing reliable groundwater level monitoring records from the across the Project area.

The calibration model run was initiated in steady-state conditions with boundary conditions applied to replicate known developments (mining associated with the Dawson Mining Complex) at the beginning of October 1990. Following this initial model conditioning period, the model transitions to transient mode for the calibration period (1990 to 2019), with quarterly stress periods applied. This stress period is sufficient to allow seasonal climatic variability to be included; and, replicate the gradual development of the Dawson Mining Complex and the commencement of CSG development. Further, the monitoring records used during the calibration process correlate with the stress periods adopted for the transient calibration.

Automatic parameter estimation was implemented with the use of PEST. Parameters that were included in the PEST process include hydraulic conductivity, storage properties, drain conductance and recharge.

6.1.5.2 Calibration Targets

Groundwater level records from across the project area were reviewed, filtered and compiled to form the calibration dataset. These records were compiled from 88 monitoring facilities (i.e. monitoring bores and vibrating-wire piezometers) for which water level measurements were available over the transient period. A total of 5,292 individual measurements were used in the calibration process.

6.1.5.3 Calibration Results

Figure 6-3 presents a comparison between observed groundwater levels and the calibrated model output equivalents. During calibration, all measurements of the calibration dataset were given equal weight, thereby seeking to extract maximum information from the calibration dataset for inference of parameters.

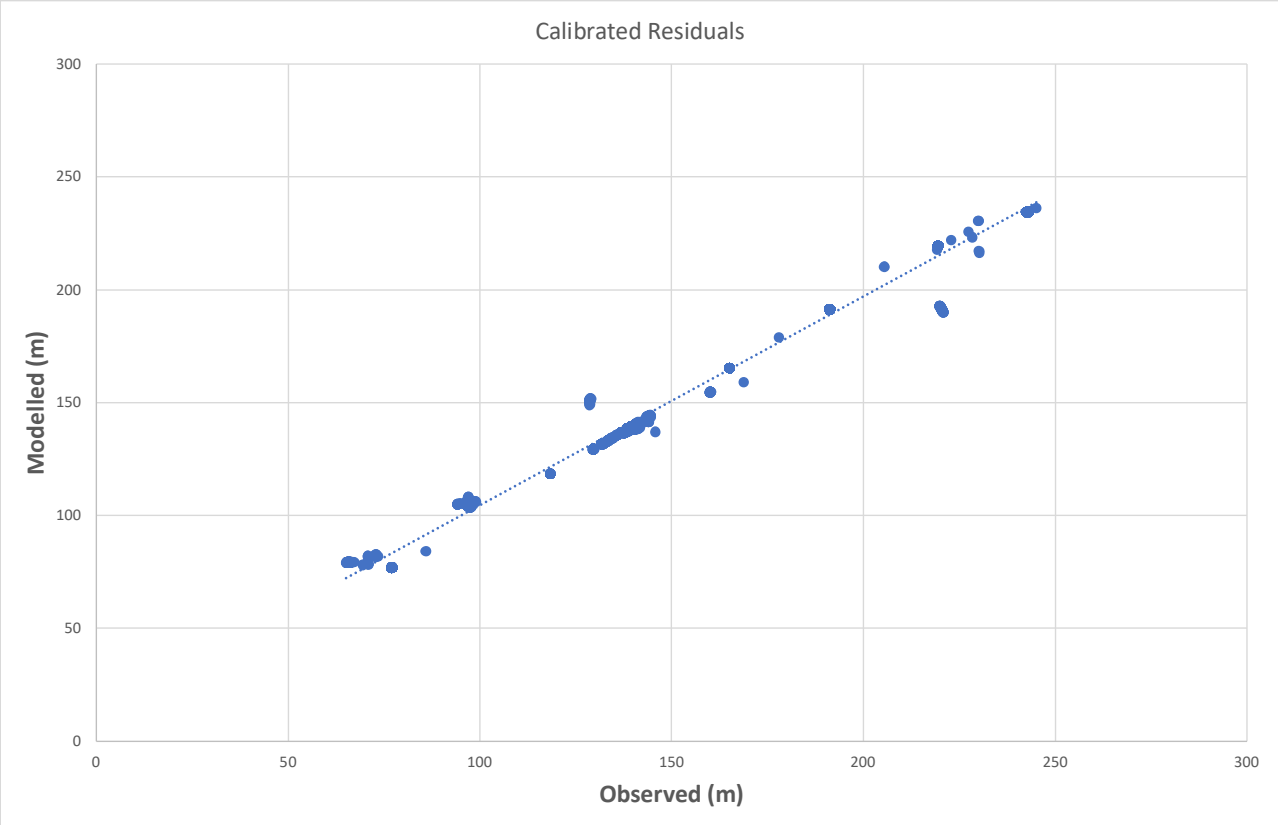

Figure 6-3 Comparison of Modelled Results and Observed Records

Table 6-3 presents statistics from the groundwater model calibration process. The calibration statistics indicated a Scaled Root Mean Square (SMRS) of errors of 6.6%, which is within limits recommended by the Australian Groundwater Modelling Guidelines (Barnett et al., 2012) of 10% SRMS.

Table 6-3 Summary of Model Calibration Performance

Statistical Metric	Value
Number of Observations	5,292
RMS error (m)	6.06
Scaled RMS (%)	6.60
Mean Sum of Residuals (m)	0.61
Correlation coefficient	0.992

6.1.6 Calibrated Hydraulic Parameters

Table 6-4 summarises the calibrated hydraulic conductivity values and calibrated storage parameters for each model layer. A summary of horizontal hydraulic conductivity data ranges, gathered from a combination of core tests, drill-stem tests and pumping tests is provided in Figure 6-4 for comparison with the model calibrated values. This comparison indicates that the majority of calibrated horizontal hydraulic conductivities from the model are comparable to field tested values.

Table 6-4 Summary Calibrated Hydraulic Parameters

Model Layer	Hydrogeological Unit	Calibrated Kh (m/day)	Calibrated Kv (m/day)	Calibrated Specific Yield	Calibrated Specific Storage
1	Alluvium	0.10 – 30.0	0.01 – 3.0	1.00×10^{-2}	3.24×10^{-6}
2	Tertiary Sediments	5.0	0.5	1.00×10^{-2}	3.26×10^{-5}
3	Tertiary Basalt	0.189	0.019	4.00×10^{-3}	3.27×10^{-6}
4	Boxvale Sandstone	8.4×10^{-3}	8.4×10^{-4}	1.92×10^{-3}	4.89×10^{-6}
5	Evergreen Formation	2.1×10^{-4}	2.1×10^{-5}	1.00×10^{-3}	2.88×10^{-3}
6	Precipice Sandstone	10.0	1.0	5.83×10^{-3}	2.22×10^{-6}
7	Moolayember Formation	1.0×10^{-2}	1.0×10^{-3}	1.00×10^{-3}	4.88×10^{-6}
8	Clematis Group	1.0×10^{-3}	1.0×10^{-4}	1.00×10^{-3}	5.68×10^{-6}
9	Rewan Group	1.65×10^{-4}	1.65×10^{-5}	2.24×10^{-3}	1.00×10^{-7}
10	Baralaba Coal Measures	1.0×10^{-8} – 2.35×10^{-2}	1.0×10^{-9} – 2.35×10^{-3}	2.92×10^{-3}	9.00×10^{-8}
11	Undivided Basement Units	1.06×10^{-5}	1.06×10^{-6}	1.71×10^{-3}	9.00×10^{-8}

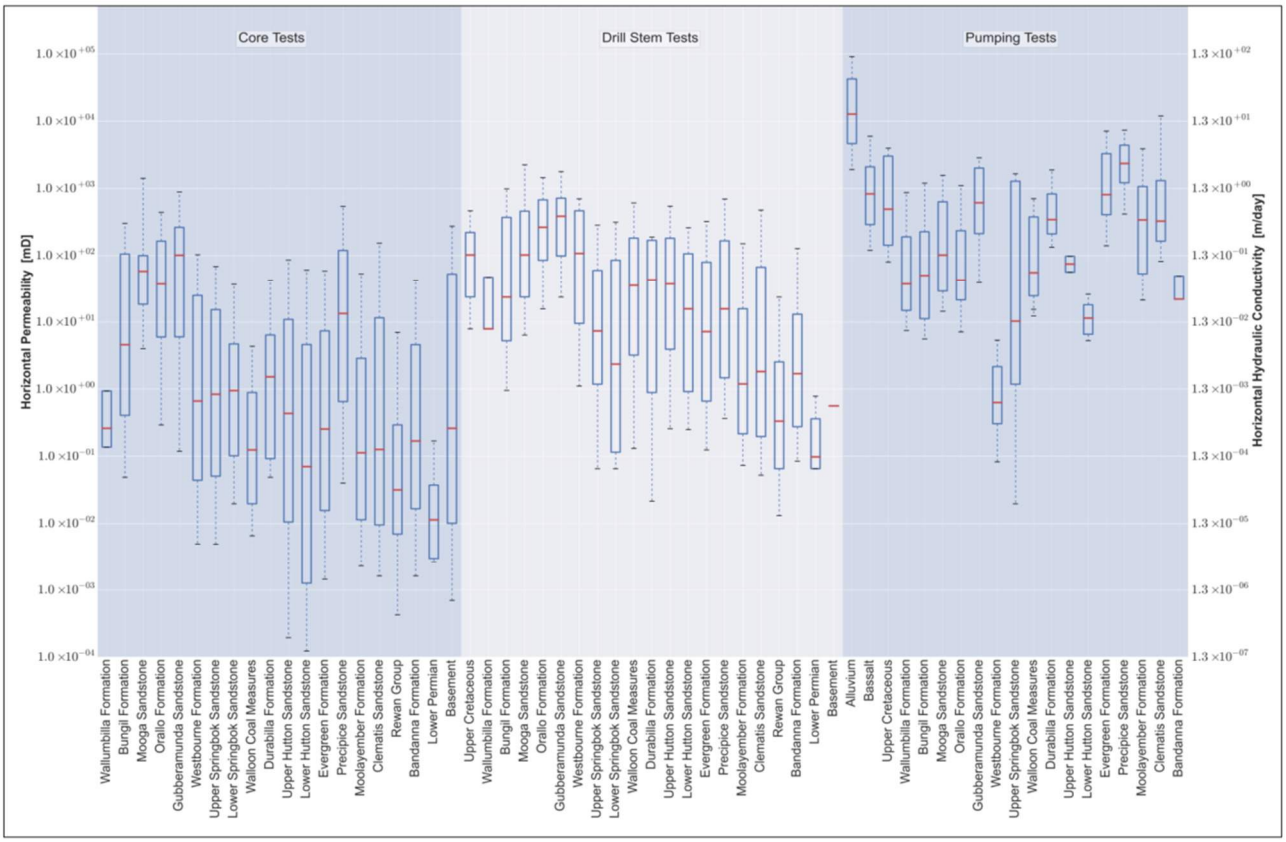

Figure 6-4 Horizontal Hydraulic Conductivities Data Ranges by Formation (Source: Hydrogeological conceptualisation report for the Surat Cumulative Management Area (OGIA 2016a))

6.2 Predictive Simulation

Two predictive model scenarios were simulated to allow assessment of potential impacts to surrounding water resource as a result of the Project development. These scenarios comprised:

- Scenario A – Cumulative Scenario; which comprises existing CSG wells, coal mining activities associated with the adjacent Dawson Mine and the CSG wells associated with the proposed Project Development.
- Scenario B – Current Conditions Scenario; which comprises the development activities identified in Scenario A, with the proposed Project development removed.

Groundwater level drawdown associated with the Project development is estimated based on the difference between the drawdown results from Scenario A and Scenario B, which provides a Project-only scenario. Scenario A provides the cumulative drawdown within the vicinity of the Project Area.

The predictive simulation was completed for the entire duration of the proposed Project development, with the predicted drawdowns abstracted from the model after three (3) years of development and at the completion of development to represent the drawdown for the IAA at the end of the UWIR period and the LTAA, respectively.

6.2.1 Scenario Results

Numerical modelling outputs for the scenarios detailed in the previous section have been used to assess the extent and magnitude of drawdown related to CSG production from the Project.

Drawdown as a result of the proposed Project development was observed in Layer 9 (Rewan Group), Layer 10 (Baralaba Coal Measures) and Layer 11 (Undivided Basement). There is no predicted drawdown in the surficial Cenozoic units (i.e. Quaternary alluvium, Tertiary sediments) above the Rewan Group. Predicted drawdown in Model Layers 9 to 11 (Rewan Group to Undivided Basement) for Project year 3 (IAA) are presented in Figure 6-5, Figure 6-6, and Figure 6-7 respectively. The maximum predicted drawdown from the entire model simulation period (LTAA) for Model Layers 9 to 11 (Rewan Group to Undivided Basement) are presented in Figure 6-8, Figure 6-9, and Figure 6-10 respectively. Drawdown associated with the proposed Project development was not predicted in Layers 1 to 8, therefore, drawdown figures for those layers have not been presented in this report.

Key observations from the predicted drawdowns include:

- Predicted drawdown / depressurisation is limited to the Rewan Group, Baralaba Coal Measures, and Undivided Basement.
- There is no drawdown predicted for the hydrostratigraphic units above the Rewan Group.
- Predicted drawdown greater than 5 m (consolidated hydrostratigraphic unit bore trigger threshold) is predicted in the Rewan Group, Baralaba Coal Measures, and Undivided Basement for both IAA and LTAA drawdown predictions.
- The highest drawdown is predicted in the Baralaba Coal Measures: the target seam for CSG production.

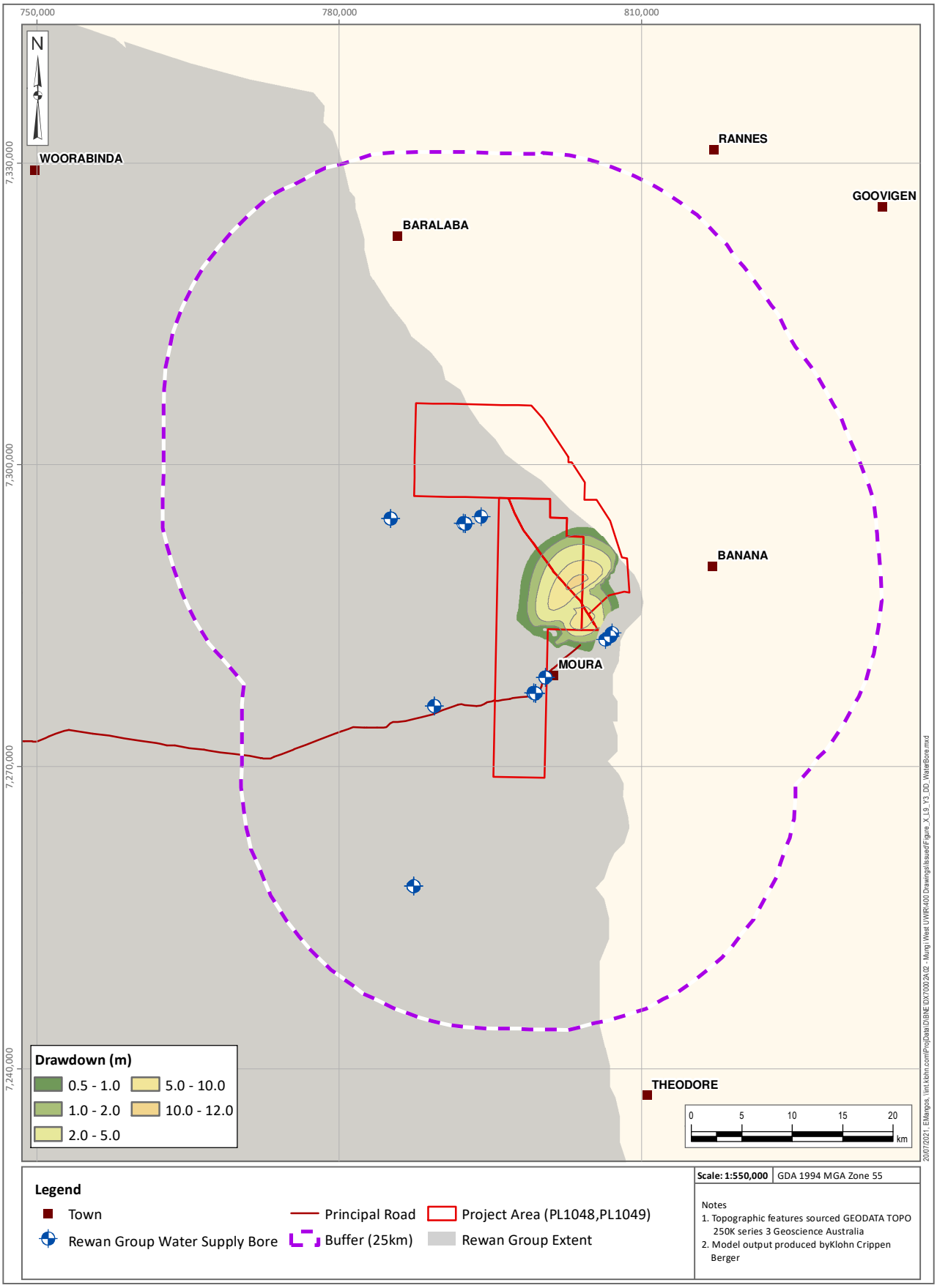

Figure 6-5 Project Year 3 Predicted Drawdown Model Layer 9 – Rewan Group

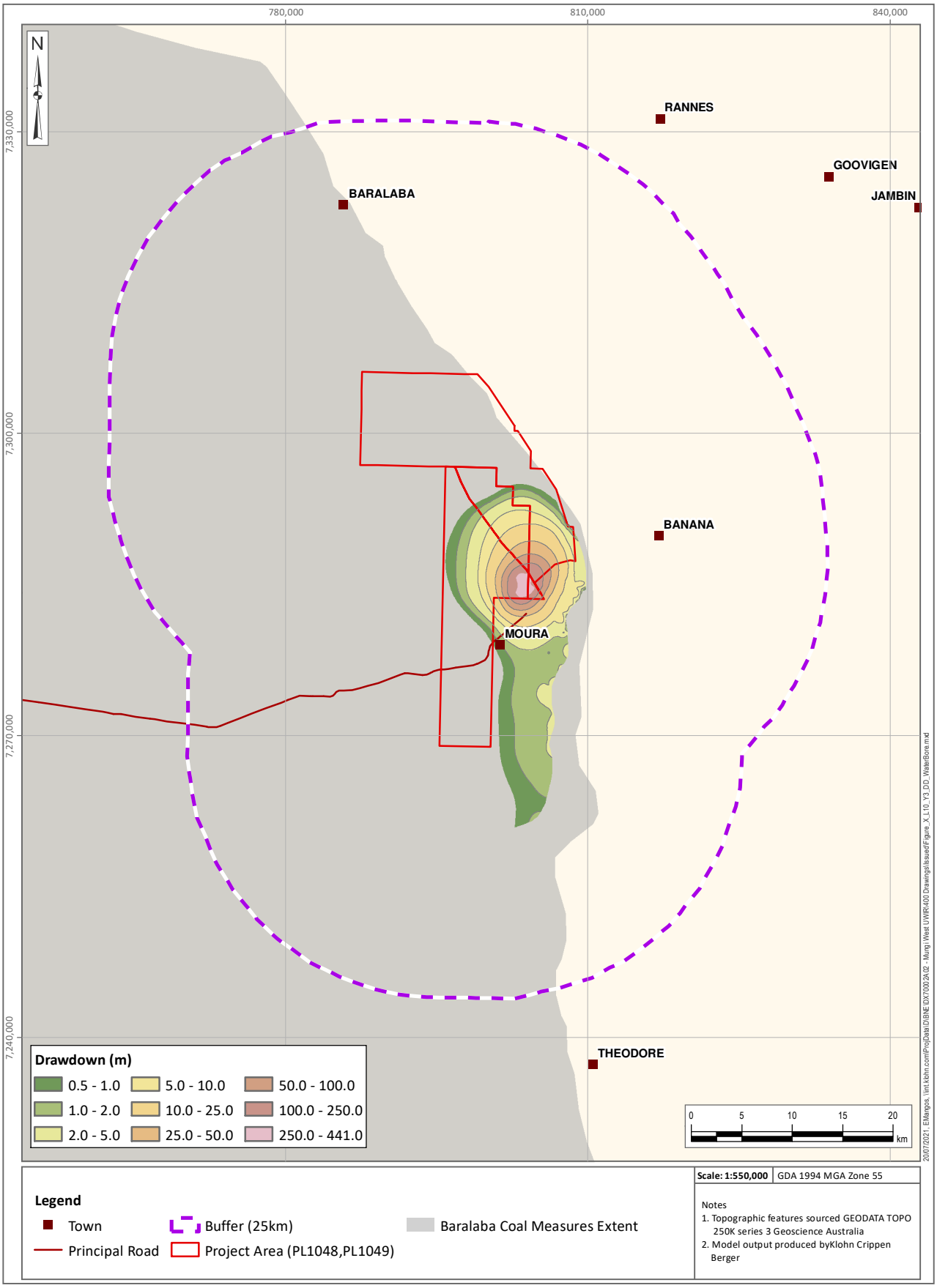

Figure 6-6 Project Year 3 Predicted Drawdown Model Layer 10 – Baralaba Coal Measures

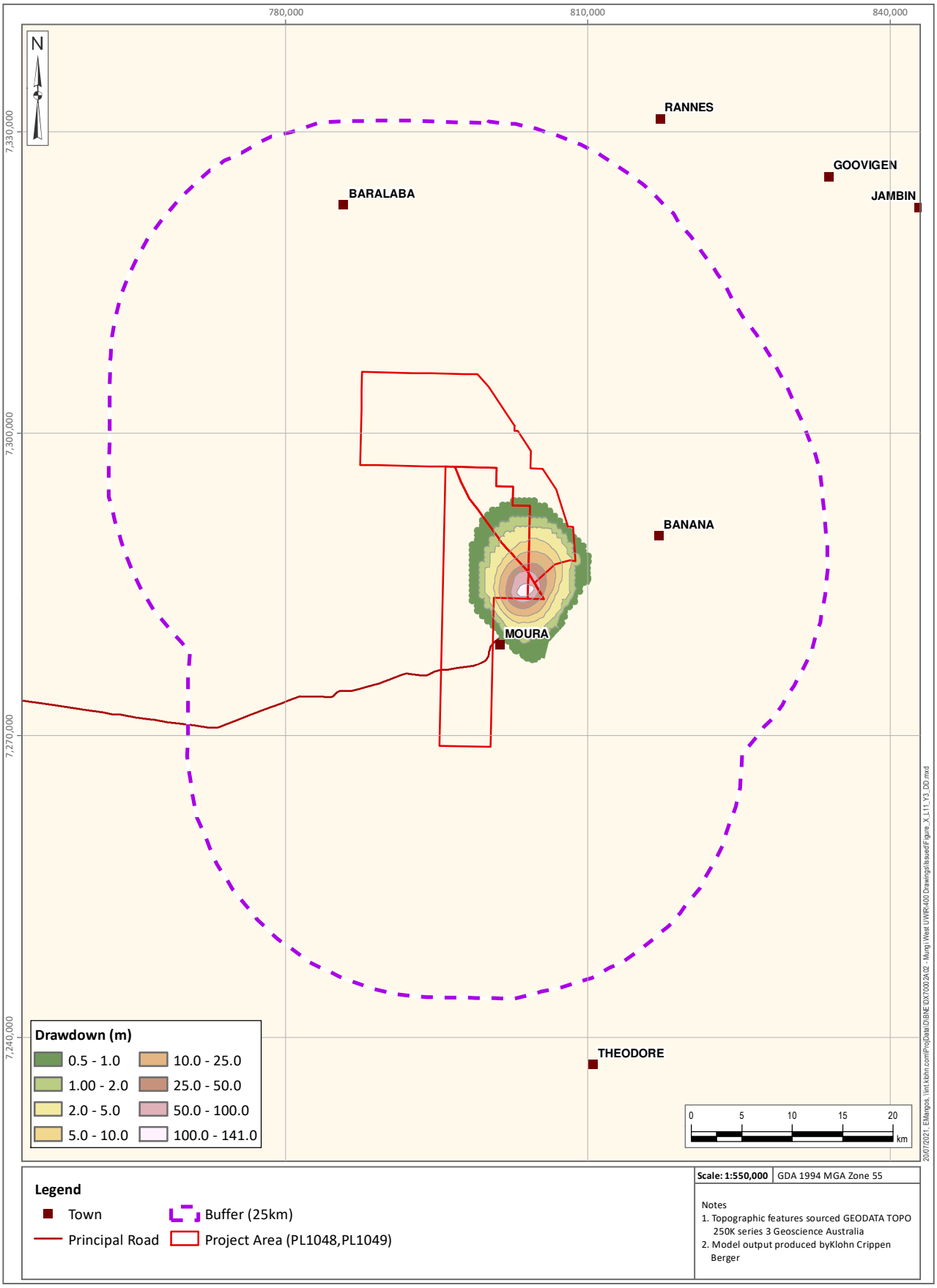

Figure 6-7 Project Year 3 Predicted Drawdown Model Layer 11 – Undivided Basement

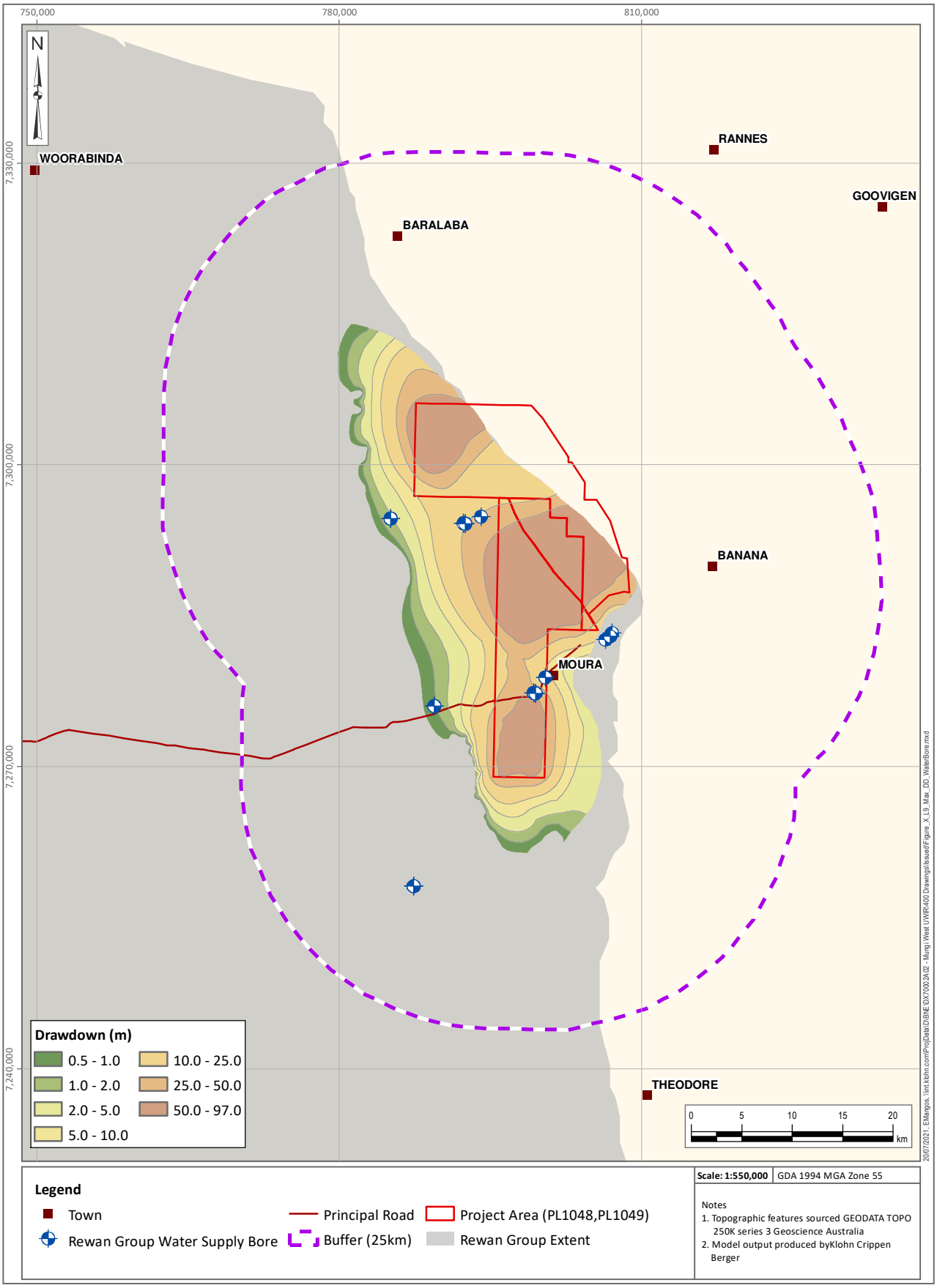

Figure 6-8 Maximum Predicted Drawdown Model Layer 9 – Rewan Group

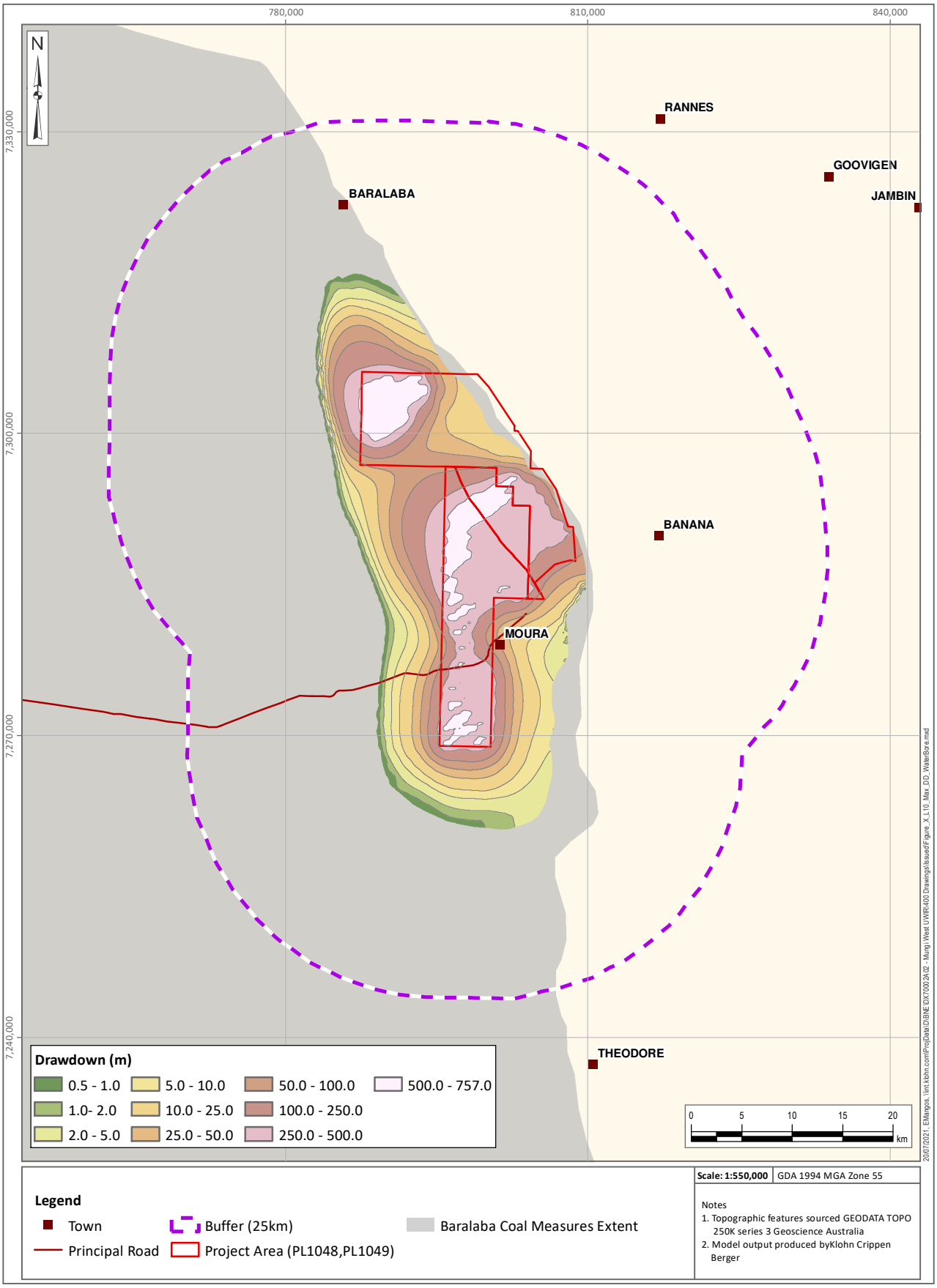

Figure 6-9 Maximum Predicted Drawdown Model Layer 10 – Baralaba Coal Measures

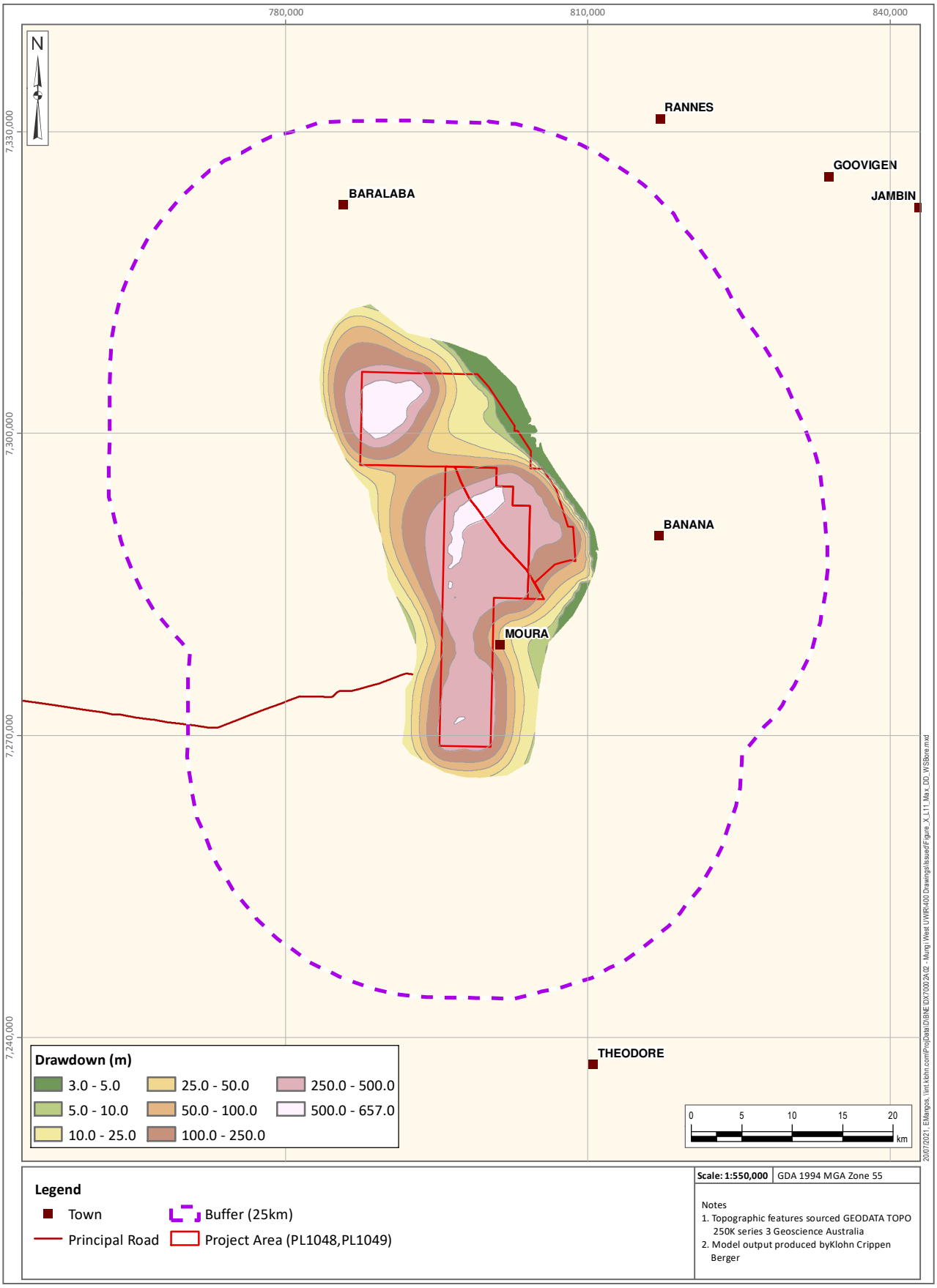

Figure 6-10 Maximum Predicted Drawdown Model Layer 11 – Undivided Basement

7 GROUNDWATER IMPACT ASSESSMENT

7.1 Coal Seam Gas Development Activities

The proposed CSG development for the Project will commence in the eastern extent of PL 1049, approximately 5 km north-northeast of Moura, adjacent to the boundary with PL 1048. In general, the CSG wells will be commissioned from east to west, from the shallowest point of the target coal seam to the deepest. During the first three years of Project development (the UWIR period) a total of 3 pads with 4 wellheads at each pad with 3 lateral wells per wellhead is anticipated to be commissioned.

Associated water produced as part of the CSG development will be managed by Westside using established off-site facilities that have been commissioned as part of adjacent operations (e.g. PL 94). Water management infrastructure to be established on the Project site (e.g. holding tanks, gathering lines) will be for the purposes of transferring the water to established management facilities.

7.2 Groundwater Production

Produced water volumes and rates are for the Project are predicted using a stochastic reservoir modelling tool which produces probabilistic distributions applied to several key reservoir parameters (i.e., permeability, porosity, and net coal). The model predictions generate production profiles (type curves) for wells across the CSG field. The production profiles are used in field development planning to provide a water forecast. Type curves are updated during the life of the project as more information (e.g. further and refined key reservoir parameters) becomes available.

Figure 7-1 displays the predicted water production rate for the Project. Peak water production is predicted to occur in 2042, at a rate of ~1.65 ML/month. The estimated cumulative water production volume is also presented in Figure 7-1. The total volume of groundwater that will be abstracted for the duration of the Project is estimated to be ~510 ML.

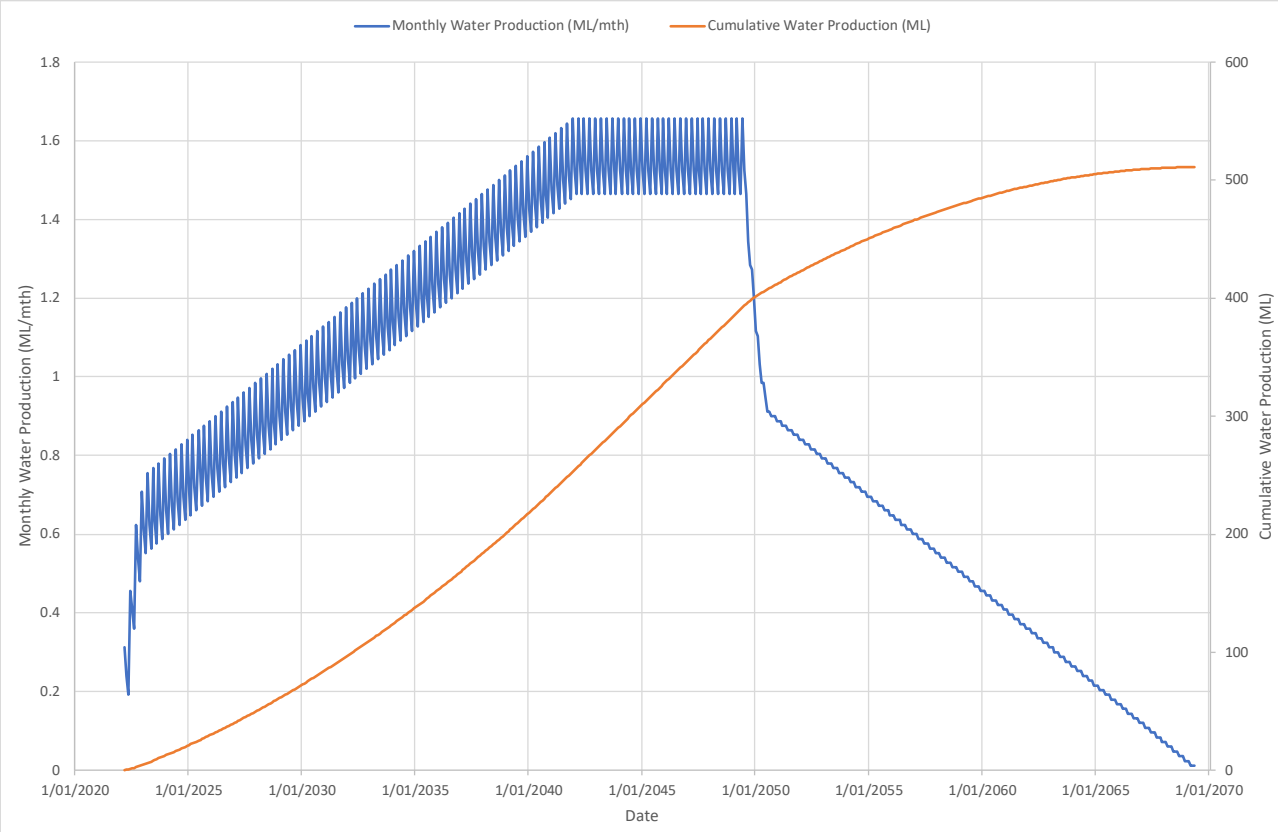

Figure 7-1 Predicted Water Production Rate and Cumulative Volume for the Project

Table 7-1 provides the annual groundwater take for Years 1, 2, and 3 of the UWIR period. The gradual increase from 5.48 ML in Year 1 to 8.57 ML in year 3 is a result of the cumulative nature of additional wells coming throughout the period, resulting in increased groundwater take annually over the UWIR period. The predicted groundwater take represents the theoretical volume of groundwater that could be removed from the groundwater regime.

Table 7-1 Predicted volume of groundwater take during the UWIR period

Year of UWIR Period	Predicted Water Production Volume (ML)
1	5.48
2	7.99
3	8.57
Total for UWIR Period	**22.04**

7.3 Groundwater Depressurisation during the UWIR Period

As identified in Section 6.2.1, predicted drawdown for the UWIR period as a result of the Project development is restricted to the Rewan Group, Baralaba Coal Measures, and Undivided Basement. Drawdown is not predicted in the surficial Cenozoic units (e.g. Quaternary alluvium, Tertiary sediments) overlying the Rewan Group.

Figure 6-5 shows that a maximum of ~12 m of drawdown is predicted in the Rewan Group. The lateral extent of drawdown in the Rewan Group exceeding 5 m (drawdown trigger threshold for bores screened in a consolidated aquifer), the IAA, is predicted to reach an extent of ~3 km from the CSG development area.

The greatest drawdown is predicted in the Baralaba Coal Measures, as a result of the proposed CSG development, where a maximum of ~441 m is predicted during the UWIR period (Figure 6-6). Peak drawdown is anticipated for the Baralaba Coal Measures as this is the target seam for gas production. The lateral extent of drawdown in the Baralaba Coal Measures exceeding 5 m is predicted to extend approximately 5 km from the CSG development area towards the south and approximately 7 km towards the north.

7.4 Groundwater Depressurisation Over the Project Life

Figure 6-8 shows maximum predicted depressurisation in the Rewan Group over the entire Project life (LTAA). Drawdown within the Rewan Group is predicted to be greatest in the central region of the Project site where the highest density of CSG wells are proposed to be located. Zones of high depressurisation are also observed in the western area of PL 1048 and southern area of PL 1049, also coinciding with increased density of CSG wells. The maximum drawdown in the Rewan Group is predicted to be ~97 m (Figure 6-8). The zone of depressurisation is predicted to extend more than 10 km west of the Project site, and less than 5 km to the east and south.

Figure 6-9 shows maximum predicted depressurisation within the Baralaba Coal Measures over the entire Project life (LTAA). Depressurisation within the Baralaba Coal Measures is predicted to be greatest in the central, northwestern and southern regions of the Project site. The Baralaba Coal Measures layer is predicted to experience a maximum depressurisation of ~757 m as a result of the CSG development. The zone of depressurisation is predicted to extend more than 10 km north and west of the Project site, and approximately 6 km to the east and south.

Propagation of depressurisation through the Rewan Group aquitard to the overlying Tertiary sediments and/or Quaternary alluvium, as a result of the proposed Project development, is not predicted to occur. Stratigraphically, the Rewan Group is the highest stratigraphic unit that is predicted to observe depressurisation impacts from the development.

7.5 Environmental Impacts

Groundwater level drawdown/depressurisation predictions from the numerical modelling results presented in Section 6.2.1 identify that drawdown/depressurisation is restricted to the Rewan Group, the Baralaba Coal Measures, and the Undivided Basement. There is no predicted drawdown impact to the shallow groundwater in the overlying Quaternary alluvium or Tertiary sediments, therefore, there will be no predicted impacts to environmental values associated with the shallow groundwater system. An assessment of the environmental impact related to the planned CSG activities is therefore not required.

7.5.1 Impacts on Groundwater Resources

Groundwater abstraction occurs as part of the CSG production process. Groundwater is removed via production wells to depressurise the coal seams, which liberates gas flow. This depressurisation, and associated gas flow, results in groundwater abstraction that is required to maintain the target operational pressure for gas production.

Water Production is authorised under the *Petroleum and Gas (Production and Safety) Act 2004* (Section 2.1). Potential impacts as result of water production may include:

- Decline in groundwater level / pressure at water bores, reducing water availability and potentially impacting groundwater EVs;
- Reduction in groundwater head resulting in reduction of groundwater discharge at spring complexes, potentially causing degradation of GDEs; and
- Reduction of baseflow to watercourses, potentially resulting in reduced availability of water to GDEs and reduced water availability to potential users downstream.

Those potential impacts, where receptors exist within the vicinity of the Project, are assessed against the *Water Act 2000* trigger thresholds as outlined in Section 2.2.

Monitoring, management, and mitigation practices associated with the above activities are discussed further in Section 8.

7.5.2 Impacts on Groundwater Users

Potential short term and long-term impacts to groundwater bores have been assessed against the *Water Act 2000* bore trigger threshold of 2 m for an unconsolidated aquifer (e.g. alluvium), and 5 m for a consolidated aquifer (e.g. Rewan Group; Baralaba Coal Measures; Undivided Basement), using the drawdown predictions from the numerical model (Section 6.2.1). The Year 3 (IAA) predicted drawdown is presented for this assessment alongside the maximum (LTAA) predicted drawdown for the Project, irrespective of timing.

Many groundwater bores within the Project vicinity are constructed to intersect multiple formations. For the impact assessment, bores screened across multiple formations have been assigned to (i.e. bore attribution) either the formation closest to the Baralaba Coal Measures, or to the Baralaba Coal Measures itself (if the bore is screened through the Baralaba Coal Measures). Based on a review of the water supply bores within a 25 km radius of the Project area, the only bores of relevance to the Project (i.e. screened in hydrostratigraphic units that are predict to drawdown/depressurise as a result of the Project development) are screened in/attributed to the Rewan Group.

Predicted drawdowns to third party water supply groundwater bores within a 25 km radius of the Project area in the Rewan Group and the Baralaba Coal Measures are presented in Table 7-2.

Table 7-2 Summary of Drawdown Predictions for Groundwater Bores in the Rewan Group

RN	Bore Use	IAA Drawdown (m)	LTAA Drawdown (m)
128034	Water Supply	0.00	26.95
128139	Water Supply	0.00	12.83
128251	Water Supply	0.00	25.57
128252	Water Supply	0.00	24.44
128253	Water Supply	0.00	0.00
128254	Water Supply	0.00	0.00
128605	Water Supply	0.00	0.00
128715	Water Supply	0.00	40.84
128716	Water Supply	0.00	39.82
161653	Water Supply	0.00	0.90
170144	Water Supply	0.00	1.78

Bores installed within unconsolidated aquifers (i.e. applicable to the groundwater bore trigger threshold of 2 m) are not predicted to have an induced drawdown in groundwater levels as a result of Project development.

No water supply bores are predicted to experience a drawdown that exceeds the trigger thresholds (>5 m) during the UWIR period (IAA). Six water supply bores have predicted drawdowns that exceed the trigger threshold over the Project life (LTAA). The location of these bores is presented in Figure 6-8. As per the requirements of the *Water Act 2000*: bore assessments will be undertaken at those bores and make good agreements will be implemented with each bore owner where required, prior to the trigger threshold being exceeded. This is further discussed in Section 8.1.2.

7.5.3 Impacts on Surface Drainage

The Project does not include any planned discharge to, or abstraction from (including abstraction due to groundwater drawdown impacts), the surface water system. Numerical modelling did not predict drawdown within the surficial Quaternary alluvium or Tertiary sediments aquifer which are potentially hydraulically connected to surface water systems in the Project area. Other potential impacts associated with Project construction and operation will be managed through implementation of the appropriate management, mitigation, and monitoring practices associated with construction and operation. There will be no discernible impacts to the surface water system, or surface water users as a result of Project development.

Drawdown on the groundwater table will therefore not impact the overlying surface drainage features.

7.5.4 Impacts on Springs

The nearest spring complex to the Project area is approximately 40 km to the southwest of the Project (Figure 5-18). Predicted depressurisation/drawdown from the proposed Project will not propagate to the spring locations, therefore, no impacts to surrounding spring complexes are expected as a result of Project development.

7.5.5 Impacts on Groundwater Dependent Ecosystems

Section 5.9.2 identified the potential TGDEs that have been mapped in the vicinity of the Project area. Typically, the mapped areas of TGDEs are located adjacent to watercourses (e.g., Dawson River), which are reliant on groundwater within the shallow Quaternary alluvium or Tertiary sediments.

The predicted groundwater level drawdowns from the numerical modelling (Section 6.2.1) indicate that drawdown resulting from the proposed Project development will be limited to the Rewan Group, Baralaba Coal Measures, and Undivided Basement; and will not propagate to the shallow Cenozoic units (i.e. Quaternary alluvium, Tertiary sediments). Therefore, there will be no impacts to the mapped potential TGDEs as a result of the Project development.

8 GROUNDWATER MONITORING PROGRAM

The following sections describe the monitoring and management measures for groundwater levels and quality and groundwater take. Each section provides an overview of the existing monitoring requirements and proposed monitoring and management measures. These measures will be implemented.

8.1 Groundwater Level and Quality Monitoring and Management

8.1.1 Environmental Authority Requirements

The EA for PL 1048 and PL 1049 (EA0002230) has identified conditions, and associated procedures, for the monitoring and management of groundwater. These comprise:

- EA Condition A7 – *Monitoring and sampling must be carried out in accordance with the requirements of the following documents (as relevant to the sampling being undertaken), as amended from time to time: - (b) for groundwater, Groundwater Sampling and Analysis – A Field Guide (2009:27 GeoCat #68901).*
- EA Conditions G10 to G12 – conditions relate to the establishment of a seepage monitoring network and program to detect/monitor seepage of contaminants to groundwater from onsite contaminant storage facilities.
- EA Conditions I11 to I13

  Condition I11 – Prior to undertaking stimulation activity, a baseline bore assessment must be undertaken of the water quality of:

  (a) all landholder's active groundwater bores (subject to access being permitted by the landholder) that are spatially located within a two (2) kilometre horizontal radius from the location of the stimulation initiation point within the target gas producing formation; and

  (b) all landholder's active groundwater bores (subject to access being permitted by the landholder) in any aquifer that is within 200 m above or below the target gas producing formation and is spatially located within a two (2) kilometre radius from the location of the stimulation initiation point; and

  (c) any other bore that could potentially be adversely impacted by the stimulation activities in accordance with the finding of the risk assessment required by conditions (I9) and (I10).

Condition I12 – Prior to undertaking stimulation activities at a well, there must be sufficient water quality data to accurately represent the water quality in the well to be stimulated. The data must include as a minimum the results of analyses for the parameters in condition (I13)

Condition I13 – Baseline bore and well assessments must include relevant analytes and physico-chemical parameters to be monitored in order to establish baseline water quality and must include, but not necessarily be limited to:

(a) pH

(b) electrical conductivity (µS/m)

(c) turbidity (NTU)

(d) total dissolved solids (mg/L)

(e) temperature (^oC)

(f) dissolved oxygen (mg/L)

(g) dissolved gases (methane, chlorine, carbon dioxide, hydrogen sulfide) (mg/L)

(h) alkalinity (bicarbonate, carbonate, hydroxide and total $CaCO_3$) (mg/L)

(i) sodium adsorption ration (SAR)

(j) anions (bicarbonate, carbonate, hydroxide, chloride, sulphate) (mg/L)

(k) cations (aluminium, calcium, magnesium, potassium, sodium) (mg/L)

(l) dissolved and total metals and metalloids (including but not necessarily being limited to: aluminium, arsenic, barium, borate (boron), cadmium, total chromium, copper, iron, fluoride, lead, manganese, mercury, nickel, selenium, silver, strontium, tin and zinc) (µg/L)

(m) total petroleum hydrocarbons (µg/L)

(n) BTEX (as benzene, toluene, ethylbenzene, ortho-xylene, para- and meta-xylene, and total xylene) (µg/L)

(o) polycyclic aromatic hydrocarbons (including but not necessarily being limited to: naphthalene, phenanthrene, benzo(a)pyrene) (µg/L)

(p) sodium hypochloride (mg/L)

(q) sodium hydroxide (mg/L)

(r) formaldehyde (mg/L)

(s) ethanol (mg/L)

(t) gross alpha + gross beta or radionuclides by gamma spectroscopy (Bq/L)

The majority of the groundwater-related conditions identified in the EA (EA0002230) relate to monitoring associated with contaminate seepage to the groundwater or baseline monitoring prior to the undertaking of stimulation activities; however, on-site contaminate storage and well stimulation is not proposed to be undertaken as part of the Project development. Therefore, the established EA conditions are not specifically applicable for the proposed Project.

8.1.2 Proposed Monitoring and Management Measures

Predicted drawdown/depressurisation results from the numerical modelling of the proposed Project development (Section 6.2.1) has identified that no third-party water supply bore will be triggered (i.e. >2 m drawdown in an unconsolidated aquifer and >5 m drawdown in a consolidated aquifer) during the UWIR period (i.e. no bores within the IAA). However, over the duration of the Project development period (LTAA) six water supply bores screened in / attributed to the Rewan Group, in the vicinity of the Project, will have the bore trigger threshold exceeded.

The numerical groundwater modelling has also identified that impacts to the surface water system, surrounding springs and mapped TGDEs will not occur as a result of the proposed Project development. This is due to the laterally extensive and thick low permeability Rewan Group aquitard that limits the propagation of drawdown from the target Baralaba Coal Measures to the shallow Cenozoic aquifers (i.e. Quaternary alluvium and Tertiary sediments). As a result, groundwater monitoring of the Quaternary alluvium and Tertiary sediments is not considered warranted for the Project.

Due to the predicted exceedance of the consolidated aquifer bore trigger threshold (>5 m drawdown) in six Rewan Group water supply bores, during the Project development and beyond the current UWIR period (LTAA), the proposed groundwater monitoring and management measures will focus on the ongoing monitoring of third-party groundwater bores within the vicinity of the CSG wells as they are commissioned/developed. The groundwater monitoring program will be based on the following:

- Groundwater monitoring is to be conducted on water supply bores screened within the Rewan Group or Baralaba Coal Measures that are located within 2 km of a proposed CSG well, prior to the establishment and development of the well.
- Groundwater monitoring will focus on the recording of groundwater levels and the collection of groundwater samples for preliminary laboratory testing. This monitoring program is proposed to focus on the assessment/identification of potential impacts to third-party water supply bores as a result of CSG development, therefore, changes in water levels and changes in basic groundwater quality (e.g. salinity) are considered as triggers for the identification of potential impacts. Water quality parameters to be analysed as part of this monitoring program should comprise:
  - pH
  - Electrical Conductivity (EC)
  - Total Dissolved Solids (TDS)
  - Major ionic constituents – Ca, Mg, K, Na, Cl, CO_3, HCO_3, SO_4

  Monitoring is proposed to be conducted on an annual basis, with the first monitoring round to be completed prior to the establishment/operation of the adjacent CSG well (within 2 km of the CSG well).
- As per the requirements of the *Water Act 2000*: should monitoring indicate that the bore trigger threshold will be exceeded make good agreements will be implemented with each bore owner where required, prior to the trigger threshold being exceeded.

8.2 Groundwater Production Monitoring and Management

8.2.1 Regulatory Requirements

As per the requirements outlined in the *Petroleum and Gas (Production and Safety) Act 2004*, the volume of produced water will be monitored and recorded and provided to the relevant authority as required. Results will be included in annual reports.

8.2.2 Proposed Monitoring and Management Measures

In accordance with the requirements of the *Petroleum and Gas (Production and Safety) Act 2004*, Westside will continue to assess actual groundwater abstraction using the acceptable methods. The method used will be reviewed annually and revised, as necessary.

The actual groundwater take assessed under the *Petroleum and Gas (Production and Safety) Act 2004*, requirements will be compared to the predicted groundwater take presented in this UWIR. This comparison will be undertaken annually. If the monitoring program shows groundwater take exceeds the predictions presented in this UWIR, an investigation will be undertaken to confirm whether the actual impacts on groundwater users or sensitive environmental features are likely to be significantly greater than expected. The investigation outcomes will be considered as part of the annual UWIR review described in Section 9.2.

9 UWIR UPDATES AND REVIEW

9.1 Roles and Responsibilities

Westside is responsible for ensuring that the UWIR is implemented.

9.2 Review and Revision

As discussed in Section 7.5, depressurisation of the Rewan Group due to the Project development is predicted to exceed the bore trigger threshold as part of the LTAA.

Hence, Westside will undertake an annual review of the accuracy of the IAA and LTAA mapping, as required by Section 376(1)(e) of the Water Act.

The review process will comprise:

- An initial review of any new geology or groundwater data to identify potentially significant departures from the data used in the UWIR to develop the IAA and LTAA mapping.
- Where potentially significant departures are identified, the potential effect of these departures on the IAA and LTAA will be investigated.
- If the investigation concludes that the IAA or LTAA are likely to have been under-estimated and additional water bores are likely to be affected, the IAA and LTAA will be revised.

The UWIR has been designed to align with the current, relevant EA groundwater conditions. It is therefore necessary to review and update the UWIR in response to any material changes to the EA conditions.

9.3 Reporting and Record Keeping

The outcome of each annual review will be reported to the DES and the OGIA following completion of each annual review. The reported outcomes will include a statement of whether there has been a material change in the information or predictions used to prepare the maps.

10 CONCLUSIONS

The key conclusions of this UWIR are as follows:

- The impacts of the Project over the UWIR period and the life of the Project has been assessed based a conceptulisation of the hydrogeological system and proposed Project development; which served as the basis for the development of numerical groundwater model that was used to quantify the potential impacts to the groundwater regime.
- CSG development will result in localised depressurisation of the target Baralaba Coal Measures, overlying Rewan Group and underlying undivided Permian basement.
- The shallow surficial Cenozoic aquifers (i.e. Quaternary alluvium, Tertiary sediments) are not predicted to experience drawdown as a result of the Project due to the laterally extensive, homogeneous and thick low permeability Rewan Group aquitard that limits propagation of drawdown from the Baralaba Coal Measures to the surficial units.
- The Project will not impact surface waters, TGDEs or spring complexes during the Project duration because:
  - Drawdown induced by the Project development does not propagate through the Rewan Group aquitard to impact the surface water system;
  - Mapped TGDEs are interpreted to source groundwater from the shallow surficial Cenozoic aquifers, which are not interpreted to be impacted by the Project development; and,
  - The nearest spring complex is approximately 40 km away from the Project and will not be impacted by drawdown/depressurisation.
- Drawdown/depressurisation is predicted to occur in six water supply bores screened in / attributed to the Rewan Group during the Project development (LTAA), but not during the current UWIR period (IAA). A monitoring and management plan for these bores will be implemented prior to the establishment and development of CSG wells within the vicinity of these bores.

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