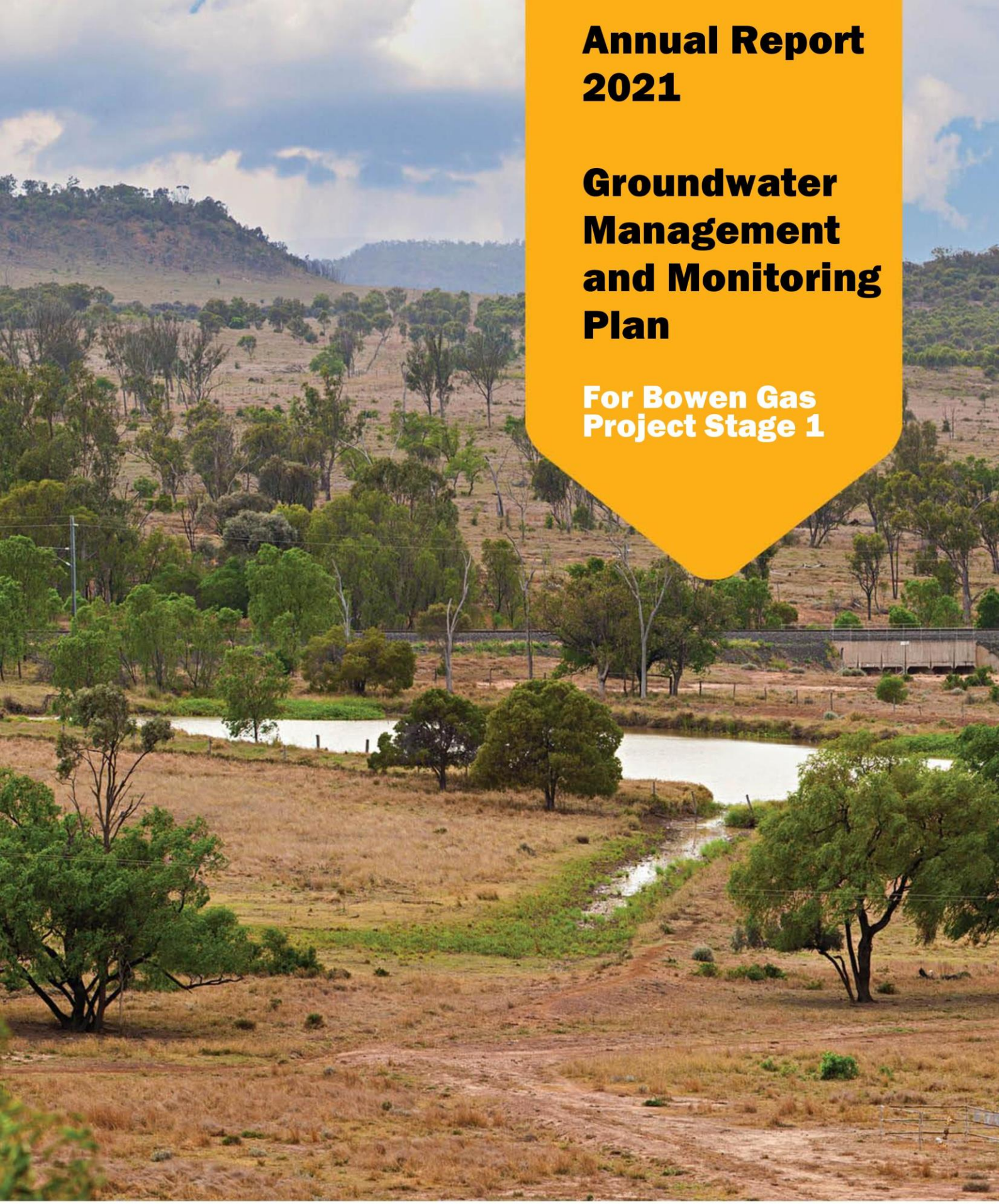
Annual Report 2021

Groundwater Management and Monitoring Plan

For Bowen Gas Project Stage 1



arrow energy
go further

May 2021

REVISION HISTORY

R□□□□□□□□	R□□□□□□□D□□□	R□□□□□□□□□□□ □ □r□
0	May 2021	Initial release.

TABLE OF CONTENTS

1 INTRODUCTION 1

2 WATER PRODUCTION REVIEW 3

3 WATER MONITORING STRATEGY (WMS) 6

3.1 MGP Area Groundwater Monitoring Network 6

3.2 BGP Area Groundwater Monitoring Network 8

4 GROUNDWATER ASSESSMENT UPDATE 12

4.1 Trigger Levels 12

4.2 Groundwater Level Monitoring 12

4.2.1 Shallow Monitoring Bores 12

4.2.1.1 MGP 12

4.2.1.2 BGP 13

4.2.2 Deep Monitoring Bores 16

4.2.2.1 MGP 16

4.2.2.1 BGP 17

4.2.3 Groundwater Flow 22

4.3 Groundwater Quality Monitoring 23

4.3.1 Shallow aquifer water quality 23

4.3.1.1 MGP 23

4.3.1.2 BGP 23

4.3.2 Deep aquifer background water quality 24

4.3.2.1 MGP 24

4.3.2.1 BGP 25

5 RESEARCH 27

6 CONCLUSION 28

APPENDICES

APPENDIX A: 2020 Annual Review of the 2019 Bowen UWIR 29
APPENDIX B: Water Level Results 75
APPENDIX C: Water Quality Results 76
APPENDIX D: Theis Recovery Analysis 78
APPENDIX E: Bowen Sector & Regional model results 80

TABLE OF FIGURES

Figure 1: Arrow Energy's Tenements in the Bowen Basin 5
Figure 2: Stage 1 development area 5
Figure 3: Groundwater Monitoring Network for MGP 7
Figure 4: Groundwater Monitoring Network for BGP 11
Figure 5: Shallow Bores Water Level Monitoring Results - MGP 14
Figure 6: BGP Shallow Bores Water Level Monitoring Results 15
Figure 7: Cumulative Rainfall Departure and Groundwater Levels 16
Figure 8: Shallow Groundwater levels vs mean Isaac River levels 16
Figure 9: MB1-D recovery data 18
Figure 10: MB2 recovery data 18
Figure 11: MB3 recovery data 19
Figure 12: Deep Bores Water Level Monitoring Results - MGP 20
Figure 13: Deep Bores Water Level Monitoring Results - BGP 21
Figure 14: Site 3 - Review of Vertical Gradients (MB1) 22

TABLE OF TABLES

Table 1: BGP well status 3
Table 2: BGP Monitoring network 10
Table 3: BGP Shallow Groundwater Monitoring Bores 13
Table 4: Recovery dates – MB1, MB2 & MB3 17
Table 5: Background Water Quality – Deep Monitoring Bores 24
Table 5: Background Water Quality – Deep Monitoring Bores 26

EXECUTIVE SUMMARY

This report forms the second annual review of the Groundwater Monitoring and Management Plan (GMMP) for the Bowen Gas Project (BGP) Stage 1. This report also includes baseline data from Arrow's existing Moranbah Gas Project (MGP) operations (PL 191, 196, 223, and 224).

The BGP GMMP was approved with conditions by the (then) Department of Environment and Energy (DoEE), now the Department of Agriculture, Water and Environment (DAWE) on 24 October 2019. This report is due annually, 3 months after the anniversary date of the commencement of the BGP. The BGP commenced on 14 February 2019[1]. On this basis, annual reports will be submitted to DAWE and uploaded to Arrow Energy's website by 14 May of each year.

This report satisfies the following requirements for the annual report as outlined in Section 6.2.4 of the GMMP. Significant updates during the report period include:

- Seven (7) wells have been installed, below the 1408 authorised operational wells. The seven wells were installed in the previous Annual Review period and are non-operational at the time of this report, with production of water from those wells expected to start in 2022.

- Three (3) locations have been installed in this reporting period as part of the BGP monitoring network to supplement the existing monitoring network established for Arrow's MGP. A total of nine (9) locations are now monitored.

- There is no apparent influence of CSG production to the Tertiary Sediment, Fort Cooper Coal Measures (FCCM) and Rewan aquifers in the installed monitoring network for the BGP. This is expected given no water production as part of the BGP has commenced.

- A review of the groundwater quality data indicates that there are no notable trends for both the shallow and deep aquifers.

- Red Hill Central Petroleum Lease (within PL486) was granted in 2019. Production had not commenced at the time of writing but is expected to commence in 2022.

- Ellensfield (within ATP1103) water production has been delayed indefinitely.
- No non-compliances were recorded and therefore no remedial actions were undertaken.

- All monitoring obligations have been met, with no exceedances under the GMMP early warning system (EWS) recorded across the monitoring network. There were, however, a number of data loss issues identified and addressed:
    - MB2: Data loss from October 2019 to January 2020 due to failed telemetry which was investigated and recommenced monitoring.
    - MB3: Data loss from October 2019 to January 2020 due to failed telemetry. Downhole pressure gauge failure was seen at the recommencement of telemetry reading. Due to this, the location of the well was moved to a nearby former production well and logging recommenced from September 2020.
    - GW001: The vibrating wire piezometer (VWP) array in GW001 failed in March 2020 and monitoring of GW004 commenced in replacement from November 2020.
- One report was completed - *Bowen Section & Regional model results memo*. This document provided a summary of a local sector model and a revised regional model developed to simulate additional production from the Red Hill field to the north of the Moranbah Gas Project (MGP).

- No out of cycle Underground Water Impact Report (UWIR) was submitted. The 2021 Annual Review of the Bowen UWIR concluded that given the updated water production forecast is less than what was modelled in the

[1] DAWE was notified by email of the commencement on 7 March 2019 (reference: 2012/6377).

2019 UWIR, the predicted impacts are expected to be less than originally modelled, and an update of the of the 2019 UWIR is not proposed.

1 INTRODUCTION

This report forms the second annual review of the Groundwater Monitoring and Management Plan (GMMP) for the Bowen Gas Project (BGP) Stage 1. The purpose of the GMMP is to addresses specific requirements for monitoring of groundwater and groundwater related impacts potentially resulting from the development of Stage 1 and contains details of:

- A groundwater monitoring network to provide for early detection of any changes in groundwater regime and impacts on groundwater dependent ecosystems;
- A baseline monitoring data acquisition program;
- An Early Warning System (EWS) including:
    - early warning indicators, trigger thresholds and limits for detecting impacts on groundwater levels, and;
    - exceedance response actions and timeframes.
- The timeframe for a regular review of the GMMP aligned with the state required Bowen UWIR; and
- Provisions to make monitoring results publicly available.

This report also includes data from Arrow's existing MGP operations (within Petroleum Leases (PLs) 191, 196, 223, and 224) which was previously described in the GMMP for baseline groundwater purposes and also supplements the GMMP monitoring network. Full analysis of the monitoring network, water production, groundwater levels and groundwater quality for the MGP is available in the 2020 Annual Review of the Bowen UWIR and attached as Appendix A.

The location of Arrow Energy's tenure in the Bowen Basin is displayed in Figure 1 , with the project area for Stage 1 displayed in Figure 2.

The GMMP was approved with conditions by the then Department of Environment and Energy (DoEE), now the Department of Agriculture, Water and Environment (DAWE) on 24 October 2019. This report is due annually, 3 months after the anniversary date of the commencement of the BGP, which was triggered on 14 February 2019. DAWE was notified of the commencement on 7 March 2019 (reference: 2012/6377). On this basis, annual reports will be submitted to DAWE and uploaded to Arrow Energy's website by 14 May of each year. Periodic revisions of the GMMP are required to be submitted to the DAWE every three years if it is deemed that there are material changes to forecast production or groundwater modelling impacts.

For the purposes of reporting and alignment with the annual review of Arrow Energy's Bowen UWIR, the data collected and analysed will be for the calendar year (i.e. 1 Jan 2020 to 31 Dec 2020) and include groundwater data for both Arrow's existing production area, the MGP and the BGP.

As per Section 6.2.4 of the GMMP, the annual report requires the following to be addressed:

- Report on any relevant ongoing studies and research projects and include any supporting technical studies as appendices to the annual report (Section 5);
- Document the number of coal seam gas wells, including (Section 2):
    - Total number of wells installed, the number of operational wells, the number of non-operational wells, and the number of decommissioned or failed wells; and
    - Confirmation that production is not from more than 1,408 operational wells.
- Provide an update on the implementation of the groundwater monitoring network and baseline monitoring, and summarise relevant monitoring results, including (Sections, 3 and 4):
    - Groundwater levels and trends (Section 4.2);

- Groundwater chemistry results and trends (Section 4.3);
- Analysis and interpretation of data and identification whether drawdown predictions made have changed materially (Section 4.2); and
- An assessment of factors contributing to observed groundwater level changes e.g. non-CSG versus CSG influences (Section 4.2).

- Provide any updates to the groundwater monitoring network if required (Section 3);
- Detail any confirmed non-compliances along with details of any remedial actions (Sections 3 and 4);
- Document compliance against the approval conditions over the preceding 12 months, including monitoring obligations and implementation of the EWS (Sections 3 and 4);
- Document corrective actions implemented to address any exceedances of trigger thresholds, limits, or non-compliance with approval conditions (Sections 3 and 4);
- Report against the performance measure criteria (Section 3); and
- Identify if an out of cycle UWIR was submitted (due to a material change or error in the information or predictions) and if practical consider a review of the GMMP outside of the 3-yearly review schedule. No out of cycle UWIR was submitted. The 2021 Annual Review of the Bowen UWIR concluded that there was no material change to water impacts as the water production forecast was less than what was modelled in the 2019 UWIR.

2 WATER PRODUCTION REVIEW

A review of actual water production and forecast water production for the MGP and BGP is presented in the 2021 Annual Review of the 2019 Bowen UWIR (Appendix A). This was submitted to DES on the 21 April 2021 (Rev0) and had not been approved at the time of writing this report. Based on the findings of the report, the predicted impacts are expected to be less than originally modelled and it was concluded that an update of the 2019 UWIR is not proposed.

Table 1 below displays the current status of production wells within the BGP. Production does not exceed the 1,408 authorised operational wells.

Table 1: BGP well status

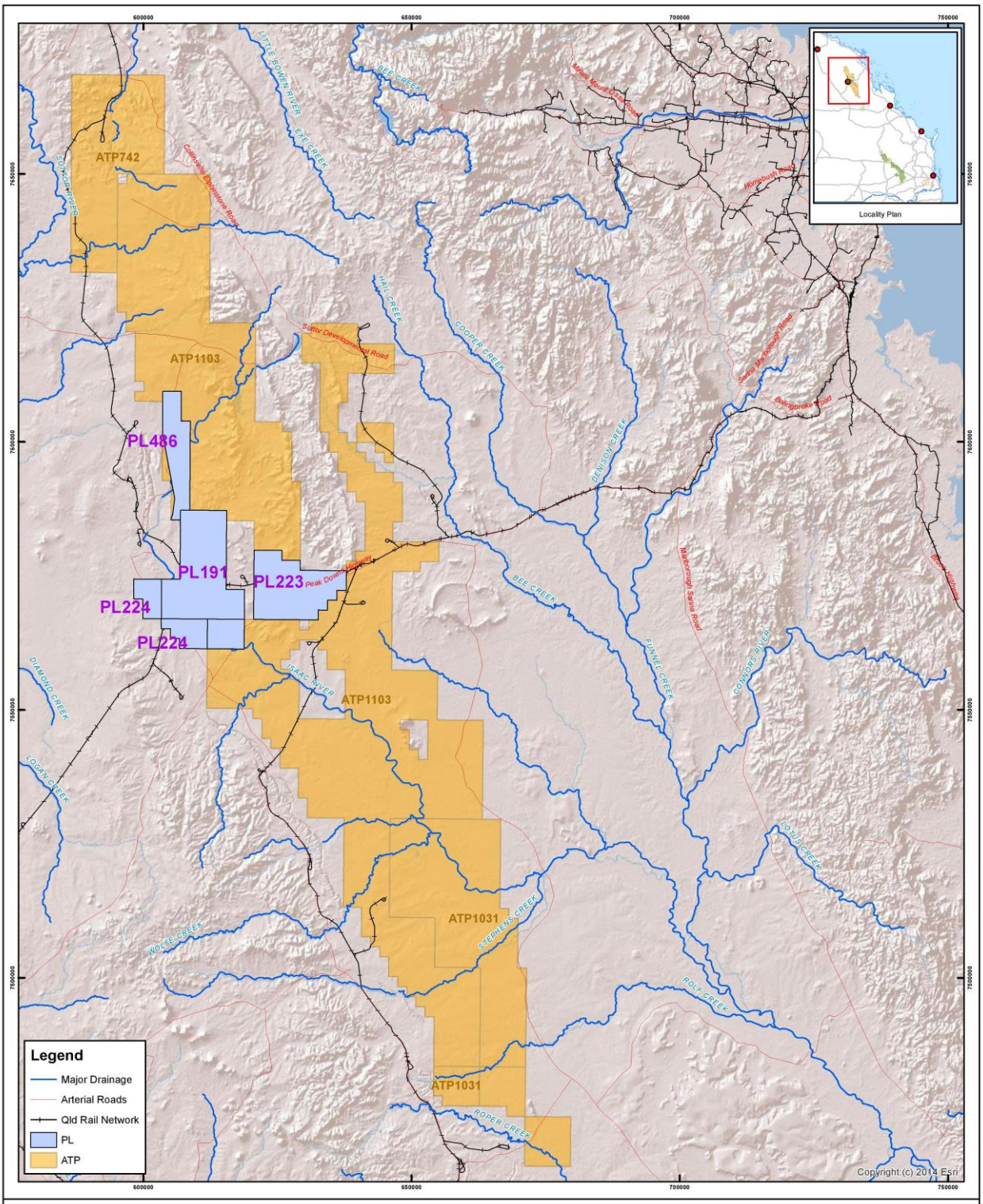
		Approximate number of anticipated production wells[1]	Wells installed	Operational wells	Non-operational wells	Decommissioned or failed wells
Project Stage 1 FDP	Red Hill Central	31	7	0	7	0
	Mavis Downs	17	0	0	0	0
	Remainder of the Project Stage 1 area	1,360	0	0	0	0
	GMMP Total	1,408	7	0	0	0

Note 1: Well locations and numbers for Red Hill, Mavis Downs, and the remainder of Project Stage 1 area are indicative only. Total well count, however, will not exceed 1,408 for Project Stage 1. The well counts are for vertical production wells only.

The following changes to the field development plan (FDP) have occurred since the 2020 Annual Review:

- Red Hill Central Petroleum Lease (within PL486) production is expected to commence in 2022;
- Mavis Downs (within ATP 1103) water production has been delayed indefinitely; and
- Ellensfield (within ATP1103) water production has been delayed indefinitely.

ARROW ENERGY - BOWEN BASIN GAS PROJECT



Arrow Energy's Tenements in the Bowen Basin

Source: Arrow Energy Pty Ltd
Geosciences Australia
Dept. Envir. and Resource Mgmt.

0 25 50
Kilometres

Scale: 1:650,000 @ A3
Coordinate System: GDA 1994 MGA Zone 55

N

arrow energy

NOT FOR CONSTRUCTION

Figure 1: Arrow Energy's Tenements in the Bowen Basin

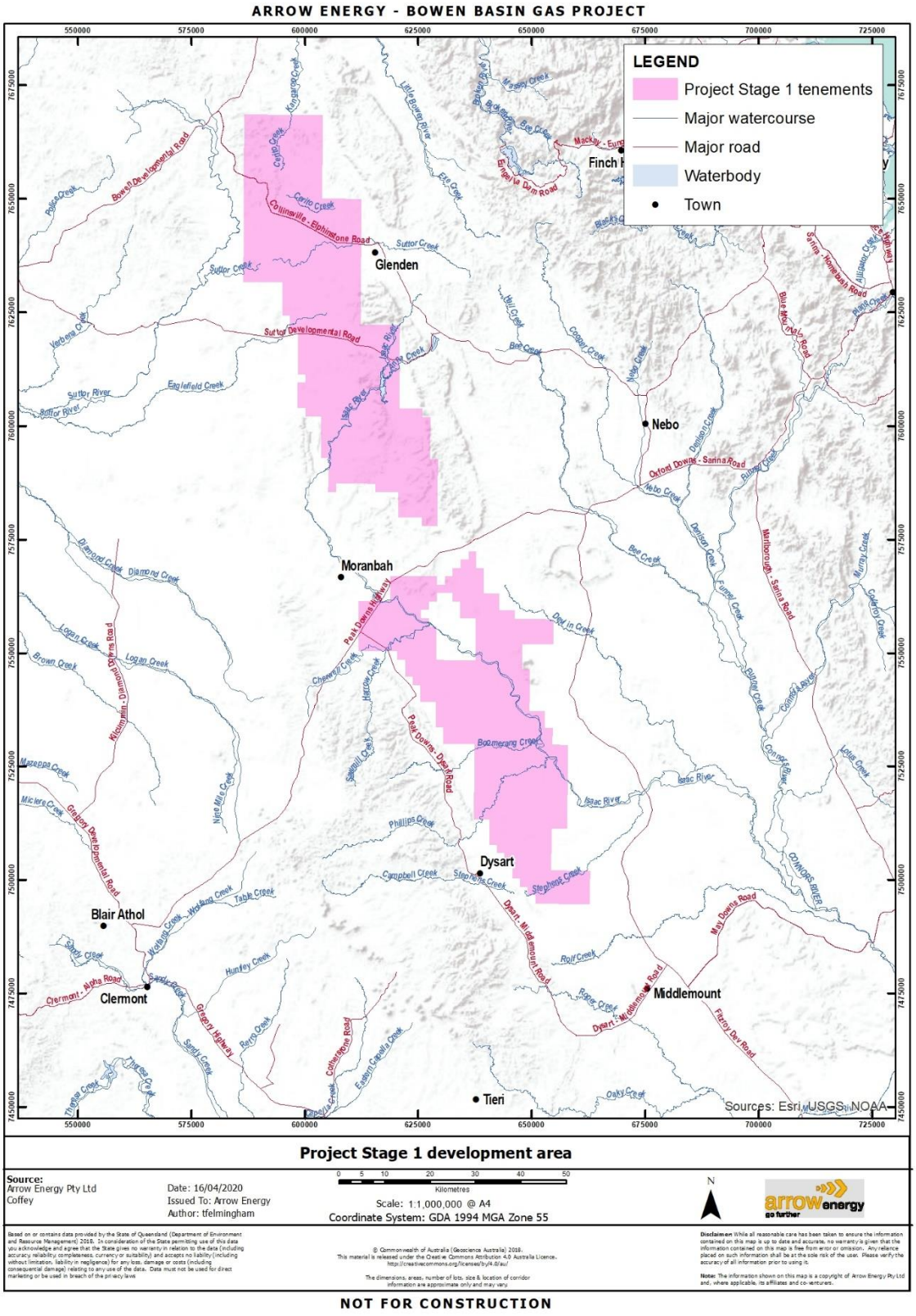


Figure 2: Stage 1 development area

3 WATER MONITORING STRATEGY (WMS)

3.1 MGP Area Groundwater Monitoring Network

A total of 17 groundwater monitoring bores form the groundwater monitoring network for the MGP Area. Figure 3 provides an overview of the spatial distribution of the groundwater monitoring network. Groundwater monitoring is being undertaken in these bores in accordance with the WMS in the approved 2019 Bowen UWIR and approval conditions. The data collected from this monitoring network is being used to supplement baseline data from the BGP groundwater monitoring network. Full discussion of the MGP groundwater monitoring network for the MGP is available in the 2021 Annual Review of the Bowen UWIR and attached as Appendix A.

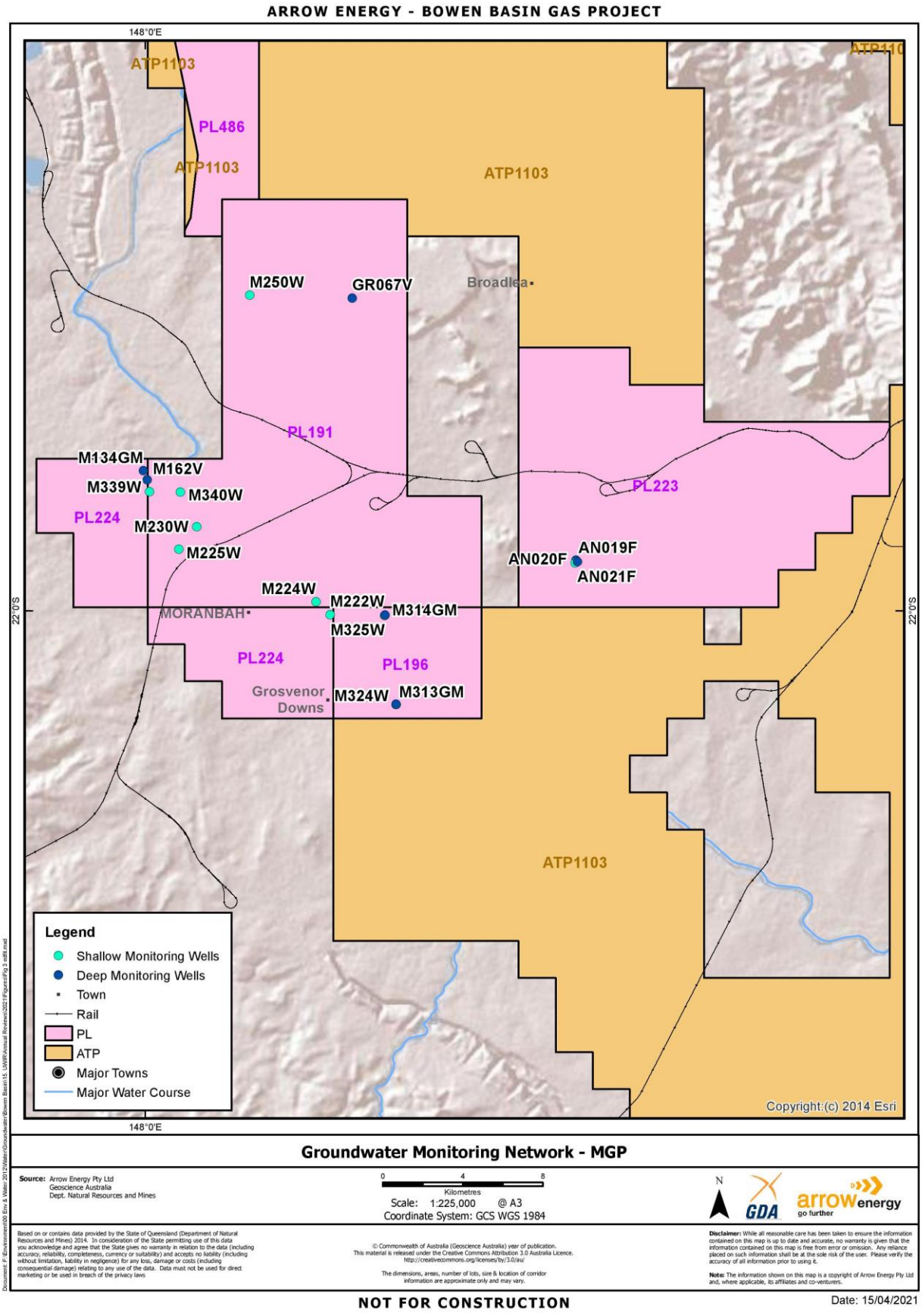


Figure 3: Groundwater Monitoring Network for MGP

3.2 BGP Area Groundwater Monitoring Network

The approved groundwater monitoring network for the BGP area is comprised of 35 monitoring intervals at 22 separate locations (comprising 12 single sites and 10 nested sites of 23 monitoring intervals) . Figure 4 provides an overview of the spatial distribution of the groundwater monitoring network. Table 2 below displays the monitoring requirements of the BGP, along with the status of each location. Note that Table 2 displays the monitoring location name as per the 2019 Bowen Groundwater Monitoring and Management Plan (GMMP) which was approved by DAWE to comply with Arrow Energy's approval for the BGP. All subsequent reporting is based off this nomenclature.

At present, nine locations have been installed as a part of the monitoring network; MB1-S/I/D, MB2, MB3, MB12, GW004, GW007 and AEN1063 as detailed below. The groundwater levels and water quality of these bores are presented in Section 4.2 and 4.3). No non-compliances have been recorded to date.

MB1-S/I/D

MB1 was installed as an appraisal (pilot) production well (originally named Red Hill-30) in January 2010. Groundwater level observations were made from the Moranbah Coal Measures (i.e. the deep interval) using the well from November 2011 to December 2011. Pumping from the well (for the pilot) was also undertaken during this time.

Pilot operation (and monitoring) ceased between December 2011 and November 2012.

The well was again monitored from 30 November 2012. The water level in Red Hill-30 had recovered to within 92% of its original baseline level prior to pumping for the pilot recommencing in December 2012.

From December 2012 the pilot was again operated (including production from Red Hill-30). Production from Red Hill-30 and the other pilot well in the pilot ceased in May and April 2013 respectively. Monitoring in Red Hill-30 continued until it was suspended in September 2013.

In October 2019, MB1 was modified by installation of a multi-level monitoring system to enable additional monitoring from the intermediate and shallow intervals to take place. Groundwater level data has been collected from all three intervals in MB1 since 11 November 2019. Drilling information for MB1 identified sufficient Quaternary / Tertiary Sediment or Rangal Coal Measures were not encountered at this location, and, the shallow and intermediate monitoring points are instead located within the Fort Cooper Coal Measures.

This monitoring location is within 10 kilometres of the Red Hill Central development area.

MB2

MB2 was installed as an appraisal (pilot) production well (originally named Red Hill-60) in January 2011. Groundwater level observations were made from the Moranbah Coal Measures using the well from September to October 2015 (1.5 months), October 2017 to May 2018 (8 months), February 2019 to October 2019 (7 months) and, following a period of data loss between October 2019 to January 2020, from January 2020 until present. This data loss affected MB2 and MB3 due to the installed telemetry system not sending data to Arrow's server. An investigation on why this occurred is ongoing at the time of this report, however an automatic alert system has been implemented that alerts Arrow personnel when telemetry data loss is found on monitoring locations and the telemetry system can be restarted to allow continuous logging.

Logged casing pressure between September 2019 and August 2020 displayed frozen values and is not likely real data. In this period, manually obtained pressure readings have been used.

Pumping (intermittently) from the well (for the pilot) was undertaken between 2012 and 2018. The well was converted to a monitoring well using the existing downhole pressure gauge in February 2019.

This monitoring location is within 10 kilometres of the Red Hill Central development area.

MB3

MB3 was installed as an appraisal (pilot) production well (originally named Red Hill-51) in November 2011. Groundwater observations were made from the Moranbah Coal Measures using the well from September 2013 to May 2014 (9 months), October 2017 to May 2018 (7 months), and February 2019 to October 2019 (7 months, with data loss affecting this site until January 2020, as for MB2). Following reinstatement of the telemetry system, it was identified that the downhole pressure gauge failed during the period of data loss. The well was converted to a monitoring well using the existing downhole pressure gauge in February 2019.

An adjacent appraisal (pilot) production well (originally named Red Hill-50) was converted to a monitoring well in September 2020 which will then fulfil monitoring requirements for MB3.

This monitoring location is within 10 kilometres of the Red Hill Central development area.

MB12

MB12 was installed as a mine monitoring bore (originally named EFGW5D) by Fitzroy Mining in June 2008. Groundwater level observations were made from the Rewan Formation through both manual water level measurements and hourly data logger measurements since January and July (respectively) 2018. A data logger was installed in the monitoring bore in July 2018.

This monitoring location is within 10 kilometres of the Red Hill Central development area.

Supplementary monitoring bores

These monitoring locations comprise existing third-party monitoring bores and landholder bores and are included in the monitoring network

GW001 and GW007

GW001, GW004 and GW007 were installed as mine monitoring bores by BHP Mitsubishi Alliance (BMA) in 2011. Arrow commenced monitoring of GW001 and GW007 in November 2019.

GW004 was chosen as a replacement of GW001 from November 2020 due to data and logger reliabilities associated with the vibrating wire piezometers installed in GW001 which failed in March 2020. A logger was deployed in GW004 during the November 2020 sampling round.

These monitoring locations are within 10 kilometres of the Red Hill Central development area.

AEN1063 (replacement for AEN1036)

A logger was deployed in a private water bore owned by a landholder, AEN1063, during the November 2020 sampling round after an access and monitoring agreement was completed with the landholder. The location of this bore is on the same property and same formation (Blackwater Group) as the monitoring point AEN1036, which was proposed in the GMMP. AEN1063 was chosen for monitoring after assessment of all bores on the property, with this bore being more suitable for long term monitoring than the original choice of AEN1036.

The following bore locations discussed below (AEN1214 and AEN1234), have been visited and assessed as suitable for long term monitoring and are awaiting execution of agreements with the landholders before logging equipment is installed. These bores are intended as part of the supplementary monitoring network and are currently visited for manual water level monitoring every six months.

AEN1214

AEN1214 is a private water bore owned by a landholder. Manual measurements every 6-months will be collected, which started from November 2020. Arrow is currently awaiting an access and monitoring agreement to be signed by the landholder for deployment of a logger.

AEN1234

AEN1234 is a private water bore owned by a landholder. Manual measurements every 6-months will be collected, which started from November 2020. Arrow is currently awaiting an access and monitoring agreement to be signed by the landholder for deployment of a logger.

Table 2: BGP Monitoring network

Monitoring location	Monitoring interval and target formation	Development area	Status/Indicative year of installation	Status
MB1	S – Quaternary / Tertiary I – RCM D – MCM	PL486	2019	Currently on monitoring Groundwater level monitoring was required twice daily until 11/11/2020, which has been achieved. Going forward, a minimum of 6-monthly water level measurements are required for remainder of CSG production. Water quality sampling was required from MB1-D at biannual frequency for the first year, which has been achieved. Going forward annual monitoring is required.
MB2	MCM		Current	Currently on monitoring. Groundwater level monitoring was required twice daily until 31/10/2020, which has been achieved. Going forward, a minimum of 6-monthly water level measurements are required for remainder of CSG production. Online date is 16 February 2019 however data was lost between 30 October 2019 and 9 January 2020.
MB3	MCM		Current	Currently on monitoring. Groundwater level monitoring was required twice daily until 31/10/2020, which has been achieved. Going forward, a minimum of 6-monthly water level measurements are required for remainder of CSG production. Online date is 16 February 2019 however data was lost between 30 October 2019 and 9 January 2020.
MB4	Unconfined alluvium		Contingent	Not currently required as criteria not yet triggered. Requirement for installation is based on (modelled) increased risk of depressurisation resulting from changes in the FDP, or MB1 groundwater level monitoring data indicate interconnectivity of MCM with overlying units.
MB5	Tertiary / Triassic	ATP1103	2020	Not currently required due to no development within 10km.
MB6	Quaternary / Tertiary	ATP742	Contingent	Not currently required as criteria not yet triggered. Requirement for installation is based on (modelled) increased risk of depressurisation resulting from changes in the FDP, or monitoring of other sites in the northern development area indicate the potential or likelihood of preferential groundwater flow occurring across formations by way of geological faults
MB7	S – Tertiary D – RCM	ATP742	2029	Not currently required due to no development within 10km.
MB8	Quaternary / Tertiary	ATP742	2030	Not currently required due to no development within 10km.
MB9	S – Quaternary / Tertiary I – RCM D – MCM / FCCM	ATP1103	2029	Not currently required due to no development within 10km.
MB10	Tertiary	ATP1103	2030	Requires installation immediately prior to commencement of pumping from Wards Well pilot wells.
MB11	S – Quaternary / Tertiary or Rewan Formation D – RCM	ATP1103	2029	Not currently required due to no development within 10km.
MB12	Quaternary / Tertiary	ATP1103	Current	Existing Fitzroy Mining monitoring bore (EFGW5D) being utilised to obtain groundwater level monitoring data in place of MB12. EFGW5D is located approximately 345m from the proposed location for MB12. Monitoring commenced in July 2018. Groundwater level monitoring will include 6-monthly water level measurements for remainder of CSG production.
MB13	S – Quaternary / Tertiary (if present) D – Blackwater Group (RCM / FCCM / MCM)	ATP1103 ATP1103	Contingent - 2028	MB13S not currently required due to no development within 10km. Requirement for installation of MB13D is based on monitoring of MB13-S and/or other monitoring points in the southern development area indicates the potential or likelihood of preferential groundwater flow occurring across formations by way of geological faults, or ongoing modelling or revised development indicates a greater risk of depressurisation impact at this location.
MB14	S – Quaternary / Tertiary I – RCM D – MCM / RCCM	ATP1103 ATP1103 ATP1103	2029	Not currently required due to no development within 10km.
MB15	S – Unconfined alluvium I – Tertiary / Triassic	ATP1103 ATP1103	2029	Not currently required due to no development within 10km.
MB16	Tertiary	ATP1103	2029	Not currently required due to no development within 10km.
MB17	S – Unconfined alluvium I – Rewan Formation	ATP 1103 (in proximity to Lake Elphinstone)	Contingent	Not currently required as criteria not yet triggered. Requirement for installation is based on if revised modelling indicates a risk of depressurisation impacts to Lake Elphinstone, or if impacts are detected at MB11-S.
Supplementary monitoring bores				
AEN1214	Rangal Coal Measures	ATP742	Current	Manual measurements recorded every 6-months. Awaiting access and monitoring agreement for deployment of logger.
AEN1063	Blackwater Group	ATP1031	Current	On monitoring as of November 2020. Suitable replacement for proposed AEN1036 as on same property and drilled to the same formation.
AEN1234	Quaternary alluvium	ATP1234	Current	Suitable replacement for proposed AEN1050. Manual measurements recorded every 6-months. Awaiting access and monitoring agreement for deployment of logger.
GW004	Alluvium Fort Cooper Coal Measures	ATP1103	Current	On monitoring as of November 2020. Replaces GW001 due to logger failure.
GW007	Alluvium Fort Cooper Coal Measures	PL486	Current	On monitoring as of November 2020.

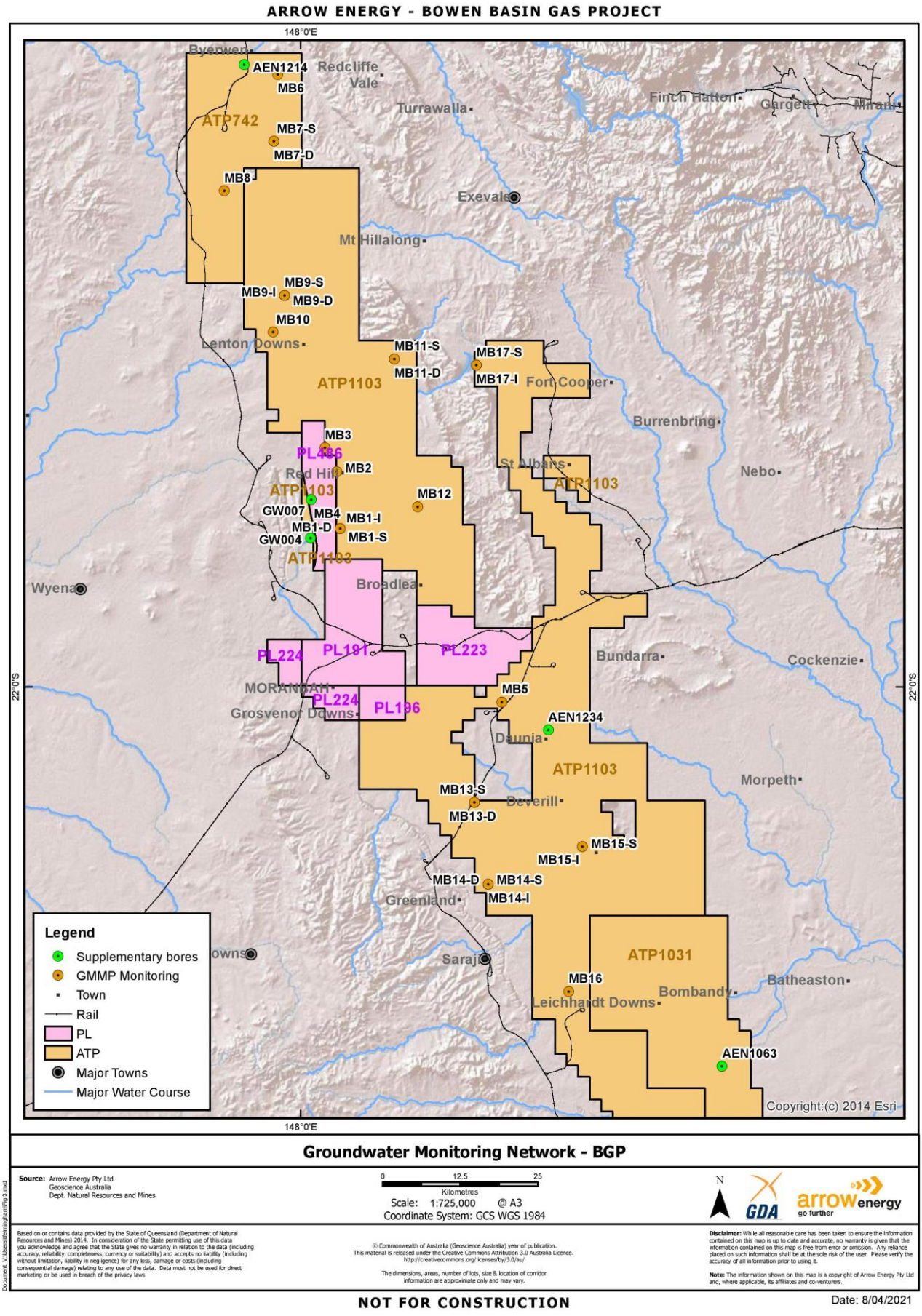


Figure 4: Groundwater Monitoring Network for BGP

4 GROUNDWATER ASSESSMENT UPDATE

4.1 Trigger Levels

Arrow's early warning system (EWS) is based on comparing modelled groundwater drawdowns derived from the GMMP groundwater model with early warning indicator levels (EWI), trigger threshold (TT), and drawdown limits, to inform escalating response actions.

The values of the EWI, TT and limits for the Quaternary age alluvium, Tertiary age sediments and basalts and Triassic age Clematis sandstone are presented below.

- EWI – Predicted drawdown by more than the applicable bore trigger threshold (BTT) (2 metres for unconsolidated aquifers and 5 metres for consolidated aquifers) for the Quaternary age alluvium, Tertiary age sediments and basalts and Triassic age Clematis sandstone;
- TT – Predicted drawdown by more than the BTT for the Quaternary age alluvium, Tertiary age sediments and basalts and Triassic age Clematis sandstone within three years;
- Limit – Predicted drawdown by more than double the applicable BTT for the Quaternary age alluvium, Tertiary age sediments and basalts and Triassic age Clematis sandstone within three years; and
- The EWS values are not assigned to the coal measures (Moranbah Coal Measures and Rangal Coal Measures) per the GMMP.

The 2019 Bowen UWIR indicated that drawdown is not predicted in the unconsolidated aquifers and the Clematis sandstone.

Analysis of the current water supply bores dataset (13 April 2021) from the Department of Resources, Mines and Energy (DNRME) indicated that predicted drawdowns for all landholder bores were below the EWS values for their targeted formation according to the 2019 Bowen UWIR.

There have been no exceedances of EWS values to date.

4.2 Groundwater Level Monitoring

In-depth analysis of the groundwater levels for the MGP is available in the 2021 Bowen UWIR Annual Review (Appendix A). Findings for the MGP groundwater levels are summarised in sections below.

4.2.1 Shallow Monitoring Bores

4.2.1.1 MGP

The groundwater levels in the MGP range from:

- 200.4 to 209.2 m Australian Height Datum (AHD) in the weathered Tertiary Basalt aquifer;
- 233.2 to 242.3 m AHD in the Tertiary Sediment aquifer;
- 209.0 to 211.7 m AHD in the Quaternary Alluvium aquifer;
- 202.4 to 206.3 m AHD in the Fort Cooper Coal Measures aquifer; and
- 237.2 to 238.6 m AHD in the Rewan Formation.

All bores located within close proximity to the Isaac River display similar depths to groundwater. This is shown in Figure 8.

The groundwater levels for bores M250W, AN021F, AN021F and AN020F are higher due to the respective surface elevation in the areas being approximately 50 to 60 m, 30 to 40 m and 85 to 95 m, respectively, above the other bores. M250W and AN021F are installed in the Tertiary Sediment and located approximately 10 km north and east of the other groundwater monitoring sites along the Isaac River, while MB12 is constructed within the Rewan Formation and located approximately 26km northeast of the other groundwater monitoring sites along the Isaac River.

A comparison of modelled drawdown predictions made in the 2019 Bowen UWIR with monitoring data to date has been undertaken. This was undertaken to review the 2019 Bowen UWIR model performance and it is not to check if the bore trigger threshold has been exceeded.

There is no predicted IAA or LAA for unconsolidated aquifers for the MGP and BGP; as modelled drawdown does not exceed the bore trigger threshold of 2 metres. The monitoring data to date supports this modelled prediction in the 2019 Bowen UWIR.

Groundwater level monitoring, as reported in the annual review for the Bowen Basin UWIR (Appendix A), indicates:

- Actual groundwater levels monitored in bore M339W have remained steady over the monitoring period;
- The water levels in M222W and M225W have continued to steadily rise since monitoring began in 2012;
- Figure 7 displays cumulative rainfall departure and groundwater levels at groundwater monitoring bores M225W, M230W, M222W and M224W. Recharge to shallow aquifers due to above mean rainfall has continued to contribute to the rising trend in groundwater levels noted in M222W and M225W with a peak at the end of 2017. The water level in M230W has declined since this peak, likely due to nearby mining operations as discussed below;
- There is no predicted IAA or LAA for any aquifer underlying PL 223; hence modelled drawdown greater than the bore trigger threshold at the end of 2019 was not predicted in the 2019 Bowen UWIR to occur at the location of bores AN020F and AN021F. AN021F is installed in the Tertiary Sediment and has increased in water level since monitoring began. AN020F is installed in the Rewan Formation which is considered to be a regional aquitard. Groundwater levels monitored at AN020F have remained steady over the monitoring period;
- A decline in groundwater level of 1.4m was noted at bore M224W between November 2017 and November 2020. As discussed in the 2019 Bowen UWIR, the water levels in this bore indicate a likely hydraulic link to the river level fluctuations. This is in-line with the conceptual hydrogeological model report in the 2019 Bowen UWIR, where there is linkage between rainfall events and river level flow periods to groundwater level. This observed decline between November 2017 and November 2019 is not considered to be due to the effects of CSG production;
- A decline in groundwater level of 5.4m was noted at bore M230W between November 2017 and November 2020. The water levels observed in this bore are considered to have been influenced by nearby mining operations; a review of mine plan schedules indicated that “drive Number-1” traversed the area in proximity to M230W between Q3 and Q4-2017 indicating that the SWL decline were expected to be a result of the Anglo underground mine development. This was similar to the decline seen in M340W (as discussed in the 2017 Annual Review of the 2016 Bowen UWIR) where a decline in groundwater levels has made this monitoring borehole dry. Both monitoring bores are in the same area, as shown in Figure 3. Accordingly, the decline is not considered to be due to the effects of CSG production.

Based on the graphically presented monitoring data in Figure 5, it is clear that there is no apparent influence of CSG production to the Quaternary alluvium, weathered Tertiary basalt, Tertiary sediment, weathered Fort Cooper coal measures and Rewan aquifers in which these bores are installed.

4.2.1.2 BGP

Groundwater level monitoring has been undertaken in the following shallow groundwater monitoring bores which form part of the BGP monitoring network. Table 3 provides a summary of these bores.

- Monitoring since January 2018 for bore MB12; and
- Monitoring since November 2019 for bores MB1-S, GW004A and GW007A.

Table 3: BGP Shallow Groundwater Monitoring Bores

Bore ID	Total Constructed Depth (m)	Screen Interval (mbgl)	Screened Formation
MB1-S	60	45 - 50	Fort Cooper Coal Measures – Girrah Seam
MB12	59.1	56 – 59	Rewan Formation
GW004A	13.5	7.5 – 13.5	Tertiary Sediment
GW007A	7.5	1.5 – 7.5	Tertiary Sediment

The groundwater level monitoring results are shown in Appendix A. Groundwater levels, as is shown in Figure 6, range from:

- 227.9 to 64.75 m Australian Height Datum (AHD) in the Tertiary Sediment aquifer;
- 209.5 m AHD in the weathered Fort Cooper Coal Measures aquifer, and

- 286.4 m AHD in the Rewan Formation.

Groundwater level monitoring, as reported in the 2020 Annual Review of the 2019 Bowen UWIR, (Appendix A) indicates:

- Groundwater levels are stable in the shallow bores;
- GW007A was recorded as dry. An alternate location may be required if GW007A is shown to be continually dry; and
- Water level decline and recovery in MB12 is due to water quality sampling (pumping) being undertaken in the bore. The frequency of water quality sampling was decreased in H2 2019 where subsequent water level data show water level recovery between monitoring events.

Based on the presented monitoring data in Figure 6, there is no apparent influence of CSG production to the Tertiary Sediment, Fort Cooper Coal Measures and Rewan aquifers in which these bores are installed and thus no thresholds have been exceeded as per the EWI. This is expected given no water production has commenced in the BGP.

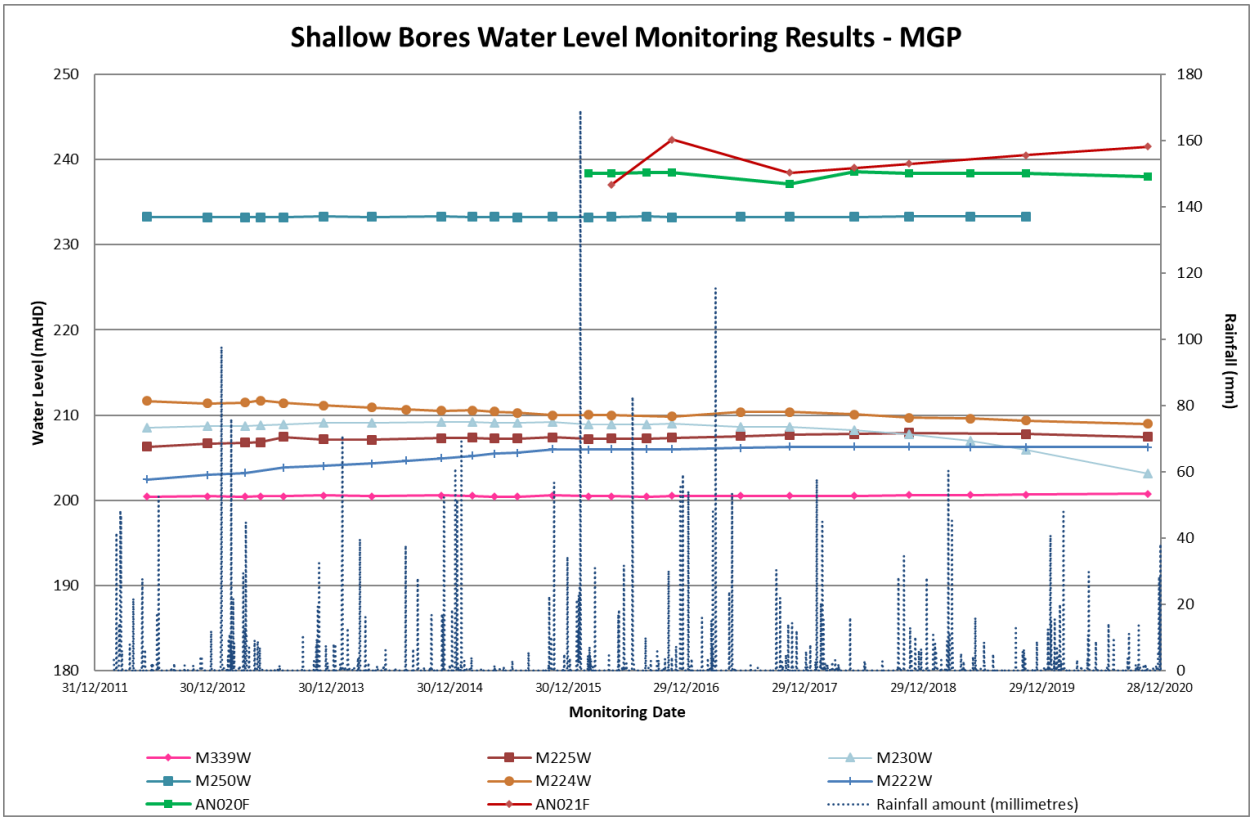


Figure 5: Shallow Bores Water Level Monitoring Results - MGP

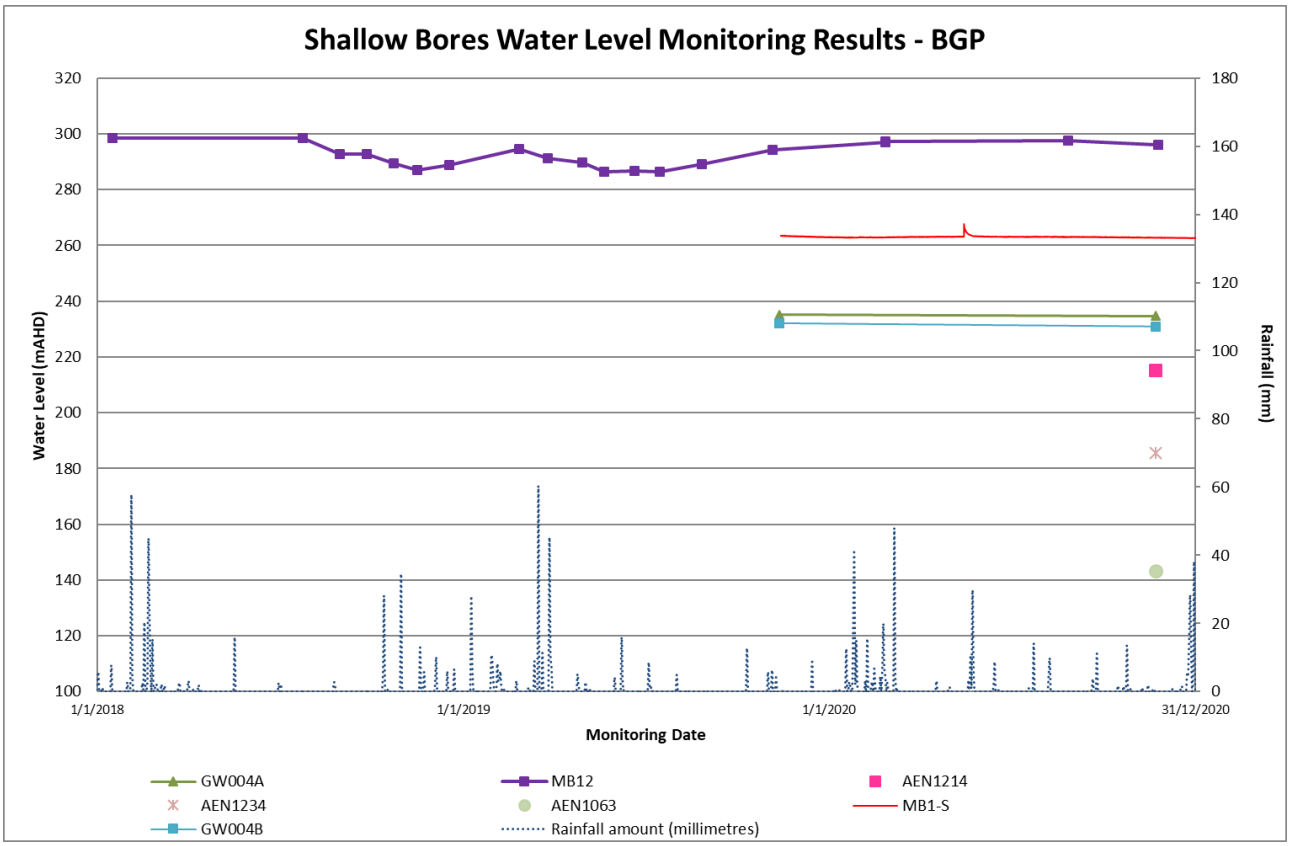


Figure 6: BGP Shallow Bores Water Level Monitoring Results

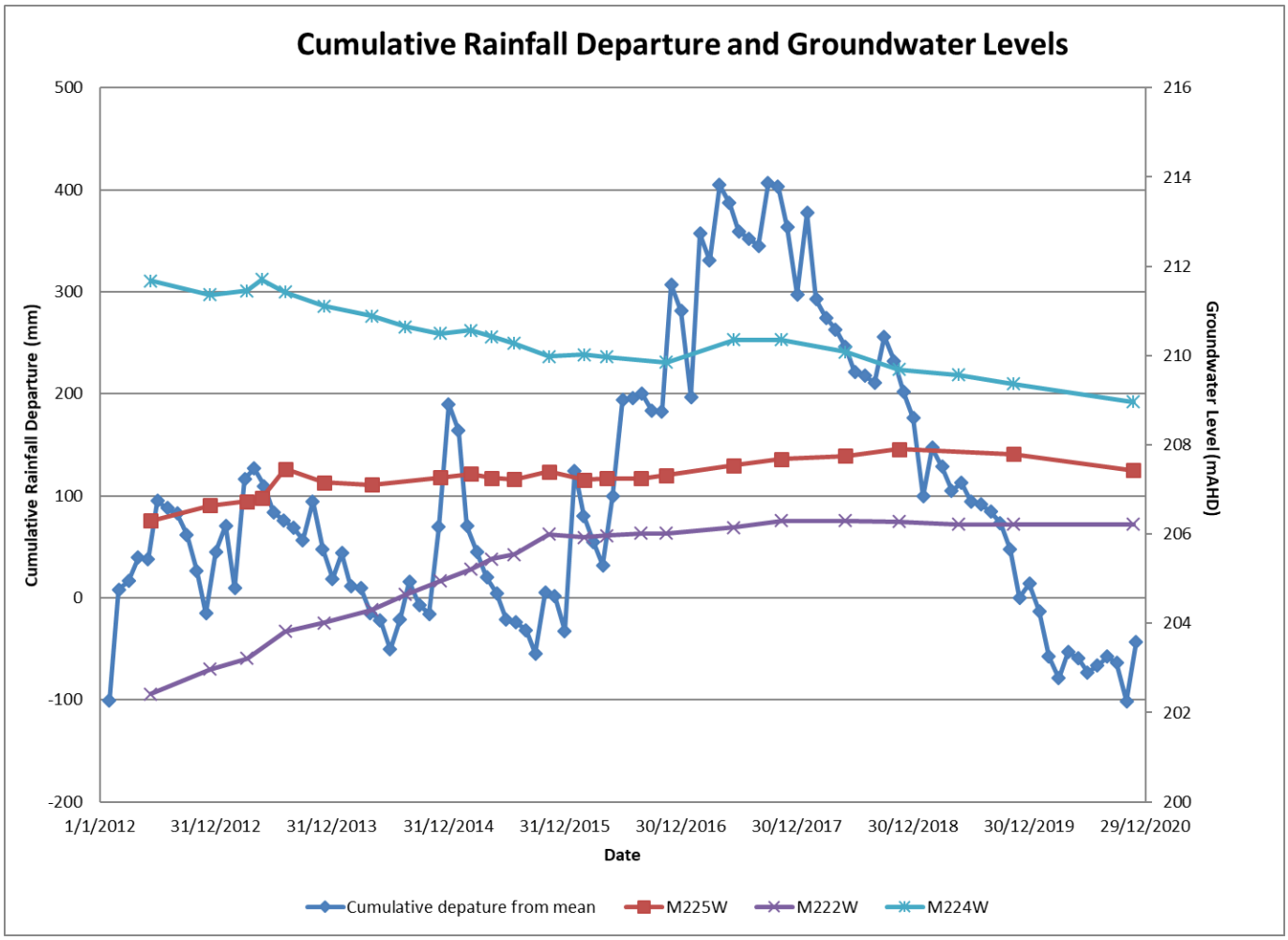


Figure 7: Cumulative Rainfall Departure and Groundwater Levels

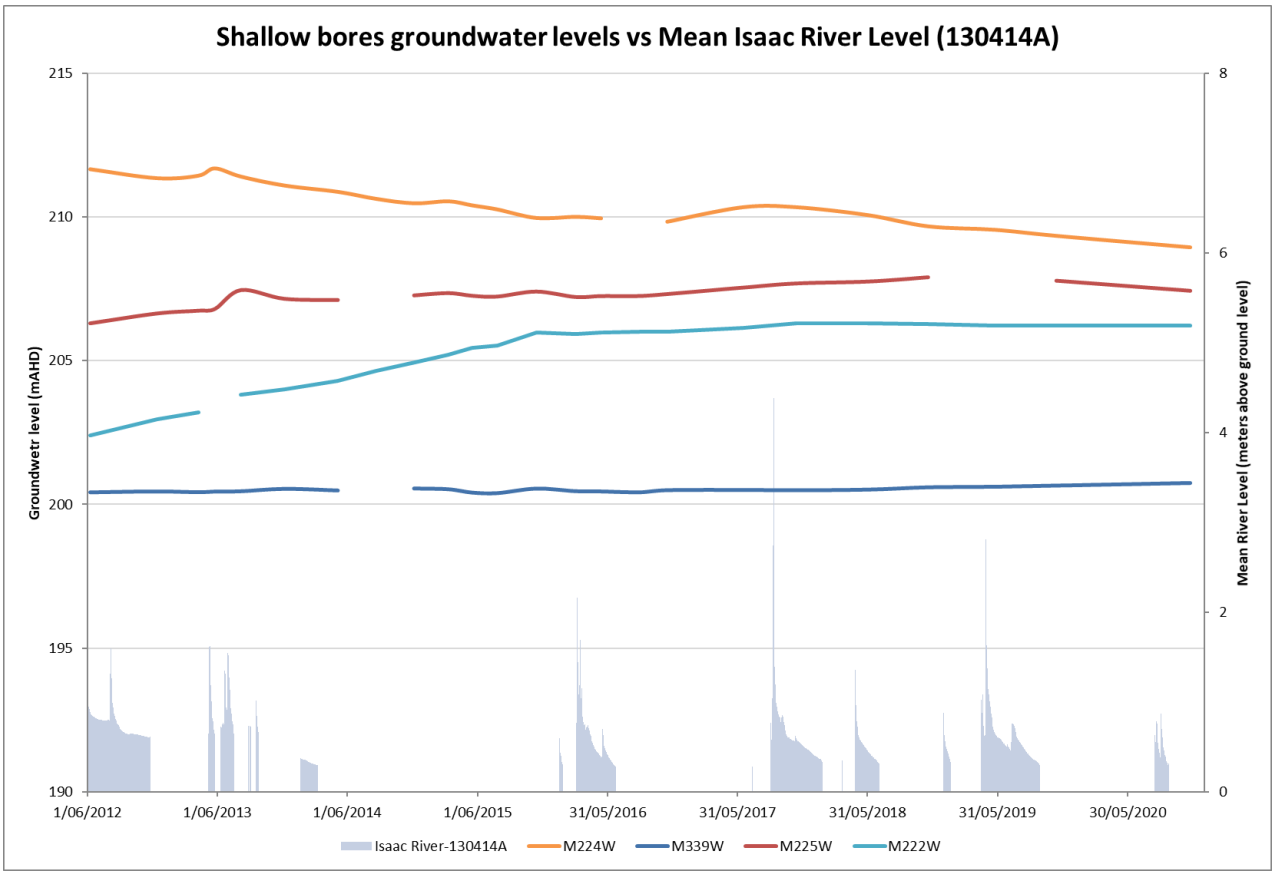


Figure 8: Shallow Groundwater levels vs mean Isaac River levels

4.2.2 Deep Monitoring Bores

4.2.2.1 MGP

The groundwater level monitoring results are shown in Figure 12. Observed groundwater levels or calculated potentiometric water levels ranged from:

- 208.3 to 216.8m AHD in the BCG;
- 49.6 to 207.7m AHD in the FCCM; and
- -129.14 to 209.5m AHD in the MCM.

Groundwater level monitoring, as reported in the 2020 Annual Review of the 2019 Bowen UWIR (Appendix A), indicated:

- Modelled drawdown in the MCM aquifer at the end of 2020 at the location of M314W was predicted in the model to be approximately 215 m. Actual groundwater levels monitored for the MCM at M314W indicate a decline in levels of approximately 3.6 m;
- Modelled drawdown in the MCM aquifer at the end of 2020 at the location of M313W and M324W was predicted in the model to be approximately 138 m. These groundwater monitoring bores are located in the southern part of PL 196 and approximately 350 m from production well GM052V. The total amount of water actually produced from GM052V during this annual review data capture period was 0 ML. Since production ceased, the water level at GM052V has continued to recover. The groundwater levels at M313W and M324W show:
    - Actual groundwater levels monitored at M324W show a maximum decline in levels by 6.63 m in March 2017. Since March 2017, the water level has recovered by 2.69 m which represents a 36% recovery of the water level prior to the drawdown as indicated in Figure 12.

    - Actual groundwater levels monitored for the MCM at M313W show the maximum decline in the water level of 74.53 m, as measured in March 2017. Since March 2017 the water level has recovered by 53.74 m which represents approximately 72% recovery of the original water level prior to the drawdown. The graphically displayed water level curve indicates the recovery will continue.
- Drawdown in the MCM aquifer at the end of 2020 at the location of M162V was predicted to be approximately 79 m. Actual groundwater levels monitored at this site have steadily declined but only by approximately 26.35 m;
- Drawdown in the MCM aquifer at the end of 2020 at the location of GR067V was predicted to be approximately 0.27. m. Decreases in water levels of up to 150 metres, noted in April and August 2016, are due to depressurisation activities in this bore associated with monitoring events. The recovery curve has subsequently stabilised and no drawdown is evident;
- Drawdown in the FCCM aquifer at the end of 2020 at the location of M324W was predicted to be 0.01 m. Actual groundwater levels monitored for the FCCM at M324W shows a decline of approximately 1.69 m;
- Drawdown in the FCCM aquifer at the end of 2020 at the location of AN019F was predicted to be 2.95 m. Actual groundwater levels monitored indicates a smaller decline of approximately 1.58 m; and
- Drawdown in the BCG aquifer at the end of 2020 at the location of M313W and M314W was not predicted to occur in the model. Actual groundwater levels monitored for the BCG at M313W and M314W indicate a decline of approximately 1.9 m and 4.45 m respectively.
- Based on the monitoring data, it is concluded that observations of drawdown were generally consistent with the drawdown predictions made in the 2019 Bowen UWIR.

4.2.2.1 BGP

The groundwater level monitoring results are shown in Figure 13. Observed groundwater levels or calculated potentiometric water level ranged from:

- 256.5 to 269.1 m AHD in the FCCM; and
- -462.2 to 299.0 m AHD in the MCM.

As displayed above, there is a large range in water levels in the MCM. This is due to recovery of water levels at the monitoring locations from historical production. Analysis of MB1-D, MB2 and MB3 water levels was conducted to determine the recovery time of the water levels to a static condition prior to modelled drawdown at these locations to fulfil the requirements of the GMMP. The Theis recovery method was used to analyse that data and concluded that MB1 has fully recovered, and MB2 and MB3 will recover fully prior to predicted drawdown. Appendix D displays the curve analysis and graphs, with Figure 9 to Figure 11 showing the water level recovery of these wells compared to the calculated recovery. These figures show:

- MB1 water level has fully recovered.
- MB2 water level is recovering in-line with the calculated recovery.
- MB3 water level recovery is less than calculated. Due to the limited amount of data since relocation of the monitoring point, analysis will be undertaken in future reports.

Table 4 displays the predicted recovery year for each bore. As discussed in Section 3.2, the location of MB3 was changed due to a failure in a pressure gauge.

Table 4: Recovery dates – MB1, MB2 & MB3

Bore ID	Recovery date	Predicted drawdown year
MB1	05/06/2014	2021
MB2	14/02/2027	2031
MB3	28/04/2027	2031

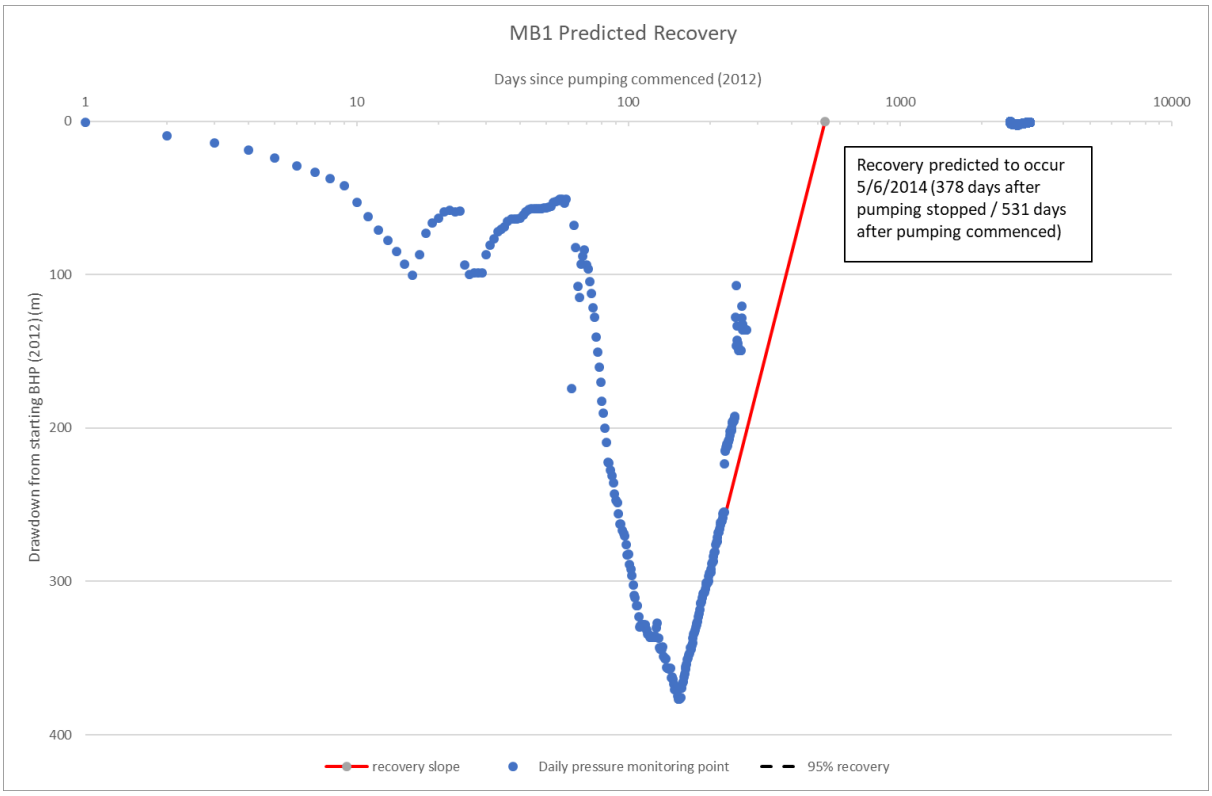


Figure 9: MB1-D recovery data

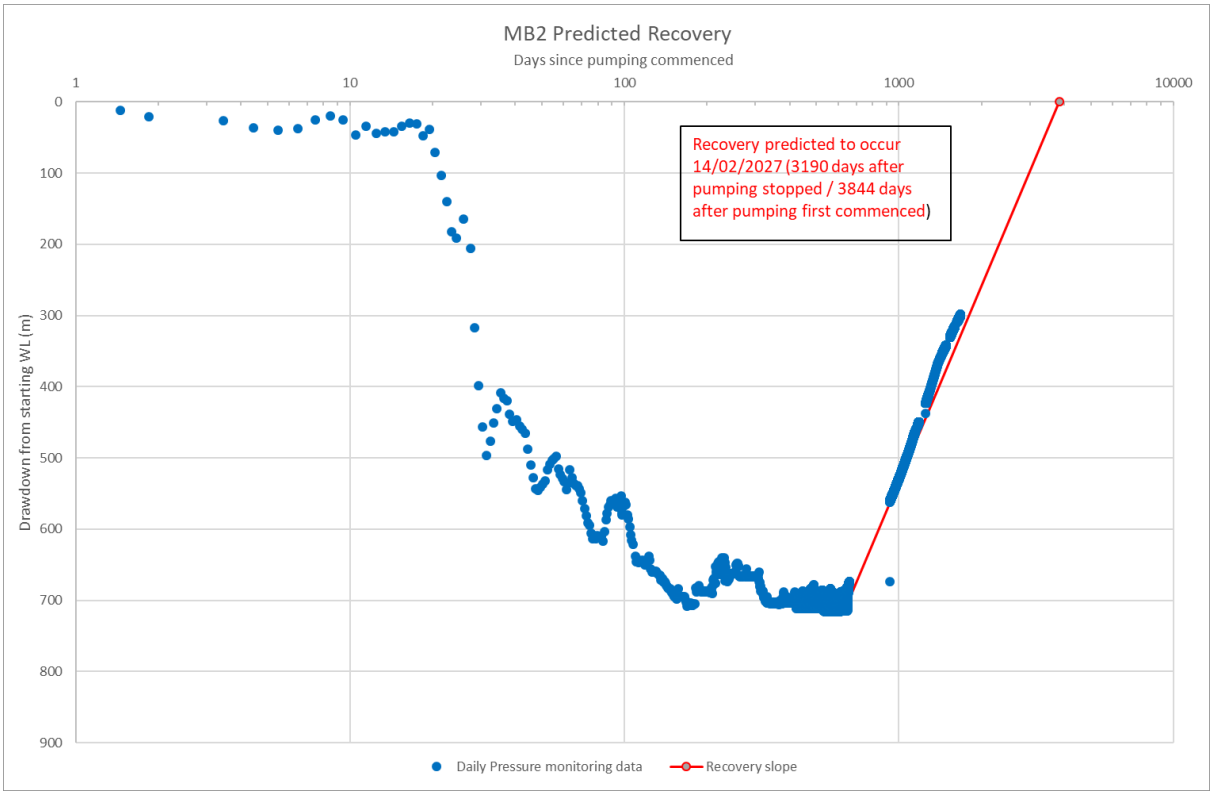


Figure 10: MB2 recovery data

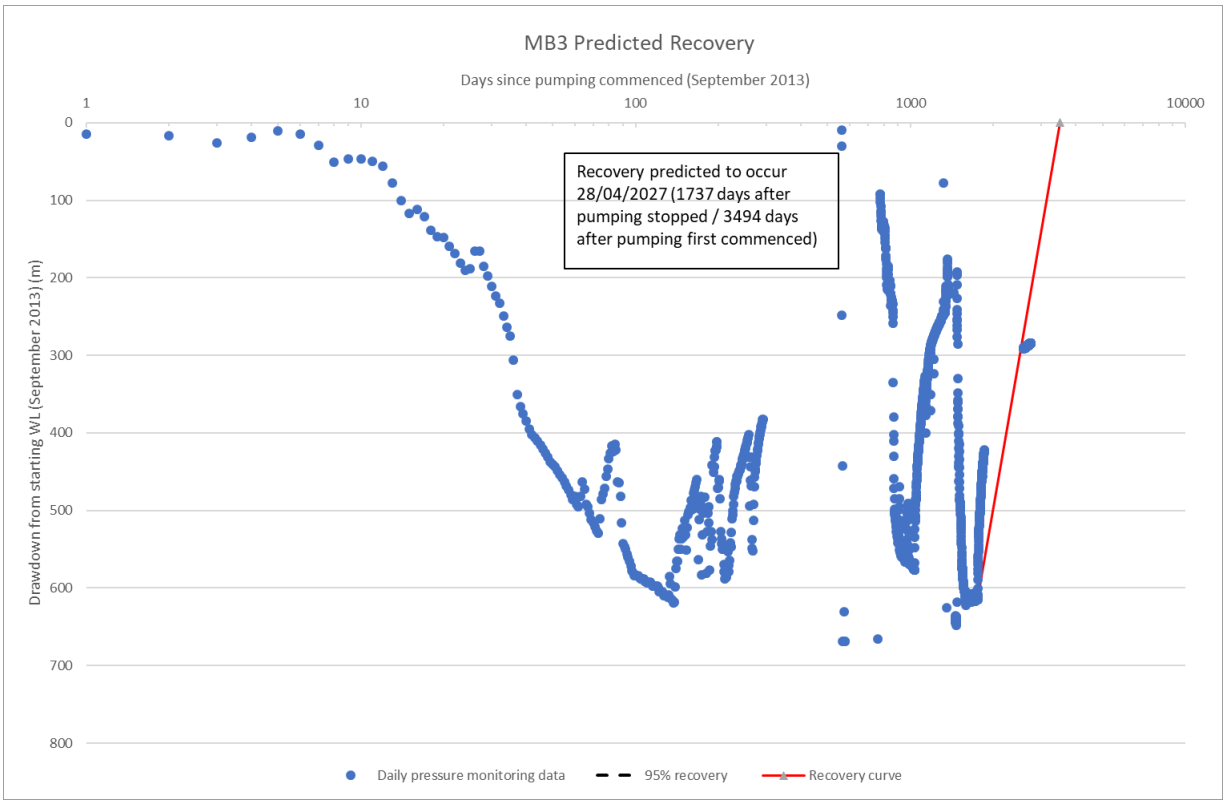


Figure 11: MB3 recovery data

A comparison of modelled drawdown predictions modelled in the 2019 Bowen UWIR with monitoring data to date has been undertaken and indicates:

- Drawdown in the MCM aquifer at the end of 2020 at the location of MB1 was predicted to be 4.8 m. MB1 was a former production well which was converted into a monitoring bore and has a recovered water level. Actual groundwater levels monitored indicates a decline of 5.3 m followed by a steady rise commencing in April 2020. This decline in water level is due to equilibration due to the workover of the well in late 2019 to equip the borehole with multiple pressure sensors and is not related to CSG activities. Due to the recovering water level, a deviation from the recovery curve (i.e. slower than expected recovery) would be used to determine if there bore is being impacted by external factors;
- Drawdown in the MCM aquifer at the end of 2020 at the location of MB2 was predicted to be 0.4 m. Actual groundwater levels monitored indicates an increase of 247.95 m. The water level in this bore is recovering from production. Due to the recovering water level, a deviation from the recovery curve (i.e. slower than expected recovery) would be used to determine if there bore is being impacted by external factors.;
- Drawdown in the MCM aquifer at the end of 2020 at the location of MB3 was predicted to be 6.3 m. Actual groundwater levels monitored indicates an increase of 181.9 m from the recovery started in June 2019. Due to the recovering water level, a deviation from the recovery curve (i.e. slower than expected recovery) would be used to determine if there bore is being impacted by external factors.;
- Drawdown in the FCCM aquifer at the end of 2019 at the location of MB1 and GW007B was predicted to be 0 m. Actual water level monitored indicates a decline of 4.61 in MB1 and 0.79 in GW007B. The observed decline, which appears to be flattening in MB1, is likely due to equilibration of pressure within the bore and the formation following the workover when the well was topped up with water; and
- MB2 and MB3 display recovering water levels. MB2 and MB3 are prior production wells.

Based on the monitoring data, it is concluded that observations of drawdown were generally consistent with the drawdown predictions made in the 2019 Bowen UWIR

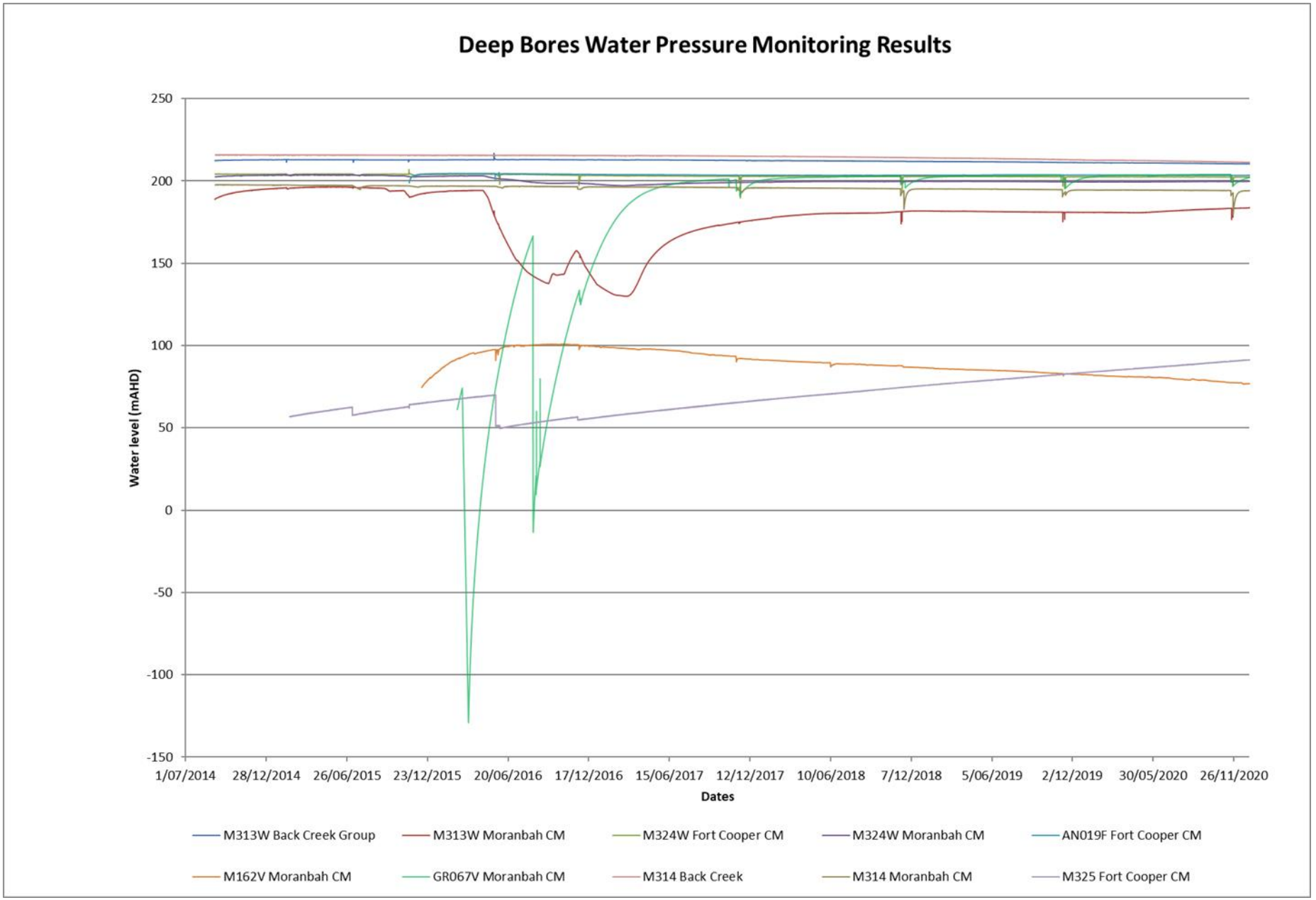


Figure 12: Deep Bores Water Level Monitoring Results - MGP

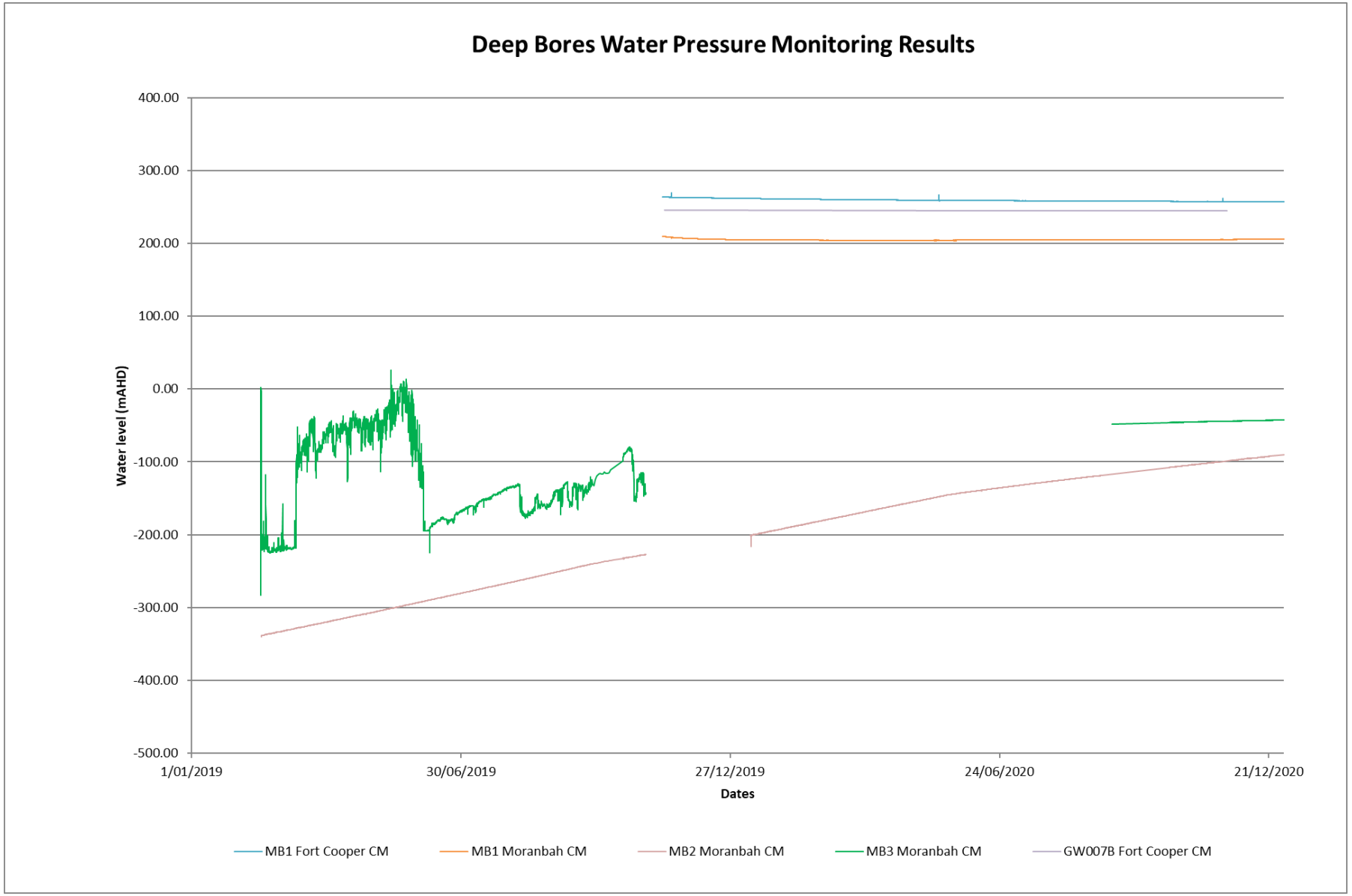


Figure 13: Deep Bores Water Level Monitoring Results - BGP

4.2.3 Groundwater Flow

A review of vertical gradients was undertaken for two monitoring locations in the MGP Area and one monitoring location in the BGP area. The conclusions for Site 1 and Site 2 in the MGP Area as outlined in the 2021 Bowen UWIR Annual Review (Appendix A) were:

- Site 1: The pressure trends between the MCM and shallow aquifer indicates no vertical hydraulic links exist at this location.
- Site 2: The pressure trends suggest that impacts are contained within the MCM and FCCM and that no vertical hydraulic links exist at this location.

A review of vertical gradients was undertaken for one monitoring location in the BGP (MB1 – denoted Site 3). Figure 14 shows the graphically displayed vertical gradients for Site 3 and based on the presented data, a decrease in water levels in the Moranbah Coal Measures is visible, with a smaller decrease seen in the Fort Cooper Coal Measures. Prior to this decrease, the Fort Cooper Coal Measures displayed similar water levels to the Quaternary Alluvium. This decline in water levels can be attributed to the workover conducted on MB1 to equip the borehole for multi-zone monitoring. During the workover process, a slug of water was introduced to 'kill' the well and due to the low permeability of the FCCM and MCM, a decline in water level was seen. As of the end of 2020, the water levels in all three zones are stabilising, with the MCM zone displaying an increase in water levels.

The sharp pressure increases in the data can be attributed to sampling events of MB1, where the pressure is bled off the borehole during sampling.

Ongoing monitoring at this site will provide further information on the interconnectivity of aquifers at these sites.

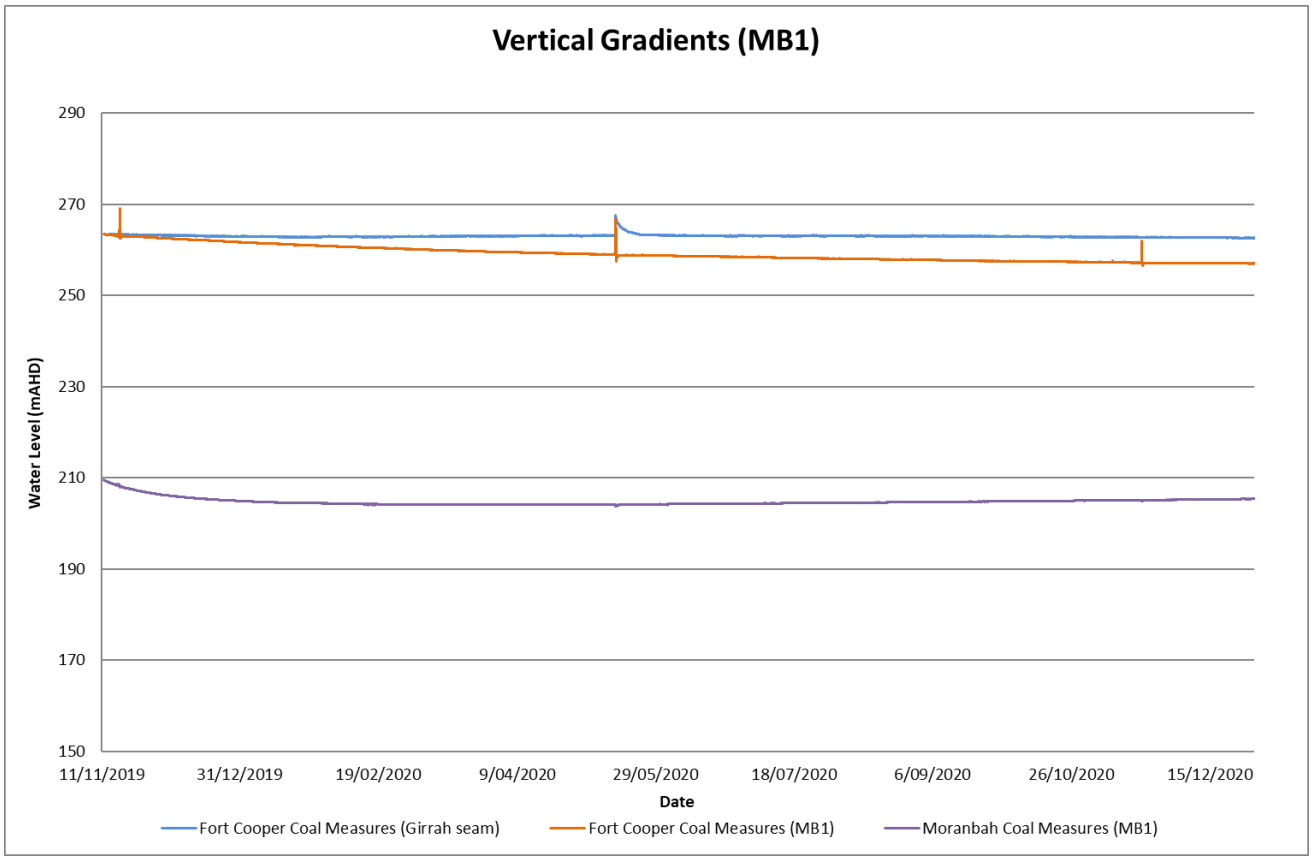


Figure 14: Site 3 - Review of Vertical Gradients (MB1)

4.3 Groundwater Quality Monitoring

The groundwater quality monitoring results are shown in Appendix B. A summary of these results is provided in the following sections.

4.3.1 Shallow aquifer water quality

4.3.1.1 MGP

The groundwater quality data indicated that there are no notable trends. In general, the data showed that:

- Groundwater quality of the quaternary alluvium varies from brackish to saline;
- Groundwater quality of the tertiary basalt aquifer varies from brackish to saline;
- Groundwater quality of the tertiary sediment aquifer is fresh to brackish;
- Groundwater quality of the weathered coal measures is brackish; and
- Groundwater quality of the Rewan Formation is brackish.

4.3.1.2 BGP

No groundwater quality data was obtained for the shallow aquifer for the BGP. At present, no shallow groundwater quality data locations are required to be collected. As the project progresses, the following locations will require groundwater quality data to be collected:

- MB5;
- MB7-S;
- MB8;
- MB9-S;
- MB10;
- MB11-S;
- MB13-S (contingent);
- MB14-S;
- MB15-S & MB13-I (contingent);
- MB16; and
- MB17-S & MB17-I (contingent).

4.3.2 Deep aquifer background water quality

4.3.2.1 MGP

Table 5 provides a summary of water quality results obtained from bores targeting the deep aquifers (M313W, M314W, M324W, M325W, AN019F, GR067V, M162V and M134GM. This provides an indication of water quality ranges for each parameter analysed based on aquifer type. Results for some parameters between different monitoring locations show high degree of variation which is likely to be attributable to the spatial heterogeneity and low permeability of the hydrogeological system. In addition to this, as displayed by the groundwater level data, groundwater recovery for some sites is slow and this is likely to result in variations in some parameters at the same monitoring location. Overall, a review of this data indicates that there are no notable trends. In general, this data shows that:

- Groundwater quality of the Fort Cooper Coal Measures aquifer is fresh to brackish; and
- Groundwater quality of the Moranbah Coal Measures is fresh to brackish.

Table 5: Background Water Quality – Deep Monitoring Bores

Parameter	Fort Cooper Coal Measures		Moranbah Coal Measures	
	Min	Max	Min	Max
pH	6.79	11.8	7.27	9.42
EC uS/cm (laboratory)	1170	11100	1710	16000
TDS mg/L (laboratory)	707	9910	1160	9810
Bicarbonate Alkalinity as $CaCO_3$ (mg/L)	<1	456	<1	<1
Total Alkalinity as $CaCO_3$ (mg/L)	<1	135	<1	456
Sulphate as SO_4 (mg/L)	<1	1380	159	2310
Chloride (mg/L)	225	1380	159	2420
Calcium (mg/L)	<1	68	<1	134
Magnesium (mg/L)	188	4920	198	5770
Sodium (mg/L)	2	276	7	209
Potassium (mg/L)	<1	256	<1	62
Arsenic mg/L (dissolved)	199	2590	212	3490
Barium mg/L (dissolved)	12	73	9	1450
Beryllium mg/L (dissolved)	<0.001	0.005	<0.001	0.013
Cobalt mg/L (dissolved)	<0.001	<0.001	<0.001	<0.001
Chromium mg/L (dissolved)	0.005	12.2	0.236	23
Copper mg/L (dissolved)	<0.001	<0.001	<0.001	0.001
Manganese mg/L (dissolved)	<0.001	0.004	<0.001	0.018
Molybdenum mg/L	<0.001	0.004	<0.001	0.01
Nickel mg/L (dissolved)	<0.001	0.582	<0.001	7.08
Selenium mg/L	<0.001	0.459	<0.001	2.19
Lead mg/L (dissolved)	<0.001	0.304	0.008	0.446
Strontium mg/L	0.006	0.114	0.001	0.082
Vanadium mg/L (dissolved)	<0.001	0.02	<0.001	0.032
Zinc mg/L (dissolved)	<0.01	<0.01	<0.01	<0.01
Boron mg/L	0.639	8.18	1.18	10.8
Iron mg/L	<0.01	<0.01	<0.01	0.02
Fluoride (mg/L)	<0.005	2.16	<0.005	0.568
Phosphate as P (mg/L)	0.24	1.17	0.46	2.4

4.3.2.1 BGP

Table 6 provides a summary of water quality results obtained from bores targeting the deep aquifers (MB1-D and GW007B). A sample was collected from GW0007B at the same visit as a water level logger download from GW007B was undertaken in November 2019. Although it is not required by the GMMP, it is included incorporated into Table 6 for analysis.

Overall, a review of this data indicates that there are no notable trends. In general, this data shows that:

- Groundwater quality of the Fort Cooper Coal Measures aquifer is brackish; and
- Groundwater quality of the Moranbah Coal Measures is brackish.

Currently, groundwater quality data is required to only be collected at MB1-D. Water quality sampling was required at MB1-D at biannual frequency for the first year, which was achieved, and sampling will continue annually going forward.

A sample was collected from GW0007B at the same visit as a water level logger download from GW007B was undertaken in November 2019. Although it is not required by the GMMP, it is included incorporated into Table 6 for analysis.

For the BGP, deep groundwater quality data will be required to be collected at the following monitoring locations as the project progresses:

- MB1-D;
- MB7-D;
- MB9-I & MB9-D;
- MB11-D; and
- MB14-I & MB14-D.

Table 6: Background Water Quality – Deep Monitoring Bores

Parameters	Units	Fort Cooper Coal Measures	Moranbah Coal Measures	
		GW007B	MB1-D	
			Min	Max
Field pH		6.79	7.95	8.26
Electrical Conductivity	µS/cm	15700	8790	9380
Total Dissolved Solids	mg/L	9910	5110	5460
Hydroxide Alkalinity (OH-) as CaCO3	mg/L	<1	<1	<1
Carbonate Alkalinity as CaCO3	mg/L	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	mg/L	1380	817	1600
Total Alkalinity as CaCO3	mg/L	1380	817	1600
Sulphate, SO4	mg/L	<1	<1	<1
Chloride, Cl	mg/L	4920	2250	2560
Calcium - Dissolved	mg/L	276	14	14
Magnesium - Dissolved	mg/L	256	10	12
Sodium - Dissolved	mg/L	2330	1900	2410
Potassium - Dissolved	mg/L	64	16	24
Arsenic-Dissolved	mg/L	0.005	0.002	0.003
Beryllium-Dissolved	mg/L	<0.001	<0.001	<0.001
Barium-Dissolved	mg/L	12.2	4.12	4.29
Cobalt-Dissolved	mg/L	0.001	0.001	0.001
Copper-Dissolved	mg/L	<0.001	0.002	0.005
Lead-Dissolved	mg/L	<0.001	0.006	0.008
Manganese-Dissolved	mg/L	0.12	0.015	0.049
Molybdenum	mg/L	0.006	0.017	0.018
Nickel-Dissolved	mg/L	0.02	0.032	0.036
Vanadium-Dissolved	mg/L	<0.01	<0.01	<0.01
Zinc-Dissolved	mg/L	2.16	0.024	0.045
Boron	mg/L	0.24	1.04	1.68
Iron	mg/L	2.94	1.14	1.53
Fluoride, F	mg/L	0.2	2	2.2
Phosphate as P in water	mg/L	0.02	0.45	0.97

5 RESEARCH

A list of research and reports produced in this reporting period are described below:

- *Bowen Section & Regional model results memo*: This document provided a summary of a local sector model and a revised regional model developed to simulate additional production from the Red Hill field to the north of the Moranbah Gas Project (MGP). The objectives of the modelling work were to:

    a. develop a local sector model of the Red Hill development;

    b. update the field development plan in the 2017 AGE regional model;

    c. change the regional model stress period setup;

    d. review and where necessary revise modelled specific storages values based on recent literature (Rau et al, 2018); and

    e. produce updated impact predictions.

This report is attached in Appendix E.

6 CONCLUSION

This report satisfies the following requirements for the annual report as outlined in Section 6.2.4 of the GMMP. Significant updates during the report period include:

- Seven (7) wells have been installed, below the 1408 authorised operational wells. The seven wells were installed in the previous Annual Review period and are non-operational at the time of this report, with production of water from those wells expected to start in 2022.

- Three (3) locations have been installed in this reporting period as part of the BGP monitoring network to supplement the existing monitoring network established for Arrow's MGP. A total of nine (9) locations are now monitored.

- There is no apparent influence of CSG production to the Tertiary Sediment, Fort Cooper Coal Measures (FCCM) and Rewan aquifers in the installed monitoring network for the BGP. This is expected given no water production as part of the BGP has commenced.

- A review of the groundwater quality data indicates that there are no notable trends for both the shallow and deep aquifers in the MGP.

- Red Hill Central (within PL486) water production is expected to commence in 2022.

- Ellensfield (within ATP1103) water production has been delayed indefinitely.

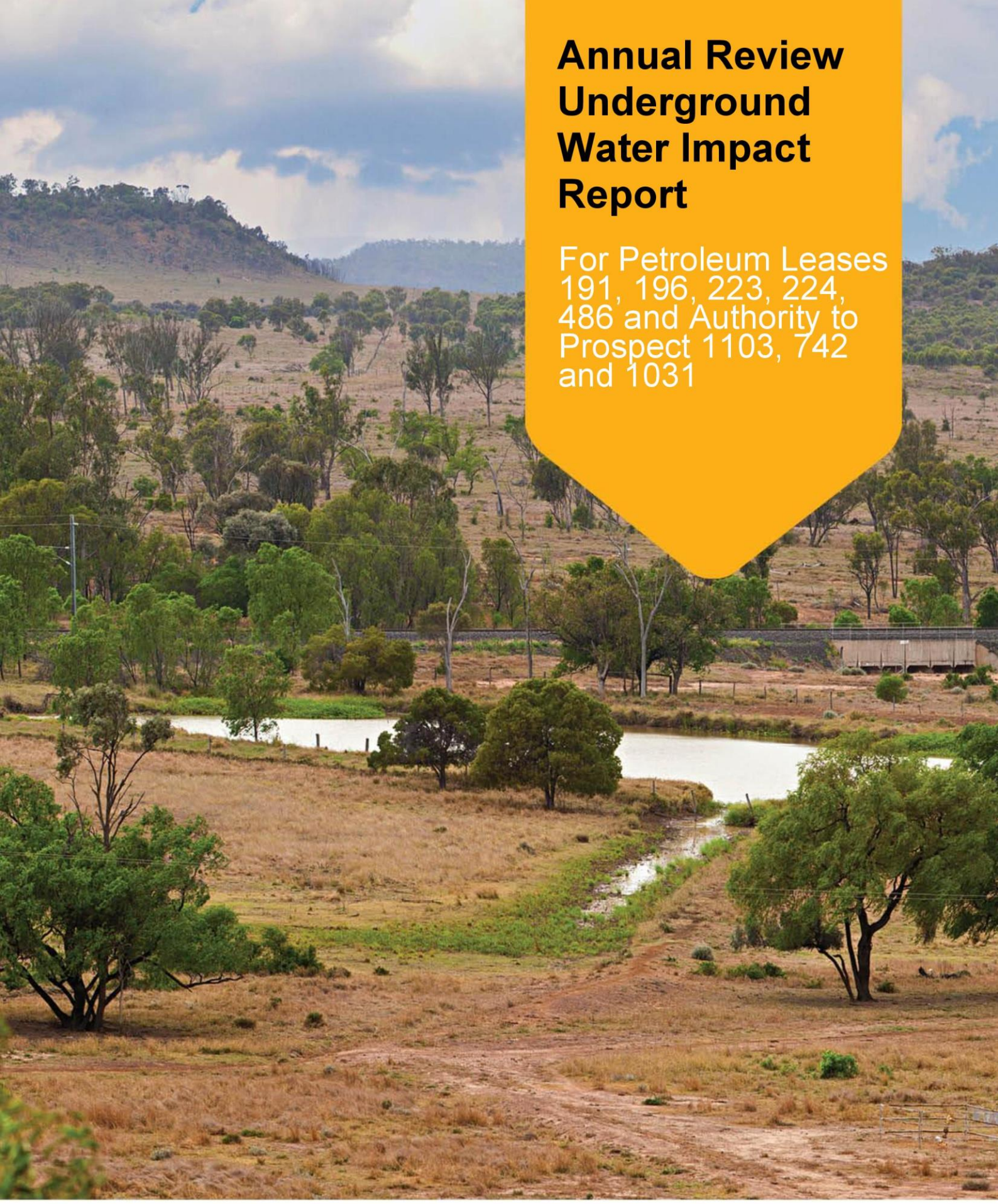
- No non-compliances were recorded and therefore no remedial actions were undertaken.

- All monitoring obligations have been met, with no exceedances under the GMMP early warning system (EWS) recorded across the monitoring network. There were, however, a number of data loss issues identified and addressed:
    - MB2: Data loss from October 2019 to January 2020 due to failed telemetry which was investigated and recommenced monitoring.
    - MB3: Data loss from October 2019 to January 2020 due to failed telemetry. Downhole pressure gauge failure was seen at the recommencement of telemetry reading. Due to this, the location of the well was moved to a nearby former production well and logging recommenced from September 2020.
    - GW001: The vibrating wire piezometer (VWP) array in GW001 failed in March 2020 and monitoring of GW004 commenced in replacement from November 2020.

- One report was completed in this period - *Bowen Section & Regional model results memo*. This document provided a summary of a local sector model and a revised regional model developed to simulate additional production from the Red Hill field to the north of the Moranbah Gas Project (MGP).

- No out of cycle Underground Water Impact Report (UWIR) was submitted. The 2021 Annual Review of the Bowen UWIR concluded that there was no material change to water impacts as the water production forecast is significantly less than what was modelled in the 2019 UWIR. This report was submitted to Queensland's Department of Environment and Science (DES) on 22 April 2021.

[illegible] D [illegible] R [illegible] B [illegible] R [illegible]



Annual Review Underground Water Impact Report

For Petroleum Leases 191, 196, 223, 224, 486 and Authority to Prospect 1103, 742 and 1031

arrow energy
go further

April 2021

REVISION HISTORY

R□□□□□□□□□□	R□□□□□□□□□D□□□	R□□□□□□□□□□□□□ □ □r□
0	April 2021	Initial release.

TABLE OF CONTENTS

1 INTRODUCTION 1

2 WATER PRODUCTION REVIEW 3

2.1 Moranbah Gas Project 4

2.1.1 Predicted Impacts 4

2.2 Bowen Gas Project 8

2.2.1 ATP 1103 9

2.2.1.1 Predicted Impacts 9

2.2.2 Red Hill Central 11

2.2.2.1 Predicted Impacts 11

2.2.3 Mavis Downs 11

2.2.3.1 Predicted Impacts 11

2.2.4 ATP 1031 11

2.2.4.1 Predicted Impacts 12

2.2.5 ATP 742 14

2.2.5.1 Predicted Impacts 14

3 WATER MONITORING STRATEGY (WMS) 15

3.1 MGP Area Groundwater Monitoring Network 15

3.2 BGP Area Groundwater Monitoring Network 17

4 GROUNDWATER ASSESSMENT UPDATE 21

4.1 Trigger Levels 21

4.2 Groundwater Level Monitoring 21

4.2.1 Shallow Monitoring Bores 21

4.2.2 Deep Monitoring Bores 26

4.2.3 Groundwater Flow 33

4.2.3.1 Site 1 33

4.2.3.1 Site 2 33

4.2.3.1 Site 3 34

5 GROUNDWATER QUALITY MONITORING 36

5.1 Shallow aquifer water quality 36

5.2 Deep aquifer water quality 38

6 SPRINGS AND GROUNDWATER DEPENDANT ECOSYSTEMS 39

7 CONCLUSION 40

TABLE OF FIGURES

Figure 1: Location of ATP 1103, 1031, 742, 832 and PL 191, 196, 223, 224 and 486 2
Figure 2: Extent of the IAA as per the 2019 UWIR 6
Figure 3: Extent of the LAA as per the 2019 UWIR 7
Figure 4: 1km buffer RH098A, RH099A and RH100A 10
Figure 5: 1km buffer Picardy 11 and 12 13
Figure 6: Groundwater Monitoring Network for MGP 16
Figure 7: Groundwater Monitoring Network for BGP 20
Figure 8: Shallow Bores Water Level Monitoring Results - MGP 24
Figure 9: Shallow Bores Water Level Monitoring Results - BGP 24
Figure 10: Cumulative Rainfall Departure and Groundwater Levels 25
Figure 11: Shallow Groundwater levels vs mean Isaac River levels 25
Figure 12: MB1 recovery data 29
Figure 13: MB2 recovery data 29
Figure 14: MB3 recovery data 30
Figure 15: Deep Bores Water Level Monitoring Results - MGP 31
Figure 16: Deep Bores Water Level Monitoring Results - BGP 32
Figure 17: Site 1 - Review of Vertical Gradients (M224W, M222W, M325W and M314W) 33
Figure 18: Site 2 - Review of Vertical Gradients (M324W and M313W) 34
Figure 19: Site 3 - Review of Vertical Gradients (MB1) 35

TABLE OF TABLES

Table 1: MGP Water Production 4
Table 2: Forecast Water Production PL 191, 196, and 224 4
Table 3: Forecast Water Production PL 486 11
Table 4: BGP Monitoring network 19
Table 5: Shallow Groundwater Monitoring Bores 21
Table 6: BGP Shallow Groundwater Monitoring Bores 23
Table 7: Deep Groundwater Monitoring Bores 27
Table 8: Recovery dates – MB1, MB2 & MB3 30
Table 9: Background Water Quality - Shallow Monitoring Bores 37
Table 10: Background Water Quality – Deep Monitoring Bores 38

EXECUTIVE SUMMARY

The 2019 Bowen Underground Water Impact Report (2019 Bowen UWIR) for Authority to Prospect (ATP) 1103, 1031, 742 and Petroleum Leases (PL) 191, 196, 223, 224 and 486 was approved with conditions by the Department of Environment and Science (DES) on 9 July 2019. The 2019 Bowen UWIR included tenures for Arrow's domestic gas project in the Bowen Basin, referred to as the Moranbah Gas Project (MGP), and an expansion project referred to as the Bowen Gas Project (BGP). This review has been undertaken in line with the *Water Act (2000)* and conditions received in relation to the annual review. This review considers:

- Any new hydrogeological data that significantly alters the conceptual model;
- Whether the taking of water for production of Coal Seam gas (CSG) has varied significantly from that forecast in the 2019 UWIR;
- Whether new or additional production of CSG is planned;
- Whether new production testing has been undertaken or is planned;
- Whether predictions made in the 2019 UWIR have materially changed; and
- The implementation of the Water Monitoring Strategy (WMS) as was proposed in the 2019 Bowen UWIR.

Key findings of the 2021 annual review for the MGP tenures consisting of PLs 191, 196, 223 and 224 are:

- Based on the observed water produced since the 2019 Bowen UWIR, there has been 6.6 ML less water produced than was forecasted in the 2019 UWIR;
- The updated water production forecast is 2.6% less than the modelled water production to the end of 2021;
- Given the updated water production forecast is less than what was modelled in the 2019 UWIR, the predicted impacts are expected to be less than originally modelled, an update of the of the 2019 UWIR is not proposed. Accordingly, a material change to the Immediately Impacted Area (IAA) or the Long-Term Affected Area (LAA) is not expected.
- The maps prepared under s.376(1)(b)(iv and v) do not require updating as there has not been a material change in the information or predictions used to prepare the maps.

Key findings of the 2021 annual review for the BGP tenures consisting of ATPs 1103, 1031, 742 and PL 486 are:

- Water production is yet to commence for PL486.
- Three production testing wells in ATP 1103 were active in 2020 (RH098A, RH099A and RH100A), with a combined water production of 2.9 ML for the annual review period (a total of 4.9 ML since the 2019 Bowen UWIR). This amount of water produced is below the Peak Downs reference pilot site. Therefore, any IAA arising from production testing wells in the 2021 annual review data capture period will be smaller than that associated with the reference pilot site.
- No landholder bores are located within the 1-kilometre IAA radius from any production testing wells. Given the updated water production forecast is less than what was modelled in the 2019 UWIR, the predicted impacts are expected to be less than originally modelled, and an update of the of the 2019 UWIR is not proposed.
- The maps prepared under s.376(1)(b)(iv and v) do not require updating as there has not been a material change in the information or predictions used to prepare the maps.[1]

Based on the above, the predictions made in the 2019 UWIR have not materially changed. The next UWIR is due to be provided to DES within 10 business days after the ninth anniversary of the day the first UWIR took effect, which is 4 April 2022, unless agreed otherwise with the regulator.

[1] For Authority to Prospect tenures (ATP), the LAA is taken to be the same as the IAA until such time as a PL is granted and production commences.

1 INTRODUCTION

This report forms the second annual review (2021 annual review) of the 2019 UWIR for Arrow Energy's MGP and BGP projects. As is required in Chapter 3, s376 (e) of the Water Act (Qld) 2000, the 2019 UWIR includes a program for:

i. Conducting an annual review of the accuracy of each map prepared under s376 paragraph (b)(iv) and (v); and
ii. Giving the chief executive a summary of the outcome of each review, including statement of whether there has been a material change in the information or predictions used to prepare the maps.

The 2019 Bowen UWIR was approved with conditions by the Department of Environment and Science (DES), and took effect on the 9 July 2019 (Notice of Approval 101/0017990).

This report satisfies the requirements for the annual review outlined in the:

- *Water Act (2000)*;
- 2019 Bowen UWIR annual review commitments; and
- 2019 Bowen UWIR approval conditions.

In addressing the annual review requirements, Arrow has considered the following:

- Any new hydrogeological data that significantly alters the conceptual model;
- Whether the taking of water for production of CSG has varied significantly from that forecast;
- Whether new or additional production of CSG is planned;
- Whether new production testing has been undertaken or is planned;
- Whether predictions made in the 2019 Bowen UWIR have changed materially; and
- The implementation of the WMS; including any updates to the WMS.

Where practical, the results and analysis of the data contained in this report has been separated into each project (MGP and BGP). The spatial distribution of these projects is shown in Figure 1.

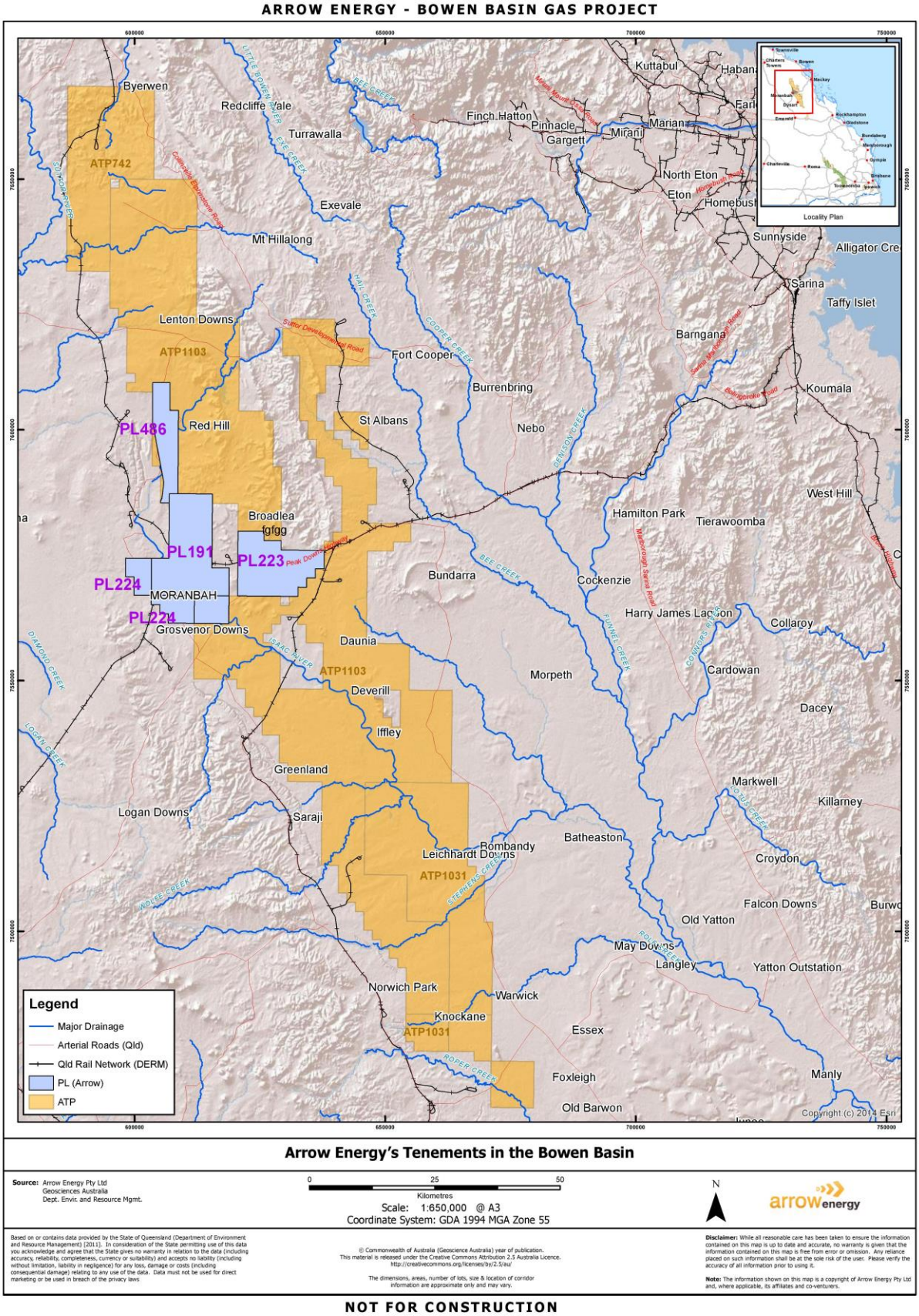


Figure 1: Location of ATP 1103, 1031, 742, 832 and PL 191, 196, 223, 224 and 486

2 WATER PRODUCTION REVIEW

A review of actual water production and forecast water production is presented in this section of this report for the MGP and BGP projects (as shown in Figure 2).

Review of water production from the ATP's and PL's is based on the following:

- 2019 Bowen UWIR data capture period from 1 January 2003 to 31 December 2018;
- 2019 Bowen UWIR water production forecast period from 1 January 2019 to 31 December 2025;
- 2020 Annual review water production forecast period from 1 January 2020 to 31 December 2025;
- 2021 Annual review data capture period from 1 January 2019 to 31 December 2020; and
- 2021 Annual review water production forecast period from 1 January 2021 to 31 December 2026.

Historical data from the Peak Downs (PD) production testing site on ATP 1103 (comprising production testing wells PD120V , PD122V, PD130V, and PD131V) was used as a reference pilot site to estimate the IAA for future production testing sites, specifically any new sites which commenced during the annual review period. Arrow has done this because the BGP is a phased expansion of production; therefore, only limited production testing has previously occurred and as a result only limited hydrogeological data exists for predicting impacts.

The annual review uses the following assessment approach outlined in the 2019 Bowen UWIR:

- Water produced at Peak Downs (part of ATP1103 production testing site between 2013 and 2015) was 26.7 ML which resulted in an Immediately Affected Area (PD IAA) in the 2019 Bowen UWIR which extended approximately 1 km from the wells. This is termed the reference pilot site;
- Actual water production from any subsequent production testing site in the annual review data capture period was compared to that produced at the reference pilot site;
- If water produced at the production testing sites in the annual review data capture period was equal to or less than the reference pilot site, then it was concluded that any resultant Immediately Affected Area (IAA) would be equal to or less than the reference pilot site; and
- If water production in the production testing well in the annual review data capture period was greater than PD IAA site, then a review of the 1m drawdown contour was undertaken to identify any existing or abandoned but useable landholder water supply bores.

2.1 Moranbah Gas Project

Table 1 and Table 2 below provide a comparison between observed water production and forecasted water production in the 2019 Bowen UWIR and the updated observed water production for the 2021 annual review data capture period. It should be noted that whilst PLs 191, 196, 223 and 224 make up the Moranbah Gas Project (MGP), production has only been undertaken on PLs 191, 196 and 224. Table 1 shows the observed water production for 1 January 2003 to 31 December 2020 and the comparison of observed to forecasted production for the 2021 annual review data capture period.

Based on the observed water produced since the 2019 Bowen UWIR, there has been 6.6 ML less water produced than was forecasted in the 2019 Bowen UWIR.

Table 1: MGP Water Production

Report	Water Production (ML) 1 Jan 2003 - 31 Dec 2018	Water Production (ML) 1 Jan 2019 - 31 Dec 2019	Water Production (ML) 1 Jan 2020 - 31 Dec 2020	Total Water Production (ML) 1 Jan 2003 - 31 Dec 2020	Difference
2019 Bowen UWIR	5334.7	218.5*	211.5*	5764.7	N/A -
2020 Annual Review	5334.7	251.4	172.0	5758.1	6.6 ML less (<1%)

* denotes forecast production

The Water production for the 2019 period presented in Table 1 (251.4 ML) differs from what was reported in the 2020 Annual Review (255.4 ML). This difference is due to updated calibration of the water flow meters from several production wells in the MGP.

Table 2 below shows the updated water production forecast for 2021 to 2026. The forecast has been updated based on new data and a better understanding of the reservoir (obtained through drilling, testing and water production analysis). The updated forecast is less than that what was outlined in the 2019 Bowen UWIR.

Table 2: Forecast Water Production PL 191, 196, and 224

Year	2019 Bowen UWIR Forecast Water Production (ML)	2020 Annual Review Forecast Water Production (ML)	Difference
2021	203.8	198.6	5.2 ML less than the 2019 Bowen UWIR (2.6% less)
2022	197.2	181.1	16.1 ML less than the 2019 Bowen UWIR
2023	191.0	179.3	11.7 ML less than the 2019 Bowen UWIR
2024	185.7	161.5	24.2 ML less than the 2019 Bowen UWIR
2025	179.7	154.0	25.7 ML less than the 2019 Bowen UWIR
2026	148.6*	148.6	N/A
Total	1106	1023.1	82.9 ML less than the 2019 Bowen UWIR (7.5% less)

* denotes forecast production from the 2021 Annual Review as the 2019 UWIR forecasted up to 2025.

2.1.1 Predicted Impacts

The impacts predicted in the 2019 Bowen UWIR define the IAA as occurring only in the Moranbah Coal Measures as shown in Figure 2 and Figure 3 below for the MGP area. The IAA is a prediction of water level decline where the drawdown is expected to exceed the bore trigger threshold of 5 metres drawdown for a 3-year period which commenced in January 2019. The LAA is a prediction of water level decline where the drawdown is expected to exceed the bore trigger threshold at any time (i.e. greater than the 3-year period).

Based on this, the prediction of the IAA is influenced by the water production from 2003 to 2022. As indicated in Table 1, the actual water production for the 2021 annual review data capture period is 6.6 ML less than the modelled water production in the 2019 Bowen UWIR. The updated water production forecast presented in Table 2 is 2.6% less than the modelled water production to the end of 2021.

This reduction in water production is due to updated reservoir information (obtained through drilling, testing and water production analysis) and changes in the field development plan (FDP) of the MGP.

It is expected that the modelled IAA and LAA in the 2019 Bowen UWIR overestimate impacts likely to occur. This is because the updated water production forecast in this annual review is now less than the forecast in the 2019 Bowen UWIR (i.e. less water is now forecasted to be produced and therefore impacts are expected to be less).

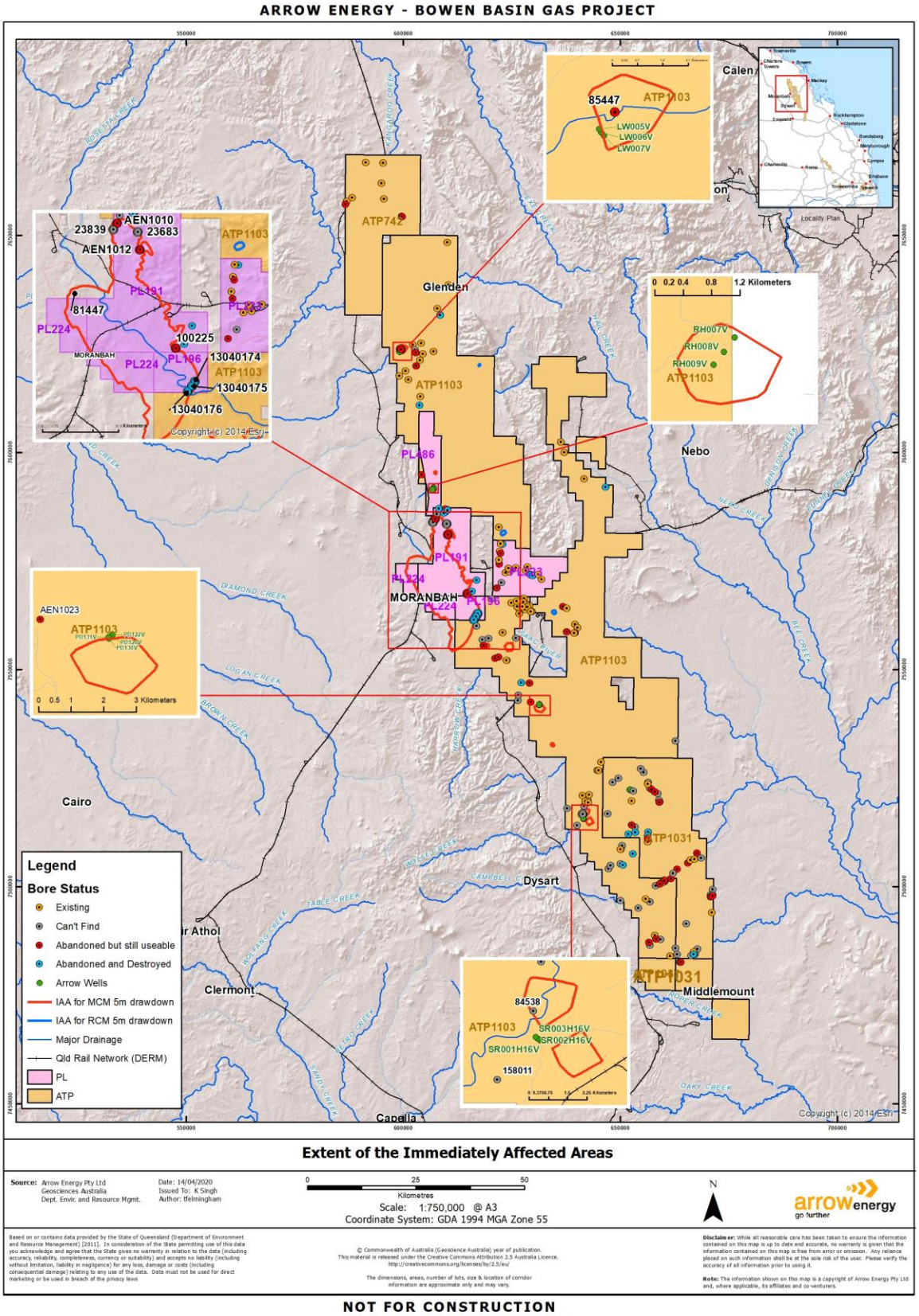


Figure 2: Extent of the IAA as per the 2019 UWIR

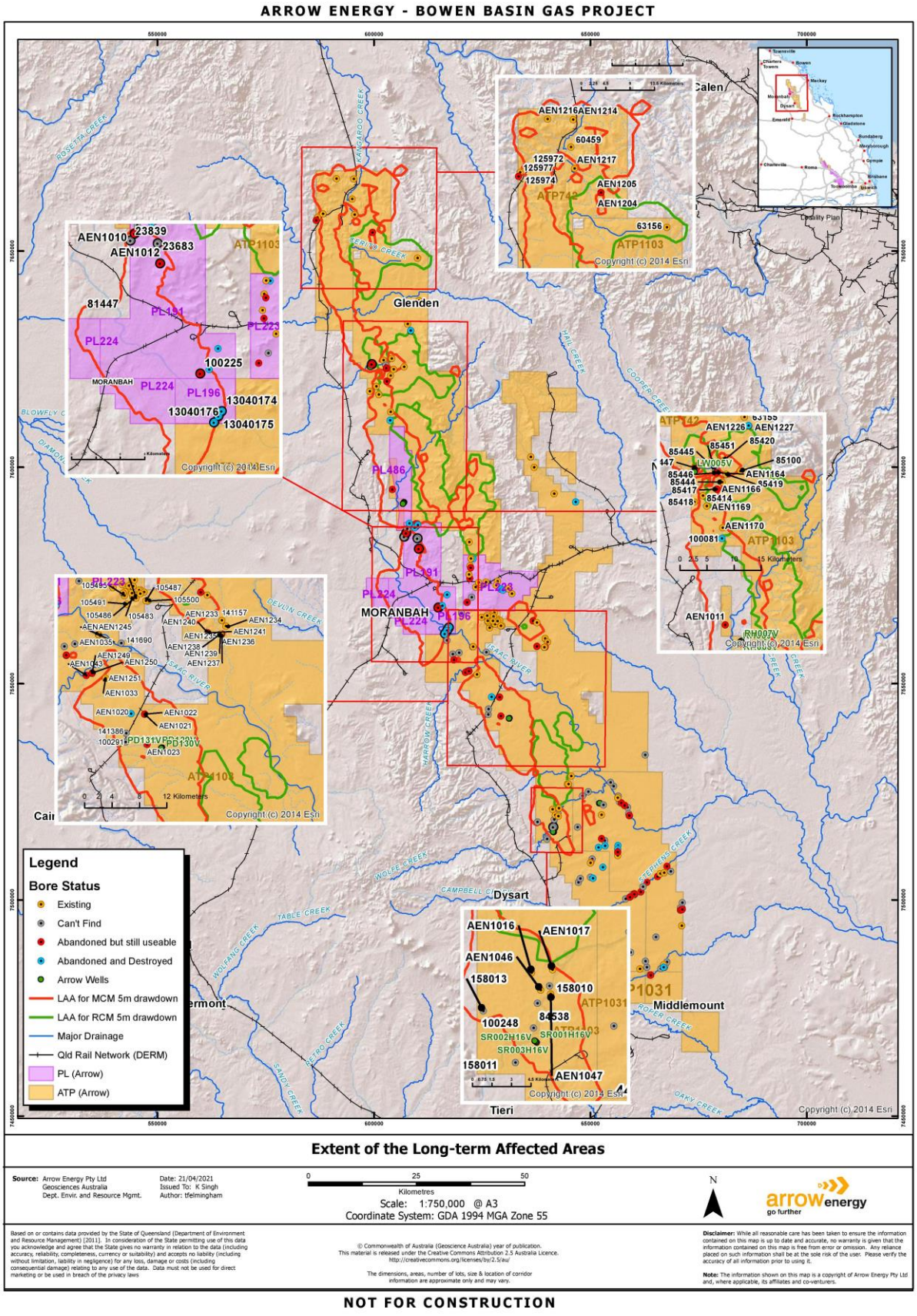


Figure 3: Extent of the LAA as per the 2019 UWIR

2.2 Bowen Gas Project

The Arrow Energy Bowen Gas Project (BGP) was approved by the Queensland Government on 8 September 2014 and the Commonwealth on 27 October 2014. Arrow's BGP involves a phased expansion of Arrow's Bowen Basin tenures. It comprises an update of development plans in the same general areas (i.e. within tenements ATP742, ATP1103, and ATP1031) from those presented in the Supplementary Report to the Environmental Impact Statement (SREIS) with the addition of development in Mavis Downs (also located within ATP1103).

The Field Development Plan (FDP) as outlined in the 2019 Bowen UWIR was as follows:

- Red Hill Central (within PL486) to commence in 2019;
- Mavis Downs (within ATP1103) to commence in 2021; and
- The remainder of field development (ATP1103, ATP742 and ATP1031) commencing 2030.

There have been a number of key changes from the 2019 Bowen UWIR this reporting period as follows:

- Red Hill Central (within PL486) water production is expected to commence in 2022
- Mavis Downs (within ATP 1103) water production has been delayed indefinitely; and
- Ellensfield (within ATP1103) water production has been delayed indefinitely.

Figure 2 and Figure 3 display the IAA and LAA for the MGP and BGP projects. For the Bowen Gas project, there is no material change to the IAA and LAA as water production has not commenced.

2.2.1 ATP 1103

ATP 1103 is a large exploration tenure located to the North, East and South of the MGP. A total of 2.1 ML of water was produced as part of production testing on ATP 1103 since the 2020 annual review (a total of 4.9 ML since the 2019 Bowen UWIR). This water volume is from production testing wells (RH098A, RH099A and RH100A) on what was ATP 1103, which has now been converted to PL 486 (Red Hill Central).

2.2.1.1 Predicted Impacts

The combined water volume for the production testing (RH098A, RH099A and RH100A) was 4.9 ML since the 2019 Bowen UWIR. This amount of water produced is below the volume produced from the reference pilot site. Therefore, any IAA arising from production testing wells in the 2021 annual review data capture period will be smaller than that associated with the reference pilot site. A 1-kilometre IAA radius consistent with the methodology outlined in the 2019 Bowen UWIR showed that no landholder bores are located in proximity to the testing as displayed in Figure 4.

Based on the limited production, no change is proposed to the modelling undertaken for the 2019 Bowen UWIR. Therefore, the maps in Figure 2 and Figure 3 do not require updating.

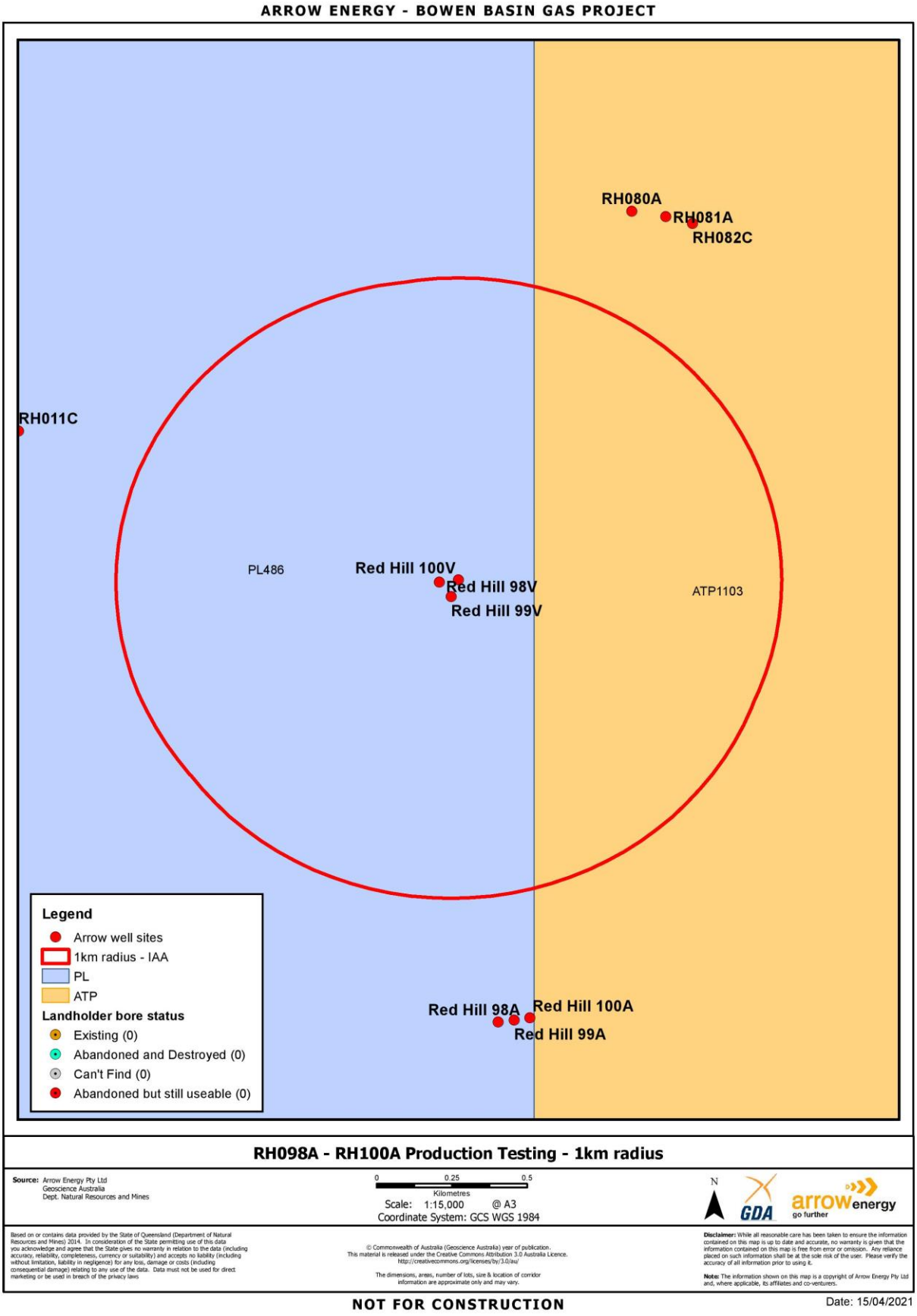


Figure 4: 1km buffer RH098A, RH099A and RH100A

2.2.2 Red Hill Central

The Red Hill Central (RHC) development is located approximately 30 km north of the township of Moranbah with the MGP area to its south. Water production from RHC was planned to occur from 2020 to 2026. The water production profile used in the 2019 Bowen UWIR indicated a total of 875 ML of water to be produced over that period.

As noted in Section 2.2.1, production testing was commenced in ATP 1103 prior to PL 486 being granted. Therefore, the water volumes for the production testing (from wells RH098A, RH099A and RH100A) are included in ATP 1103 water volumes. That production testing does not form part of the RHC development. Therefore, as production from the RHC development has not commenced, a total of 0 ML of water has been produced on RHC since the 2019 UWIR.

Table 3 below shows the current water production forecast for 2021 to 2026. Based on no water being produced since the 2019 Bowen UWIR and the updated forecast used for the 2020 Annual Review, 539.4 ML less water is now forecasted to be produced for the period to 2026.This reduction in forecasted water production is due to updated reservoir information (e.g. testing and water production analysis) and an improved forecast for RHC.

Table 3: Forecast Water Production PL 486

Year	2019 Bowen UWIR Forecast Water Production (ML)	2020 Annual Review Forecast Water Production (ML)	Difference
2021	125	0	125 ML less than current forecast (100% less)
2022	125	63.8	61.2 ML less than current forecast
2023	125	11.8	113.2 ML less than current forecast
2024	125	6	119.0 ML less than current forecast
2025	125	4	121 ML less than current forecast
2026	3.1*	3.1	N/A
Total	628.1*	88.7	539.4 ML less than the 2019 Bowen UWIR (85.9% less)

* denotes forecast production from the 2021 Annual Review as the 2019 UWIR forecasted up to 2025.

2.2.2.1 Predicted Impacts

Water production for the 2021 annual review data capture period was 0 ML. As a result, there is no material change[2] in the information or predictions made in the 2019 Bowen UWIR. Based on this, no change is proposed to the modelling undertaken for the 2019 Bowen UWIR. Therefore, the maps in Figure 2 and Figure 3 do not require updating.

2.2.3 Mavis Downs

The Mavis Downs development is located to the south of PL223 in ATP 1103, approximately 24 km east of the township of Moranbah. This development borders the MGP to the west. Mavis Downs production was forecast to occur from 2021 to 2030, with a total of 673 ML of water to be produced, however production has been indefinitely delayed.

2.2.3.1 Predicted Impacts

Water production for the 2021 annual review data capture period was 0 ML. As a result, there is no potential for an increase to the impacts predicted in the 2019 Bowen UWIR. Based on this, no change is proposed to the modelling undertaken for the 2019 Bowen UWIR. Therefore, the maps in Figure 2 and Figure 3 do not require updating.

2.2.4 ATP 1031

ATP 1031 lies approximately 100 km to the south of the MGP. A total of 0.47 ML of water has been produced as part of production testing on ATP 1031 for the annual review data capture period. This is from production wells Picardy011A and Picardy 12A.

[2] Arrow defines a material change as only occurring if water production increases above the original forecast used in the 2019 UWIR.

2.2.4.1 Predicted Impacts

The combined water volume for the production testing was 0.47 ML for the annual review period. This amount of water produced is below the volume produced from the reference pilot site. Therefore, any IAA arising from production testing wells in the 2021 annual review data capture period will be smaller than that associated with the reference pilot site. A 1-kilometre IAA radius consistent with the methodology outlined in the 2019 Bowen UWIR showed that no landholder bores are located in proximity to the testing as displayed Figure 5.

Based on the limited production, no change is proposed to the modelling undertaken for the 2019 Bowen UWIR. Therefore, the maps in Figure 2 and Figure 3 do not require updating.

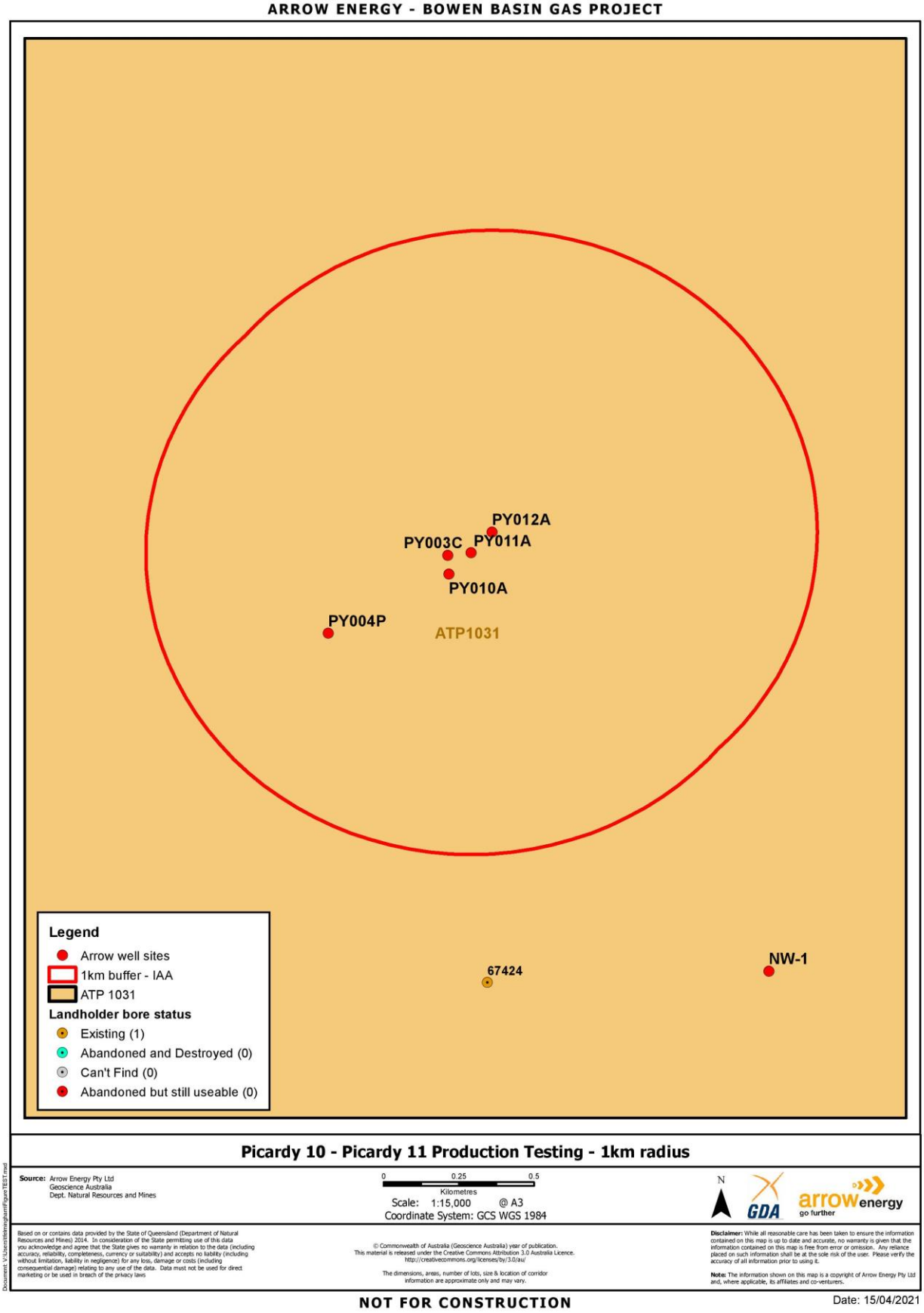


Figure 5: 1km buffer Picardy 11 and 12

2.2.5 ATP 742

ATP 742 is located approximately 50 kilometres north of the MGP. A total of 0 ML of water has been produced as part of production testing on ATP 742 for the 2021 annual review data capture period.

2.2.5.1 Predicted Impacts

No further production testing has been undertaken in any wells on ATP 742 since the UWIR and therefore there is no material change in the information or predictions made in the 2019 Bowen UWIR. Based on this, no change is proposed to the modelling undertaken for the 2019 Bowen UWIR. Therefore, the maps in Figure 2 and Figure 3 do not require updating.

3 WATER MONITORING STRATEGY (WMS)

3.1 MGP Area Groundwater Monitoring Network

A total of 16 groundwater monitoring bores form the groundwater monitoring network for the MGP Area. Figure 6 provides an overview of the spatial distribution of the groundwater monitoring network. Groundwater monitoring is being undertaken in these bores in accordance with the WMS in the approved 2019 Bowen UWIR.

As discussed in Section 4.3 and the 2019 UWIR, drawdown observed in monitoring bore M162V has resulted in water level dropping below the pump intake and as a result water sampling could not be undertaken. Sampling has been undertaken at production well (M134GM) since 2017, which is located approx. 480 m north of M162V. The well has been completed to approximately the same depth as M162V and intersects the MCM seam. Water quality sampling will be undertaken in production well M134GM until water levels recover sufficiently to allow sampling to be carried out again in M162V.

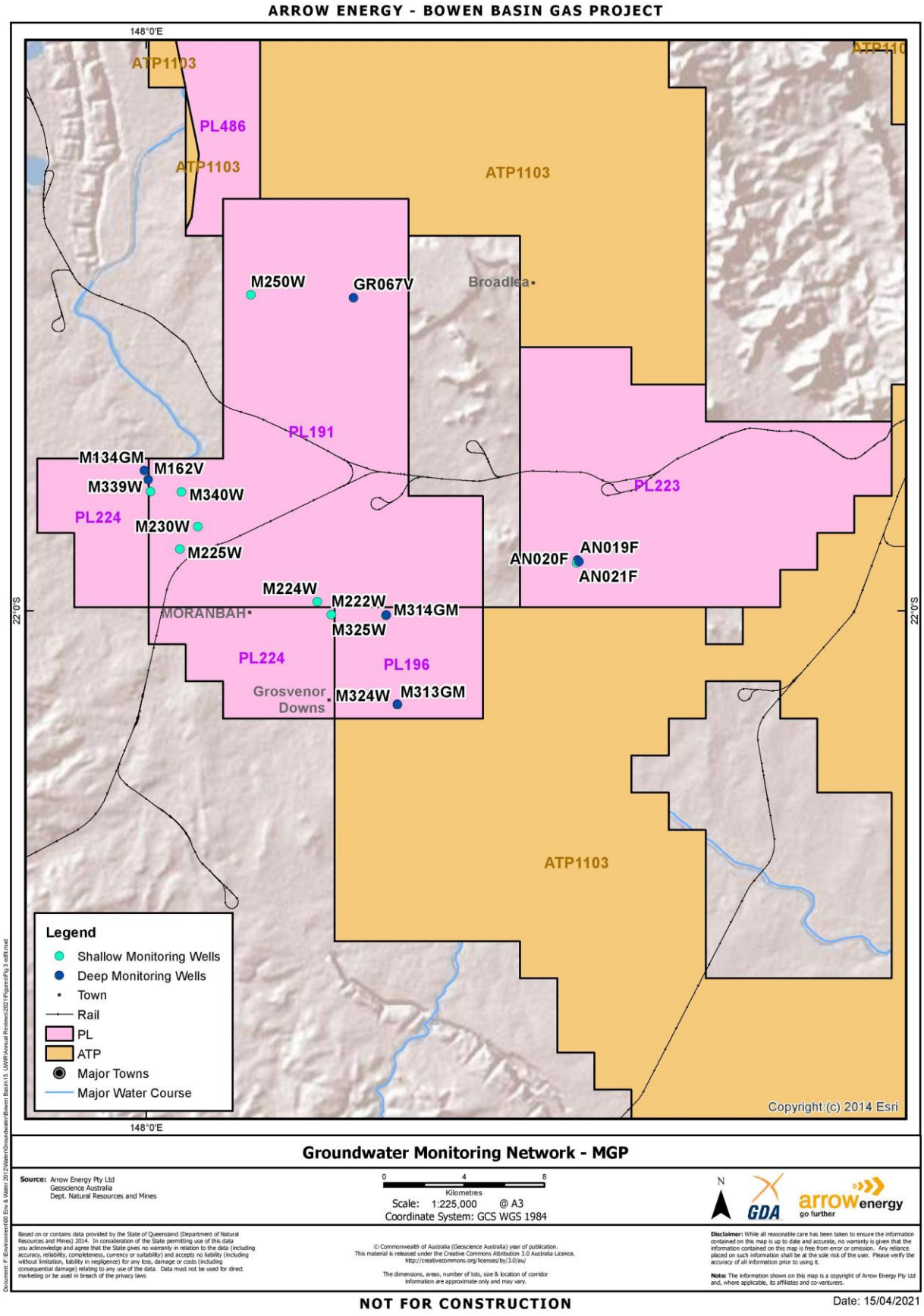


Figure 6: Groundwater Monitoring Network for MGP

3.2 BGP Area Groundwater Monitoring Network

The network is comprised of 35 monitoring intervals at 22 separate locations (comprising 12 single sites and 10 nested sites of 23 monitoring intervals) form the approved groundwater monitoring network for the BGP area. Figure 7 provides an overview of the spatial distribution of the groundwater monitoring network. Table 4 below displays the monitoring requirements of the BGP, along with the status of each location. Note that Table 4 displays the monitoring location name as per the 2019 Bowen Groundwater Monitoring and Management Plan (GMMP) which was submitted to the Commonwealth Department of the Environment and Energy to comply with Arrow Energy's approval for the BGP on 18 October 2019. All subsequent reporting is based off this nomenclature.

The network includes phased installation of the monitoring bores in advance of CSG development in the vicinity of the bores as detailed in Section 8.1.1.1 of the 2019 UWIR. At present, 9 monitoring points have been installed at seven locations as a part of the monitoring network; MB1-S/I/D, MB2, MB3, MB12, GW004, GW007 and AEN1063 as detailed below.

MB1-S/I/D

MB1 was installed as an appraisal (pilot) production well (originally named Red Hill-30) in January 2010. Groundwater level observations were made from the Moranbah Coal Measures (i.e. the deep interval) using the well from November 2011 to December 2011. Pumping from the well (for the pilot) was also undertaken during this time.

Pilot operation (and monitoring) ceased between December 2011 and November 2012.

The well was again monitored from 30 November 2012. The water level in Red Hill-30 had recovered to within 92% of its original baseline level prior to pumping for the pilot recommencing in December 2012.

From December 2012 the pilot was again operated (including production from Red Hill-30). Production from Red Hill-30 and the other pilot well in the pilot ceased in May and April 2013 respectively. Monitoring in Red Hill-30 continued until it was suspended in September 2013.

In October 2019, MB1 was modified by installation of a multi-level monitoring system to enable additional monitoring from the intermediate and shallow intervals to take place. Groundwater level data has been collected from all three intervals in MB1 since 11 November 2019. Drilling information for MB1 identified sufficient Quaternary / Tertiary Sediment or Rangal Coal Measures were not encountered at this location, and, the shallow and intermediate monitoring points are instead located within the Fort Cooper Coal Measures.

MB2

MB2 was installed as an appraisal (pilot) production well (originally named Red Hill-60) in January 2011. Groundwater level observations were made from the Moranbah Coal Measures using the well from September to October 2015 (1.5 months), October 2017 to May 2018 (8 months), February 2019 to October 2019 (7 months) and, following a period of data loss between October 2019 to January 2020, from January 2020 until present. This data loss affected MB2 and MB3 due to the installed telemetry system not sending data to Arrow's server. An investigation on why this occurred identified that the route cause was human error. Following this, routine manual checking of the reporting status of the telemetry system was implemented. Additionally, an automatic alert system was then implemented in January 2021 that alerts Arrow personnel when telemetry data loss is found on monitoring locations and the telemetry system can be restarted to allow continuous logging.

Pumping (intermittently) from the well (for the pilot) was undertaken between 2012 and 2018. The well was converted to a monitoring well using the existing downhole pressure gauge in February 2019.

MB3

MB3 was installed as an appraisal (pilot) production well (originally named Red Hill-51) in November 2011. Groundwater observations were made from the Moranbah Coal Measures using the well from September 2013 to May 2014 (9 months), October 2017 to May 2018 (7 months), and February 2019 to October 2019 (7 months, with data loss affecting this site until January 2020, as for MB2). Following reinstatement of the telemetry system, it was identified that the downhole pressure gauge failed during the period of data loss. The well was converted to a monitoring well using the existing downhole pressure gauge in February 2019.

An adjacent appraisal (pilot) production well (originally named Red Hill-50) was converted to a monitoring well in September 2020 which will then fulfil monitoring requirements for MB3.

MB12

MB12 was installed as a mine monitoring bore (originally named EFGW5D) by Fitzroy Mining in June 2008. Groundwater level observations were made from the Rewan Formation through both manual water level measurements and hourly data logger measurements since January and July (respectively) 2018. A data logger was installed in the monitoring bore in July 2018 which is still in operation.

Supplementary monitoring bores

These monitoring locations comprise existing third-party monitoring bores and landholder bores and are included in the monitoring network

GW004 and GW007

GW001, GW004 and GW007 were installed as mine monitoring bores by BHP Mitsubishi Alliance (BMA) in 2011. Arrow commenced monitoring of GW001 and GW007 in November 2019.

GW004 was chosen as a replacement of GW001 from November 2020 due to data and logger reliabilities associated with the vibrating wire piezometers installed in GW001 which failed in March 2020. A logger was deployed in GW004 during the November 2020 sampling round.

AEN1063

A logger was deployed in AEN1063 during the November 2020 sampling round after an access and monitoring agreement was completed with the landholder. The location of this bore is on the same property and same formation (Blackwater Group) as the monitoring point AEN1036, proposed in the GMMP. AEN1063 was chosen for monitoring after assessment of the bores on the property, with this bore being the most suitable for long term monitoring.

Bore locations for the remaining supplementary monitoring have been visited and assessed as suitable for long term monitoring and are awaiting execution of agreements with the landholders before logging equipment is installed. These bores are currently visited for manual water level monitoring every six months.

Table 4: BGP Monitoring network

Monitoring location	Monitoring interval and target formation	Development area	Status/Indicative year of installation	Status
MB1	S – Quaternary / Tertiary I – RCM D – MCM	PL486	2019	Currently on monitoring Groundwater level monitoring was required twice daily until 11/11/2020, which has been achieved. Going forward, a minimum of 6-monthly water level measurements are required for remainder of CSG production. Water quality sampling was required from MB1-D at biannual frequency for the first year, which has been achieved. Going forward annual monitoring is required.
MB2	MCM		Current	Currently on monitoring. Groundwater level monitoring was required twice daily until 31/10/2020 ,which has been achieved. Going forward, a minimum of 6-monthly water level measurements are required for remainder of CSG production. Online date is 16 February 2019 however data was lost between 30 October 2019 and 9 January 2020.
MB3	MCM		Current	Currently on monitoring. Groundwater level monitoring was required twice daily until 31/10/2020, which has been achieved. Going forward, a minimum of 6-monthly water level measurements are required for remainder of CSG production. Online date is 16 February 2019 however data was lost between 30 October 2019 and 9 January 2020.
MB4	Unconfined alluvium		Contingent	Not currently required as criteria not yet triggered. Requirement for installation is based on (modelled) increased risk of depressurisation resulting from changes in the FDP, or MB1 groundwater level monitoring data indicate interconnectivity of MCM with overlying units.
MB5	Tertiary / Triassic	ATP1103	2020	Not currently required due to no development within 10km.
MB6	Quaternary / Tertiary	ATP742	Contingent	Not currently required as criteria not yet triggered. Requirement for installation is based on (modelled) increased risk of depressurisation resulting from changes in the FDP, or monitoring of other sites in the northern development area indicate the potential or likelihood of preferential groundwater flow occurring across formations by way of geological faults
MB7	S – Tertiary D – RCM	ATP742	2029	Not currently required due to no development within 10km.
MB8	Quaternary / Tertiary	ATP742	2030	Not currently required due to no development within 10km.
MB9	S – Quaternary / Tertiary I – RCM D – MCM / FCCM	ATP1103	2029	Not currently required due to no development within 10km.
MB10	Tertiary	ATP1103	2030	Requires installation immediately prior to commencement of pumping from Wards Well pilot wells.
MB11	S – Quaternary / Tertiary or Rewan Formation D – RCM	ATP1103	2029	Not currently required due to no development within 10km.
MB12	Quaternary / Tertiary	ATP1103	Current	Existing Fitzroy Mining monitoring bore (EFGW5D) being utilised to obtain groundwater level monitoring data in place of MB12. EFGW5D is located approximately 345m from the proposed location for MB12. Monitoring commenced in July 2018. Groundwater level monitoring will include 6-monthly water level measurements for remainder of CSG production.
MB13	S – Quaternary / Tertiary (if present) D – Blackwater Group (RCM / FCCM / MCM)	ATP1103 ATP1103	Contingent - 2028	MB13S not currently required due to no development within 10km. Requirement for installation of MB13D is based on monitoring of MB13-S and/or other monitoring points in the southern development area indicates the potential or likelihood of preferential groundwater flow occurring across formations by way of geological faults, or ongoing modelling or revised development indicates a greater risk of depressurisation impact at this location.
MB14	S – Quaternary / Tertiary I – RCM D – MCM / RCCM	ATP1103 ATP1103 ATP1103	2029	Not currently required due to no development within 10km.
MB15	S – Unconfined alluvium I – Tertiary / Triassic	ATP1103 ATP1103	2029	Not currently required due to no development within 10km.
MB16	Tertiary	ATP1103	2029	Not currently required due to no development within 10km.
MB17	S – Unconfined alluvium I – Rewan Formation	ATP 1103 (in proximity to Lake Elphinstone)	Contingent	Not currently required as criteria not yet triggered. Requirement for installation is based on if revised modelling indicates a risk of depressurisation impacts to Lake Elphinstone, or if impacts are detected at MB11-S.
Supplementary monitoring bores				
AEN1214	Rangal Coal Measures	ATP742	Current	Manual measurements recorded every 6-months. Awaiting access and monitoring agreement for deployment of logger.
AEN1063	Blackwater Group	ATP1031	Current	On monitoring as of November 2020. Suitable replacement for proposed AEN1036 as on same property and drilled to the same formation.
AEN1234	Quaternary alluvium	ATP1234	Current	Suitable replacement for proposed AEN1050. Manual measurements recorded every 6-months. Awaiting access and monitoring agreement for deployment of logger.
GW004	Alluvium Fort Cooper Coal Measures	ATP1103	Current	On monitoring as of November 2020. Replaces GW001 due to logger failure.
GW007	Alluvium Fort Cooper Coal Measures	PL486	Current	On monitoring as of November 2020.

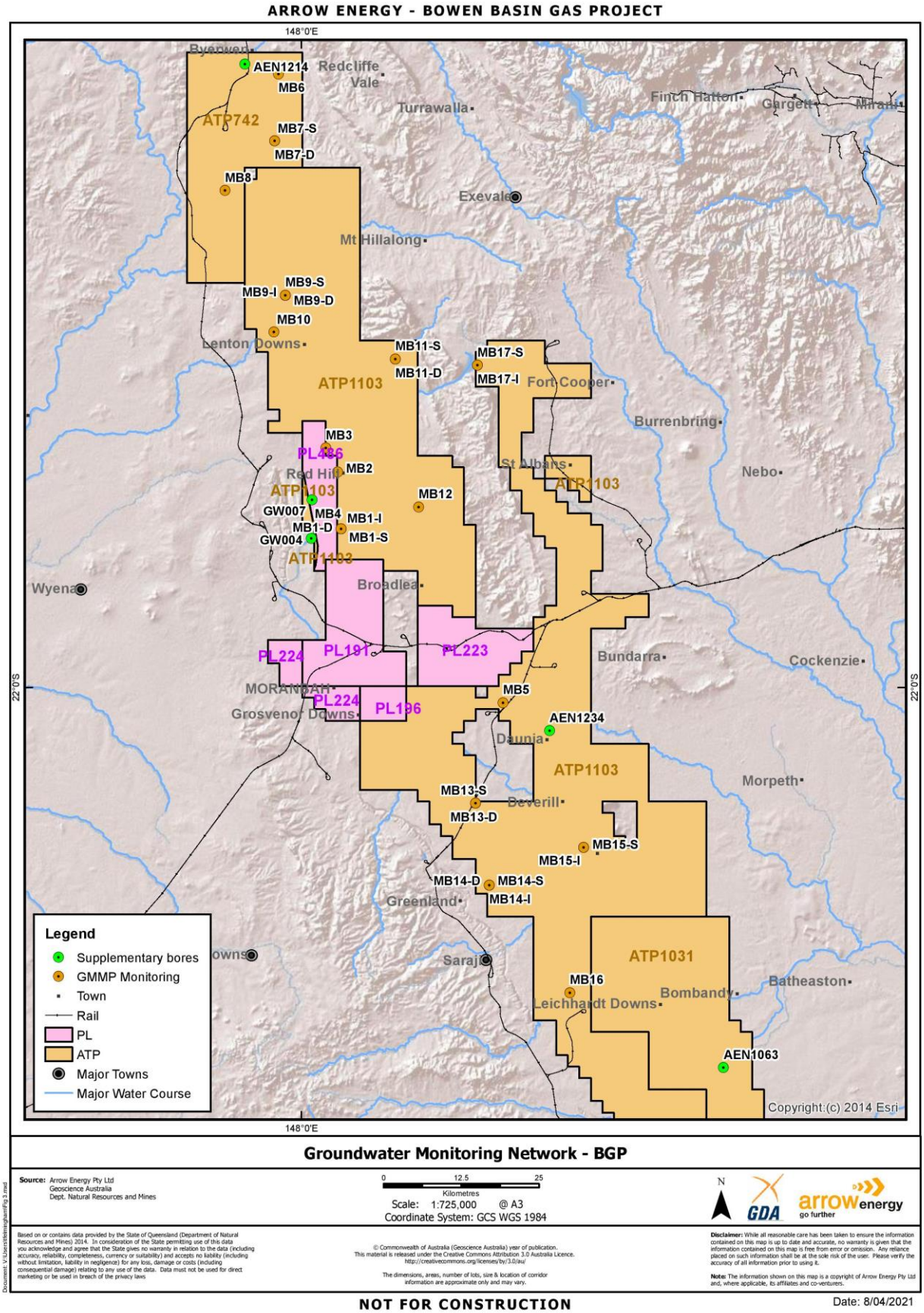


Figure 7: Groundwater Monitoring Network for BGP

4 GROUNDWATER ASSESSMENT UPDATE

4.1 Trigger Levels

The trigger levels associated with the 2019 Bowen UWIR are the bore trigger threshold as defined in the Water Act (2000). Bore trigger threshold, for an aquifer, means a decline in the water level in the aquifer that is –

a) If a regulation prescribes the bore trigger threshold for an area in which the aquifer is situated – the prescribed threshold for the area; or
b) Otherwise –
    i. For a consolidated aquifer – 5m; or
    ii. For an unconsolidated aquifer – 2m.

Based on this, the applicable bore trigger threshold for the MGP and BGP is 5 m for a consolidated aquifer and 2 m for an unconsolidated aquifer. Consistent with the Water Act, no trigger thresholds are proposed for water quality.

4.2 Groundwater Level Monitoring

4.2.1 Shallow Monitoring Bores

Groundwater level monitoring has been undertaken in the following shallow groundwater monitoring bores which form part of the 2019 Bowen UWIR groundwater monitoring network for the MGP and BGP Area (Table 5 provides a summary of these bores).

- Monitoring since June 2012 for bores M339W, M225W, M340W, M230W, M250W, M224W, M222W;
- Monitoring since March 2016 for bores AN020F and AN021F;
- Monitoring since January 2018 for bore MB12;
- Monitoring since November 2019 for bores MB1-S and GW007A;
- Monitoring since November 2020 for bores GW004A, GW004B, AEN1214, AEN1234 and AEN1063.

Table 5: Shallow Groundwater Monitoring Bores

Bore ID	Network	Total Constructed Depth (m)	Screen Interval (mbgl)	Screened Formation
M339W	MGP	41.0	35.0 – 41.0	Weathered Tertiary Basalt
M225W	MGP	34.0	23.0 – 34.0	Weathered Tertiary Basalt
M340W	MGP	27.3	19.3 – 27.3	Weathered Tertiary Basalt
M230W	MGP	32.0	29.0 – 32.0	Weathered Tertiary Basalt
M250W	MGP	56.5	44.5 – 56.5	Tertiary Sediment
M224W	MGP	32.5	26.5 – 32.5	Quaternary Alluvium
M222W	MGP	30.2	20.0 – 26.0	Weathered Fort Cooper Coal Measures
AN020F	MGP	77.0	70.0 – 72.0	Rewan Formation
AN021F	MGP	27.0	20.0 – 22.0	Tertiary Sediment
MB1-S	BGP	60	45.0 – 50.0	Fort Cooper Coal Measures – Girrah Seam
MB12	BGP	59.1	56.0 – 59.0	Rewan Formation
GW004A	BGP	13.5	7.5 – 13.5	Tertiary Sediment
GW004B	BGP	59	53.0 – 59.0	Fort Cooper Coal Measures
GW007A	BGP	7.5	1.5 – 7.5	Tertiary Sediment
AEN1214	BGP	37.32	-[1]	Rangal Coal Measures
AEN1234	BGP	60.7	-[1]	Blackwater Group
AEN1063	BGP	52.6	39.6 – 45.7	Blackwater Group

[1] – The exact screened interval will be determined during the next site visit.

The groundwater level monitoring results are shown in Appendix A. Groundwater levels, are shown in Figure 8 to Figure 10 and are discussed below for the MGP and BGP areas.

MGP:

The groundwater levels in the MGP range from:

- 200.4 to 209.2 m Australian Height Datum (AHD) in the weathered Tertiary Basalt aquifer;
- 233.2 to 242.3 m AHD in the Tertiary Sediment aquifer;
- 209.0 to 211.7 m AHD in the Quaternary Alluvium aquifer;
- 202.4 to 206.3 m AHD in the Fort Cooper Coal Measures aquifer; and
- 237.2 to 238.6 m AHD in the Rewan Formation.

All bores located within close proximity to the Isaac River display similar depths to groundwater. This is shown in Figure 11.

The groundwater levels for bores M250W, AN021F, AN021Fand AN020F are higher due to the respective surface elevation in the areas being approximately 50 to 60m, 30 to 40m and 85 to 95m, respectively, above the other bores. As indicated in Table 5, M250W and AN021F are installed in the Tertiary Sediment and located approximately 10 km north and east of the other groundwater monitoring sites along the Isaac River, while MB12 is constructed within the Rewan Formation and located approximately 26km northeast of the other groundwater monitoring sites along the Isaac River.

A comparison of modelled drawdown predictions made in the 2019 Bowen UWIR with monitoring data to date has been undertaken. There is no predicted IAA or LAA for unconsolidated aquifers for the MGP and BGP; as modelled drawdown does not exceed the bore trigger threshold of 2 metres. The monitoring data to date supports this modelled prediction in the 2019 Bowen UWIR.

Groundwater monitoring further indicates:

- Actual groundwater levels monitored in bore M339W have remained steady over the monitoring period.
- The water levels in M222W and M225W have continued to steadily rise since monitoring began in 2012.
- Figure 10 displays cumulative rainfall departure and groundwater levels at groundwater monitoring bores M225W, M230W, M222W and M224W. Recharge to shallow aquifers due to above mean rainfall has continued to contribute to the rising trend in groundwater levels noted in M222W and M225W with a peak at the end of 2017. The water level in M230W has declined since this peak, likely due to nearby mining operations as discussed below.
- There is no predicted IAA or LAA for any aquifer underlying PL 223; hence modelled drawdown greater than the bore trigger threshold at the end of 2019 was not predicted in the 2019 Bowen UWIR to occur at the location of bores AN020F and AN021F. AN021F is installed in the Tertiary Sediment and has increased in water level since monitoring began. AN020F is installed in the Rewan Formation which is considered to be a regional aquitard. Groundwater levels monitored at AN020F have remained steady over the monitoring period.
- A decline in groundwater level by greater than the bore trigger threshold was noted at bore M224W between November 2017 and November 2019. As discussed in the 2019 Bowen UWIR, the water levels in this bore indicate a possible hydraulic link to the river level fluctuations. This is in-line with the conceptual hydrogeological model report in the 2019 Bowen UWIR, where there is linkage between rainfall events and river level flow periods to groundwater level. This decline greater than the bore trigger threshold between November 2017 and November 2019 is not considered to be due to the effects of CSG production.
- A decline in groundwater level by greater than the bore trigger threshold was noted at bore M230W between November 2017 and November 2019. The water levels observed in this bore are considered to have been influenced by nearby mining operations; a review of mine plan schedules indicated that “drive Number-1” traversed the area in proximity to M230W between Q3 and Q4-2017 indicating that the SWL decline were expected to be a result of the Anglo underground mine development. This was similar to the decline seen in M340W (as discussed in the 2017 Annual Review of the 2016 Bowen UWIR) where a decline in groundwater levels has made this monitoring borehole dry. Both monitoring bores are in the same area, as shown in Figure 6. Accordingly, the decline is not considered to be due to the effects of CSG production.
- Water level decline and recovery in MB12 is due to water quality sampling (pumping) being undertaken in the bore. The frequency of water quality sampling was decreased in H2 2019 where subsequent water level data show water level recovery between monitoring events.

Based on the graphically presented monitoring data in Figure 8, it is clear that there is no apparent influence of CSG production to the Quaternary alluvium, weathered Tertiary basalt, Tertiary sediment, weathered Fort Cooper coal measures and Rewan aquifers in which these bores are installed. This data supports the groundwater modelling predictions in the

2019 Bowen UWIR and drawdown greater than the bore trigger threshold due to CSG production is not observed as was predicted.

BGP:

Groundwater level monitoring has been undertaken in the following shallow groundwater monitoring bores which form part of the BGP monitoring network. Table 6 provides a summary of these bores.

- Monitoring since January 2018 for bore MB12; and
- Monitoring since November 2019 for bores MB1-S, GW001A and GW007A.

Table 6: BGP Shallow Groundwater Monitoring Bores

Bore ID	Total Constructed Depth (m)	Screen Interval (mbgl)	Screened Formation
MB1-S	60	45 - 50	Fort Cooper Coal Measures – Girrah Seam
MB12	59.1	56 – 59	Rewan Formation
GW001A	6.5	6.5	Tertiary Sediment
GW007A	7.5	1.5 – 7.5	Tertiary Sediment

The groundwater level monitoring results are shown in Appendix A. Groundwater levels, as is shown in Figure 8, range from:

- 227.9 to 64.75 m Australian Height Datum (AHD) in the Tertiary Sediment aquifer;
- 209.5 m AHD in the weathered Fort Cooper Coal Measures aquifer, and
- 286.4 m AHD in the Rewan Formation.

Groundwater level monitoring, as reported in the annual review for the Bowen Basin UWIR, (Appendix A) indicates:

- Groundwater levels are stable in the shallow bores;
- GW007A was recorded as dry. An alternate location may be required if GW007A is shown to be continually dry; and
- Water level decline and recovery in MB12 is due to water quality sampling (pumping) being undertaken in the bore. The frequency of water quality sampling was decreased in H2 2019 where subsequent water level data show water level recovery between monitoring events.

Based on the presented monitoring data in Figure 8, there is no apparent influence of CSG production to the Tertiary Sediment, Fort Cooper Coal Measures and Rewan aquifers in which these bores are installed. This is expected given no water production has commenced in the BGP.

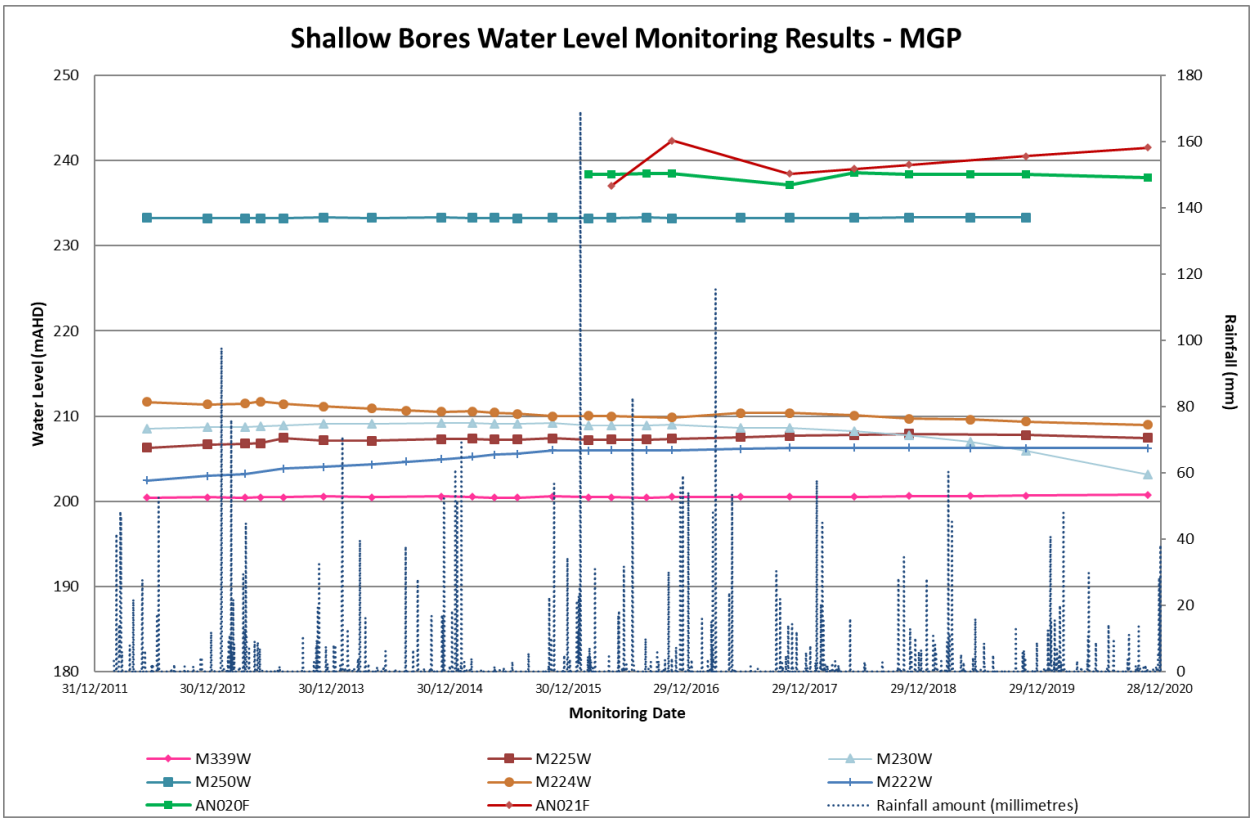


Figure 8: Shallow Bores Water Level Monitoring Results - MGP

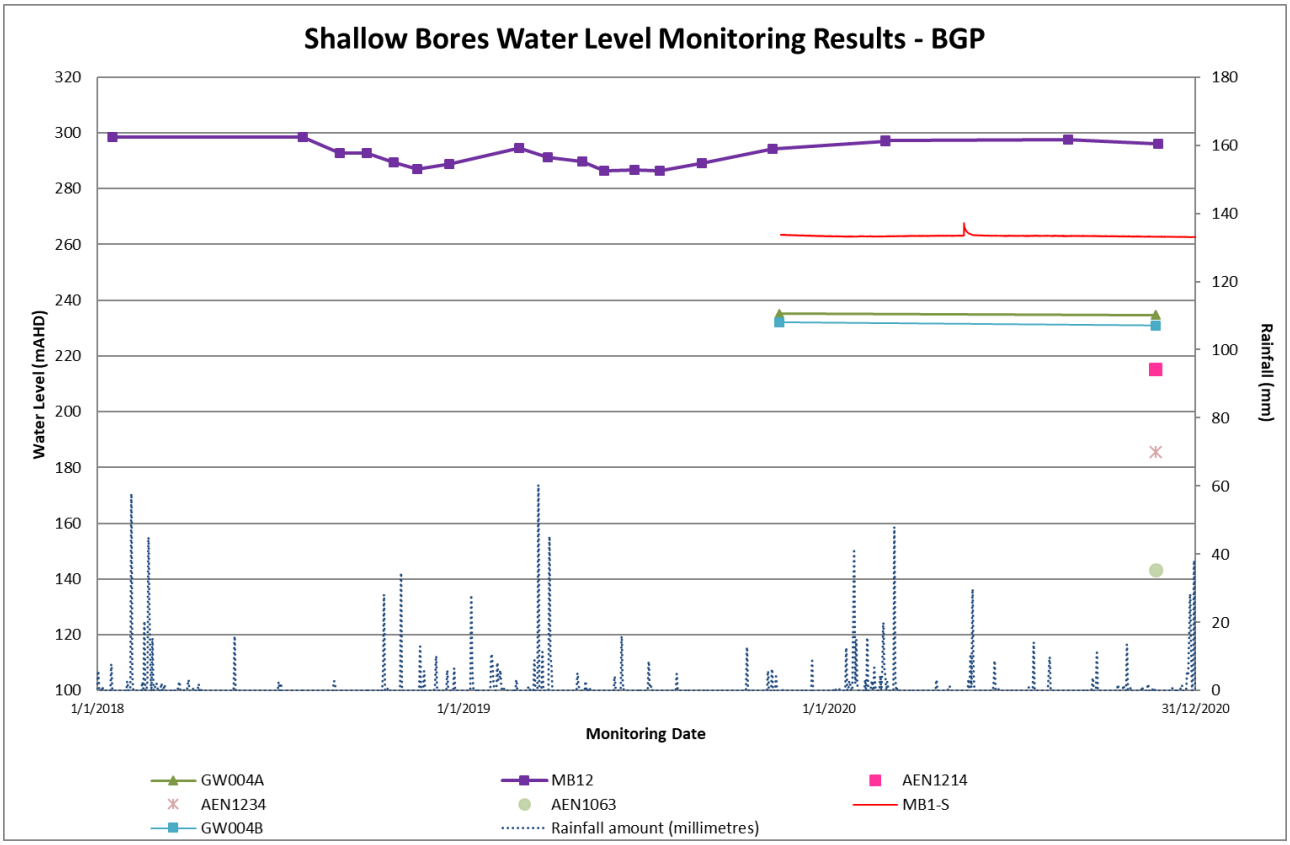


Figure 9: Shallow Bores Water Level Monitoring Results - BGP

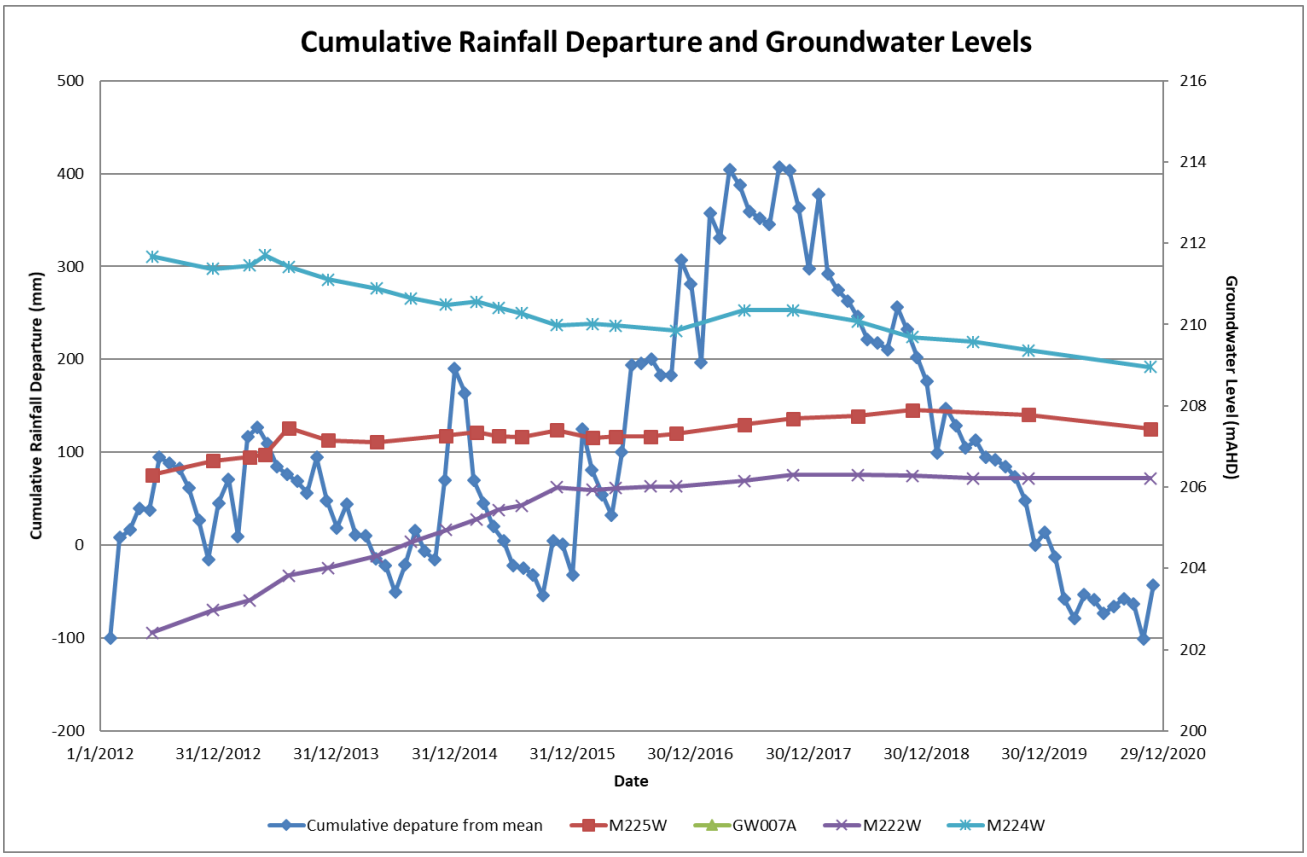


Figure 10: Cumulative Rainfall Departure and Groundwater Levels

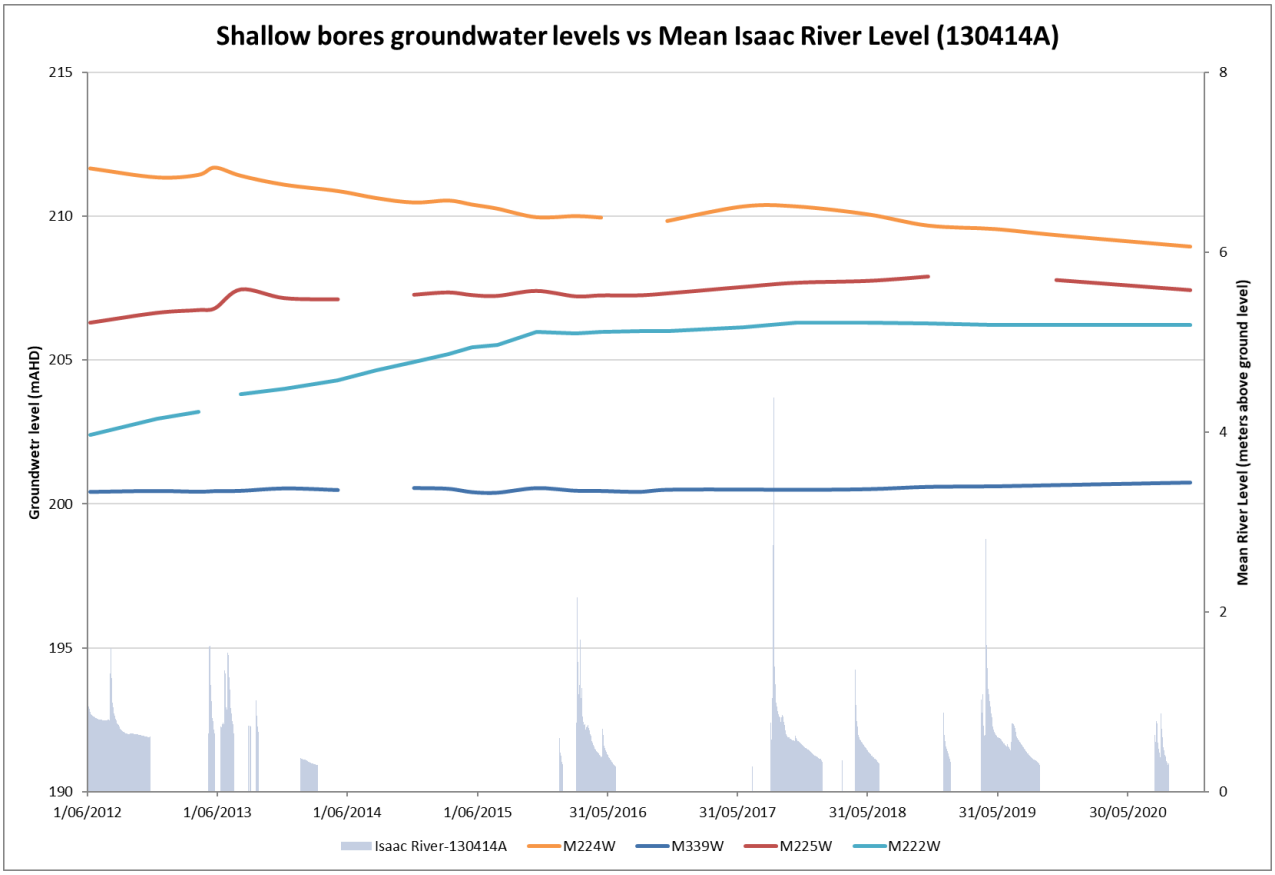


Figure 11: Shallow Groundwater levels vs mean Isaac River levels

4.2.2 Deep Monitoring Bores

Groundwater level monitoring has been undertaken in the following deep groundwater monitoring bores which form part of the 2019 Bowen UWIR groundwater monitoring network.

- Monitoring since November 2011 for MB1-D and since November 2019 for MB1-I (as detailed in Section 3.2);
- Monitoring since September 2015 for bore MB2 (as detailed in Section 3.2);
- Monitoring since September 2013 for bore MB3 (as detailed in Section 3.2);
- Monitoring since September 2014 for bores M313W, M314W, M324W;
- Monitoring since February 2015 for bore M325W;
- Monitoring since November 2015 for bores AN019F
- Monitoring since December 2015 for bore M162V;
- Monitoring since February 2016 for bore GR067V; and
- Monitoring since November 2019 for bore GW007B (as detailed in Section 3.2).

Table 7 provides details for these bores. As previously indicated in the 2018 Annual Review for the 2016 Bowen UWIR, available data suggested that the permeability of the formation that M325W is installed into is so low that recovery of groundwater levels in the Fort Cooper Coal Measures would take a very long time. The updated water level data supports the previous statement and recovery of the bore continued during the Annual Review period.

Declines in groundwater levels greater than the bore trigger threshold have been observed at bores M324W (MCM), M313W (MCM) and M162V (MCM). Monitoring data suggests that there is influence of CSG production to the MCM.

No decline in groundwater levels greater than the bore trigger threshold is observed at bores M314W (MCM), M325W (MCM), M324W (FCCM), M313W (BCG), M314W (BCG), AN019F (FCCM), and GR067V (MCM).

Table 7: Deep Groundwater Monitoring Bores

Bore ID	Total Constructed Depth (m)	Screen Interval (mbgl)	Screened Formation
M313W	532.4	313.0 – 316.5 507.0 – 510.0	Moranbah Coal Measures (QA Seam) Back Creek Group
M314W	560.5	210.5 – 213.5 551.5 – 553.5	Moranbah Coal Measures (QA Seam) Back Creek Group
M324W	240.0	163.0 – 166.0 187.0 – 190.0	Fort Cooper Coal Measures Moranbah Coal Measures (QA Seam)
M325W	202.3	180.5 – 182.0	Fort Cooper Coal Measures
AN019F	290.0	269.0 – 271.0	Fort Cooper Coal Measures
M162V	276.0	252.0 – 256.0	Moranbah Coal Measures
GR067V	610.9	543.2 – 610.9	Moranbah Coal Measures
MB1	550	336 -340 423.9-506.6	Fort Cooper Coal Measures Moranbah Coal Measures
MB2	834	701.1-814.7	Moranbah Coal Measures
MB3	796.3	712.3 – 717.9	Moranbah Coal Measures
GW007B	181.5	175.5 – 181.5	Fort Cooper Coal Measures

MGP:

The groundwater level monitoring results are shown in Figure 15. Observed groundwater levels or calculated potentiometric water levels ranged from:

- 208.3 to 216.8m AHD in the BCG;
- 49.6 to 207.7m AHD in the FCCM; and
- -129.14 to 209.5m AHD in the MCM.

A comparison of modelled drawdown predictions modelled in the 2019 Bowen UWIR with monitoring data to date has been undertaken and indicates:

- Modelled drawdown in the MCM aquifer at the end of 2020 at the location of M314W was predicted in the model to be approximately 215 m. Actual groundwater levels monitored for the MCM at M314W indicates decline in levels of approximately 3.6 m;
- Modelled drawdown in the MCM aquifer at the end of 2020 at the location of M313W and M324W was predicted in the model to be approximately 138 m. Actual groundwater levels monitored at M324W shows a maximum decline in levels by 6.63 m in March 2017. Since March 2017, the water level has recovered by 2.69 m which represents a 36% recovery of the water level prior to the drawdown as indicated in Figure 15. Actual groundwater levels monitored for the MCM at M313W shows the maximum decline in the water level of 74.53 m, as measured in March 2017. Since March 2017 the water level has recovered by 53.74 m which represents approximately 72% recovery of the original water level prior to the drawdown and as indicated in Figure 15. The graphically displayed water level curve indicates the recovery will continue. These groundwater monitoring bores are located in the southern part of PL 196 and approximately 350 m from production well GM052V. The total amount of water actually produced from GM052V during this annual review data capture period was 0 ML. Since production ceased, the water level has continued to recover;
- Drawdown in the MCM aquifer at the end of 2020 at the location of M162V was predicted to be approximately 79 m. Actual groundwater levels monitored at this site shows a steady groundwater level decrease of approximately 26.35 m;
- Drawdown in the MCM aquifer at the end of 2020 at the location of GR067V was predicted to be approximately 0.27. m. Decreases in water levels of up to 150 metres, noted in April and August 2016, are due to depressurisation activities in this bore associated with monitoring events. The recovery curve has subsequently stabilised and a standing water level of 204 mAHD is evident;

- Drawdown in the FCCM aquifer at the end of 2020 at the location of M324W was predicted to be 0.01 m. Actual groundwater levels monitored for the FCCM at M324W shows a decline of approximately 1.69 m;
- Drawdown in the FCCM aquifer at the end of 2020 at the location of AN019F was predicted to be 2.95 m. Actual groundwater levels monitored indicates a small decline of approximately 1.58 m; and
- Drawdown in the BCG aquifer at the end of 2020 at the location of M313W and M314W was not predicted to occur in the model. Actual groundwater levels monitored for the BCG at M313W and M314W indicate a decline of approximately 1.9 m and 4.45 m respectively.

Based on the monitoring data, it is concluded that observations of drawdown were generally consistent with respect to predicted exceedances of the bore trigger threshold as follows:

- Modelled drawdown greater than the bore trigger threshold was not predicted to occur at bores M313W (BCG), M314W (BCG), AN019F (FCCM), M324W (FCCM), MB1 (FCCM and MCM), GW001 (FCCM) and GW007 (FCCM) which is confirmed by the monitoring data;
- Modelled drawdown greater than the bore trigger threshold was predicted to occur at bore M314W (MCM), however monitoring data shows that water level in this bore is less than the bore trigger threshold;
- Monitoring data shows that drawdown greater than the bore trigger threshold was detected at monitoring bores M314W (MCM), M324W (MCM) and M162V (MCM). There are no existing or useable landholder bores within a 2 km radius of these locations (M162V, M313W and M324W) in the IAA aquifer.
- Modelled drawdown at sites M313W and M324W predicted drawdown greater than the bore trigger threshold, which was confirmed in the monitoring data, however drawdown detected at M313W is significantly less than that predicted; and
- Modelled drawdown at site M162V did not predict drawdown greater than the bore trigger threshold whereas the monitoring data shows drawdown greater than the bore trigger threshold. Monitored drawdown is most likely due to localised drawdown influences from nearby production.

BGP:

The groundwater level monitoring results are shown in Figure 16. Observed groundwater levels or calculated potentiometric water level ranged from:

- 256.5 to 269.1 m AHD in the FCCM; and
- -462.2 to 299.0 m AHD in the MCM.

A comparison of modelled drawdown predictions modelled in the 2019 Bowen UWIR with monitoring data to date has been undertaken and indicates:

- Drawdown in the MCM aquifer at the end of 2020 at the location of MB1 was predicted to be 4.8 m. Actual groundwater levels monitored indicates a decline of 5.3 m followed by a steady 1.7 m rise commencing in April 2020. This decline in water level is due to equilibration due to the workover of the well in late 2019 to equip the borehole with multiple pressure sensors and is not related to CSG activities. This is further discussed in Section 4.2.3.1;
- Drawdown in the MCM aquifer at the end of 2020 at the location of MB2 was predicted to be 0.4 m. Actual groundwater levels monitored indicates an increase of 247.95 m. The water level in this bore is recovering from production;
- Drawdown in the MCM aquifer at the end of 2020 at the location of MB3 was predicted to be 6.3 m. Actual groundwater levels monitored indicates an increase of 181.9 m from the recovery started in June 2019;
- Drawdown in the FCCM aquifer at the end of 2019 at the location of MB1 and GW007B was predicted to be 0 m. Actual water level monitored indicates a decline of 4.61 in MB1 and 0.79 in GW007B. The observed decline, which appears to be flattening in MB1, is likely due to equilibration of pressure within the bore and the formation following the workover when the well was topped up with water; and
- MB2 and MB3 display recovering water levels. MB2 and MB3 are prior production wells.

Analysis of MB1, MB2 and MB3 water levels was conducted to determine the recovery time of the water levels to a static condition prior to modelled drawdown at these locations to fulfil the requirements of the GMMP. The Theis recovery method was used to analyse that data and concluded that MB1 has fully recovered, and MB2 and MB3 will recover fully prior to predicted drawdown. Appendix C displays the curve analysis and graphs, with Figure 12 to Figure 14 showing the water level recovery of these wells compared to the calculated recovery. These figures show:

- MB1 water level has fully recovered.
- MB2 water level is recovering in-line with the calculated recovery.
- MB3 water level recovery is less than calculated. Due to the limited amount of data since relocation of the monitoring point, analysis will be undertaken in future reports.

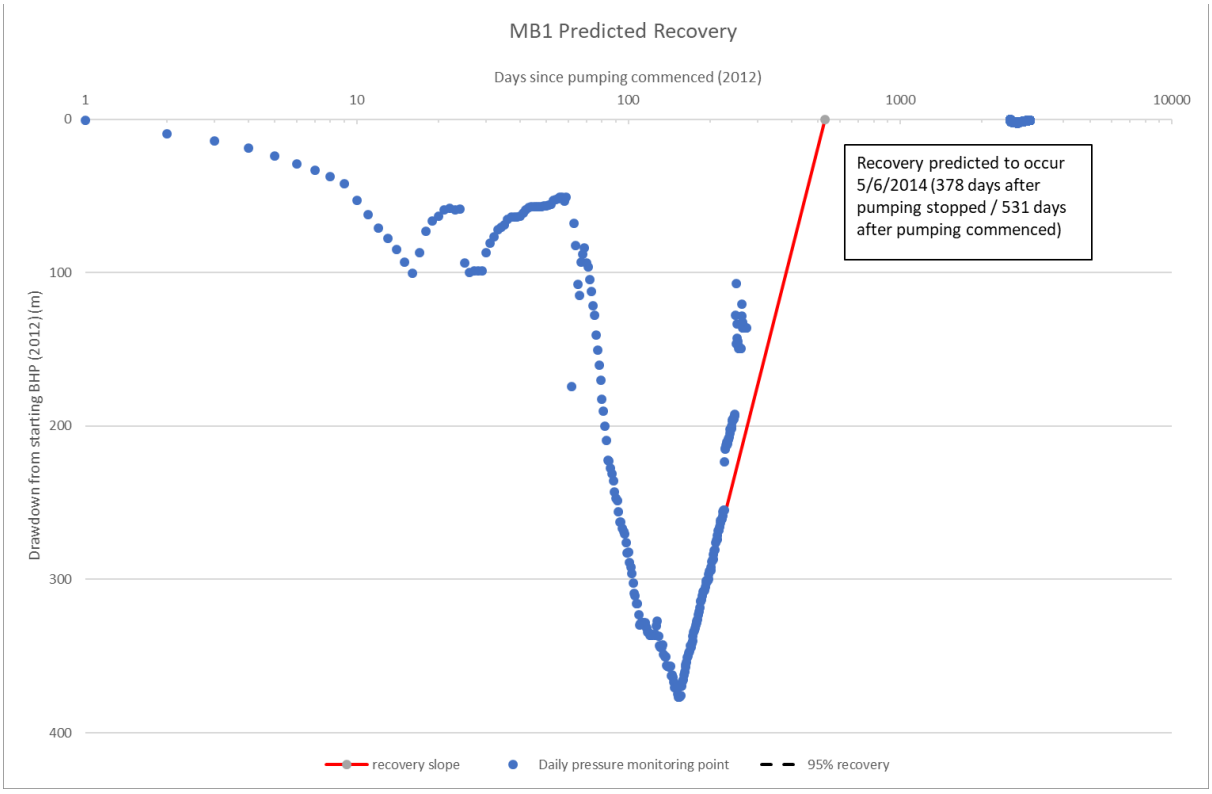


Figure 12: MB1 recovery data

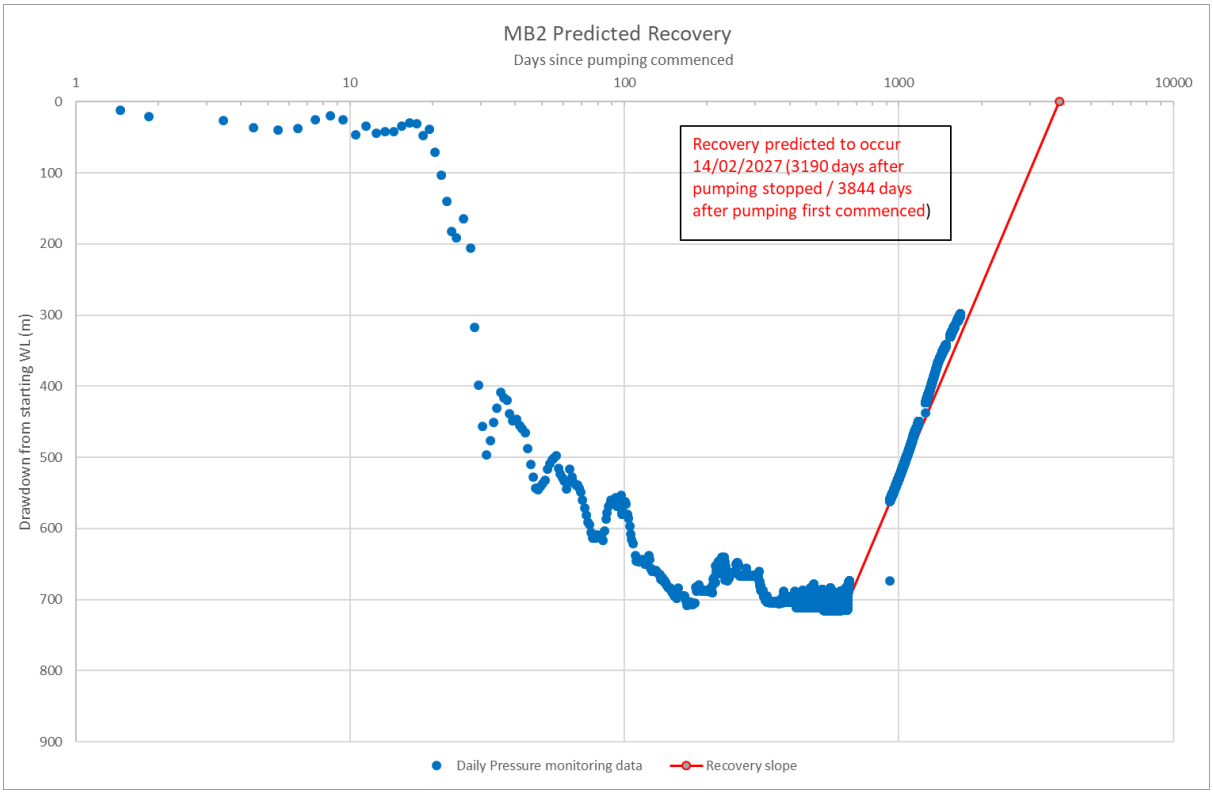


Figure 13: MB2 recovery data

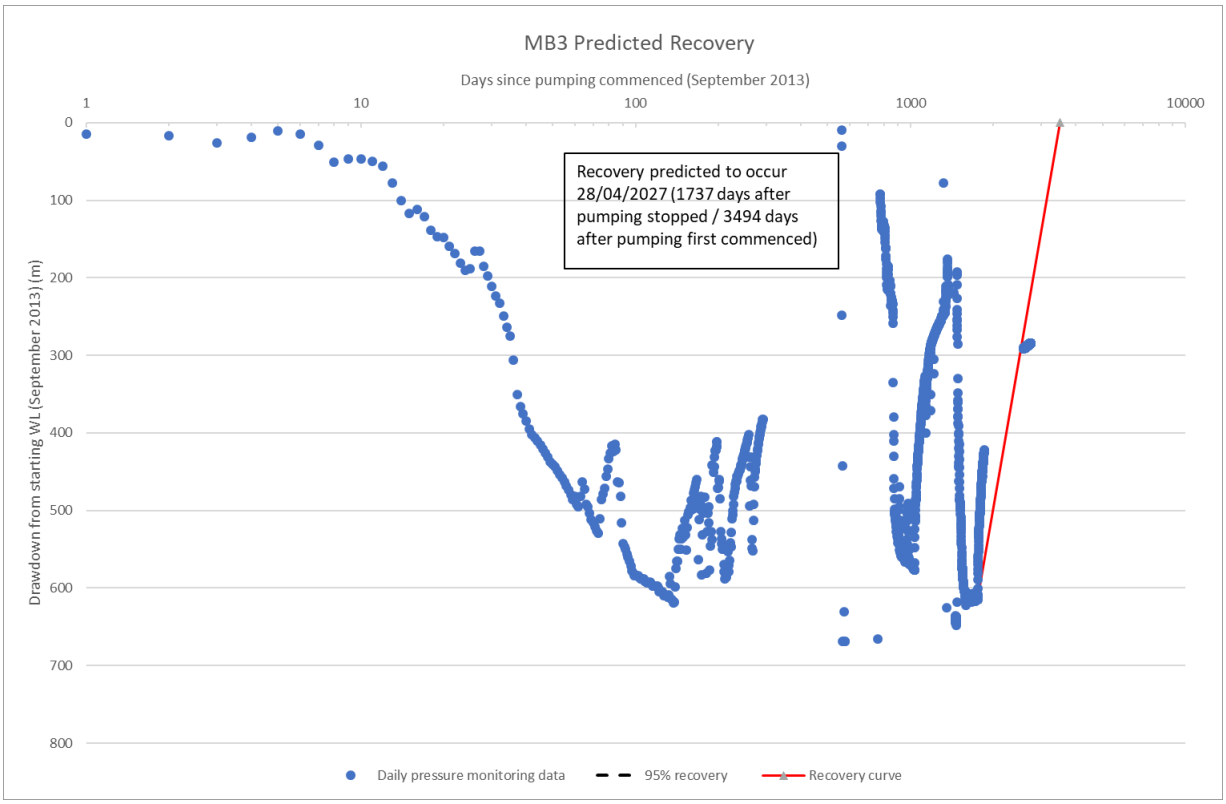


Figure 14: MB3 recovery data

Table 8 displays the predicted recovery year for each bore. As discussed in Section 3.2, the location of MB3 was changed due to a failure in a pressure gauge.

Table 8: Recovery dates – MB1, MB2 & MB3

Bore ID	Recovery date	Predicted drawdown year
MB1	05/06/2014	2021
MB2	14/02/2027	2031
MB3	28/04/2027	2031

Based on the monitoring data, it is concluded that observations of drawdown were generally consistent with respect to predicted exceedances of the bore trigger threshold as follows:

- Monitoring data shows that drawdown greater than the bore trigger threshold was detected at monitoring bores MB1. This was due to equilibration due to the workover of the well in late 2019 to equip the borehole with multiple pressure sensors and is not related to CSG activities There are no existing or useable bores within a 2 km radius at this location in the IAA aquifer.
- MB2 and MB3 display recovering water levels.

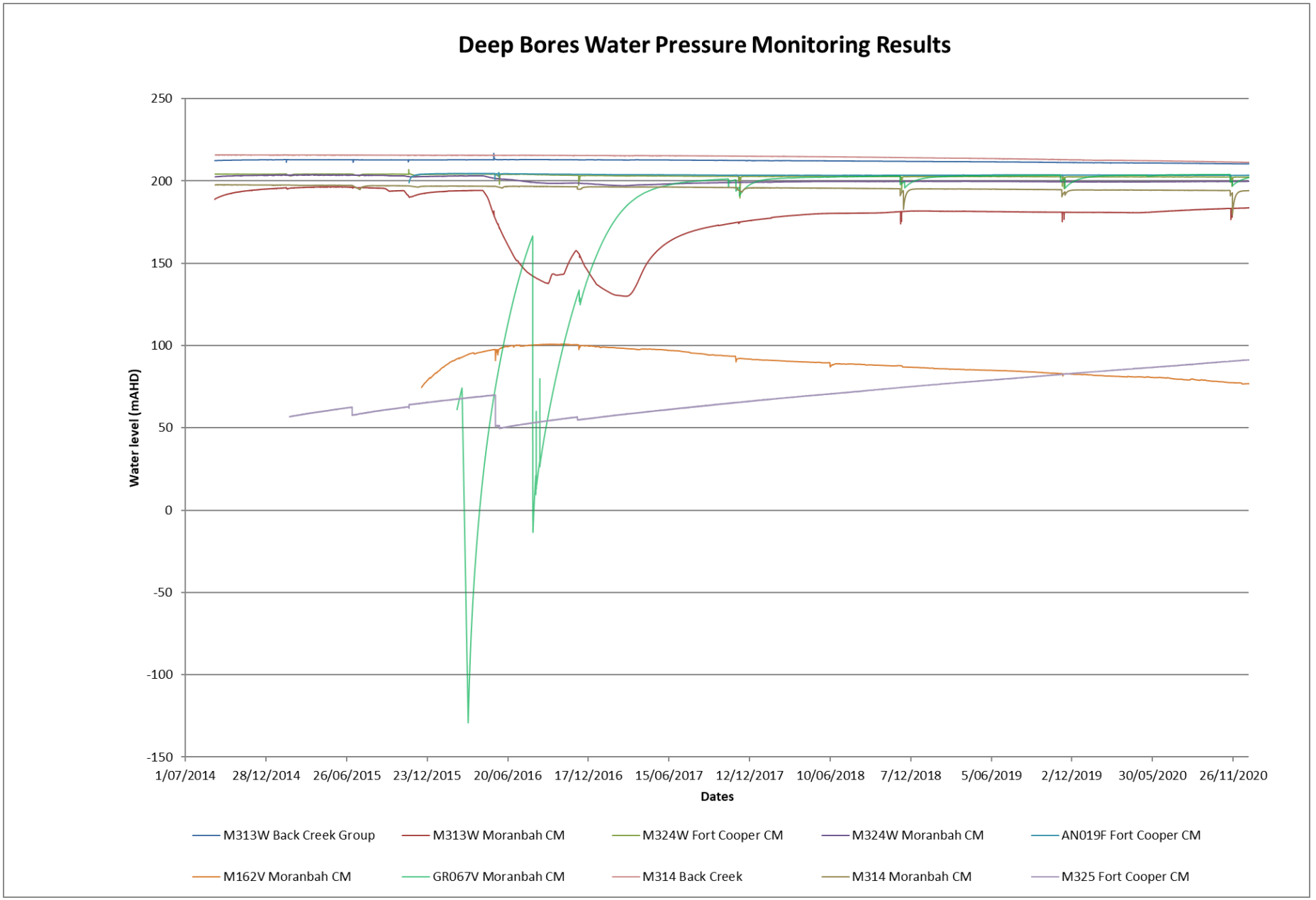


Figure 15: Deep Bores Water Level Monitoring Results - MGP

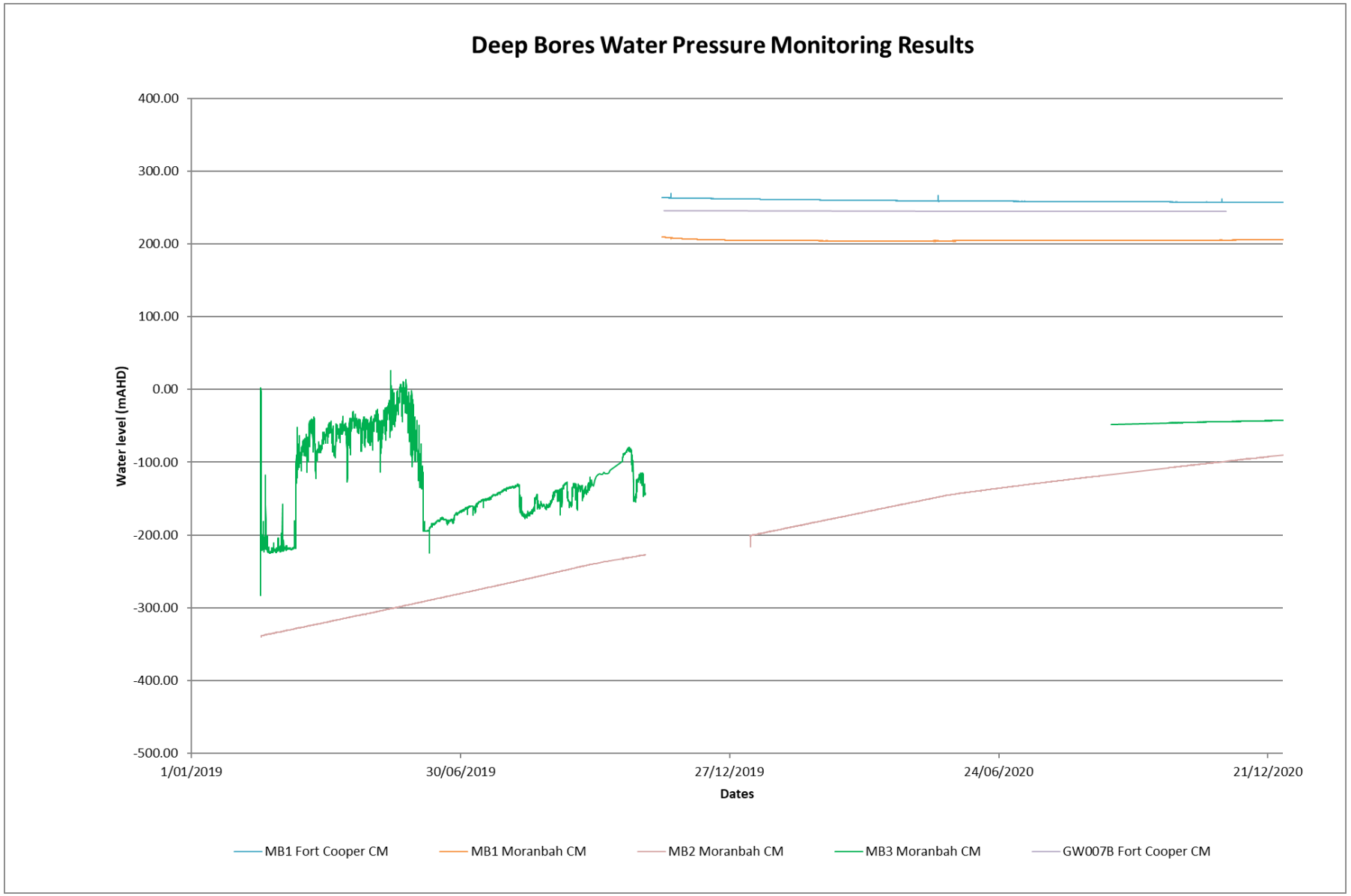


Figure 16: Deep Bores Water Level Monitoring Results - BGP

4.2.3 Groundwater Flow

A review of vertical gradients was undertaken for three monitoring locations in the MGP Area. Monitoring at each site included:

- Site 1: From deepest to shallowest; BCG (M314W), MCM (M314W), FCCM (M325W) as well as data from monitoring approximately 3 km north west in FCCM (M222W) and Quaternary Alluvium (M224W);
- Site 2: From deepest to shallowest; BCG (M313W), MCM (M313W), MCM (M324W), FCCM (M324W); and
- Site 3. From deepest to shallowest, MCM, FCCM and FCCM (Girrah seam), in MB1.

4.2.3.1 Site 1

Figure 17 below shows the vertical gradients for Site 1 and the latest data indicates the FCCM aquifer, at bore M325W, has the lowest water level. The collected and graphically displayed data indicate a very steady and continued recovery of approximately 34m. With the exception of Site 1, there is an apparent gradient toward the MCM (the target coal seams for CSG production from the MGP) i.e. upward from the BCG and downward from the Quaternary Alluvium, to the FCCM and then to the MCM.

As discussed in Section 4.2.1, water levels in monitoring bore M222W which is constructed into the FCCM show a rising trend in response to above average rainfall recharge. Water levels in M224W constructed in the Quaternary Alluvium show that trends in water levels are linked to flows in the nearby Isaac River.

As discussed in Section 4.2.2, a decline in water levels have been observed in M314W within MCM and the BCG. The water level trends between the MCM and shallow aquifer seem to indicate no vertical hydraulic links exist at this location.

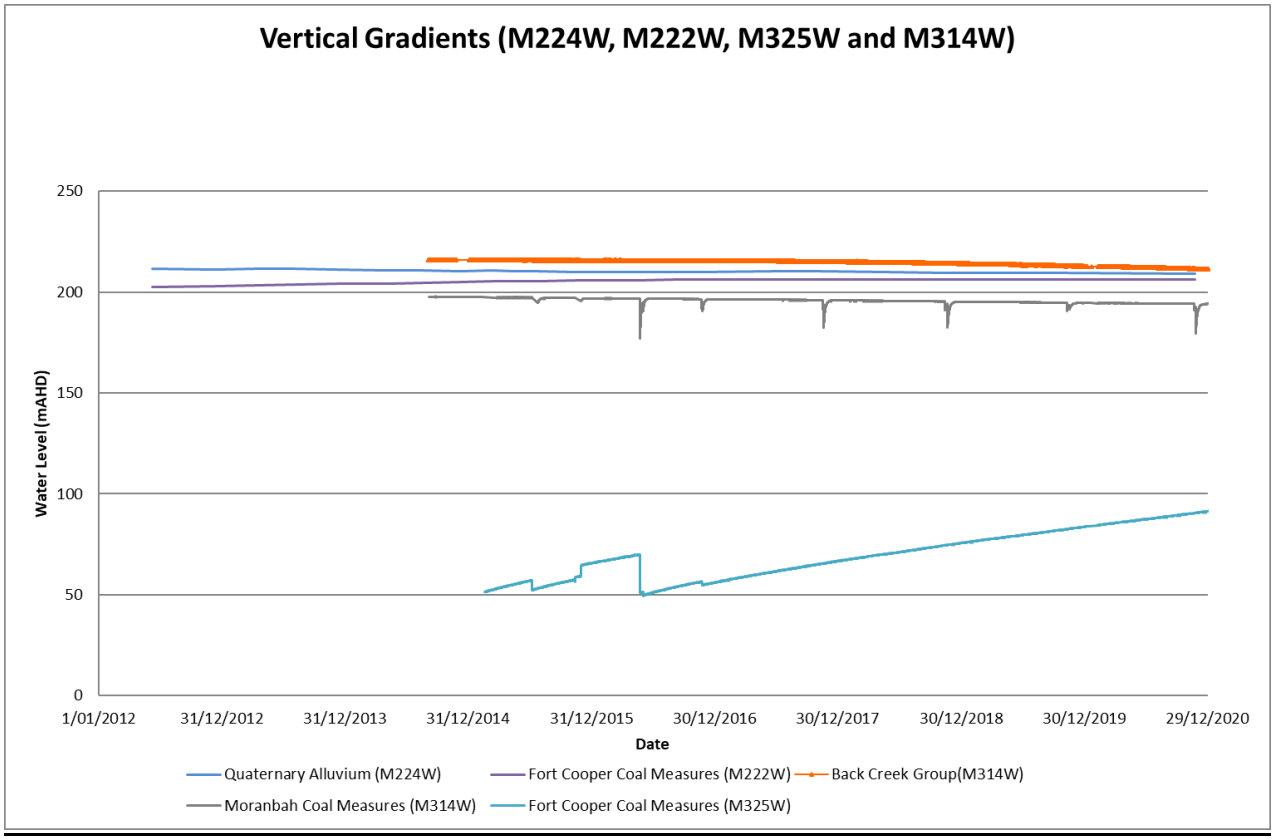


Figure 17: Site 1 - Review of Vertical Gradients (M224W, M222W, M325W and M314W)

4.2.3.1 Site 2

Figure 18 shows the graphically displayed vertical gradients for Site 2 and based on the presented data, the lower water levels in the MCM aquifer has reduced since production ceased in GM052V and recovery continues.

As discussed in Section 4.2.2, drawdown as a result of water production in CSG wells to the MCM aquifer is evident at site M313W and M324W but since the production ceased in April 2017, the water level recovery is evident in both monitoring boreholes. Monitoring data for the FCCM and BCG at this site indicates a slight decline in water levels. Decline in water

levels noted for the FCCM are observed to correlate to the water production in CSG wells and consequential drawdown in the underlying MCM. This suggests that there is some transmission of impacts from the MCM to the shallower FCCM. Whilst there is some decline in water levels in the deeper Back Creek Group aquifer, it is does not clearly correlate to the water production in the CSG wells and ongoing monitoring will confirm this. Based on this, monitoring data suggests that impacts are contained within the MCM and FCCM.

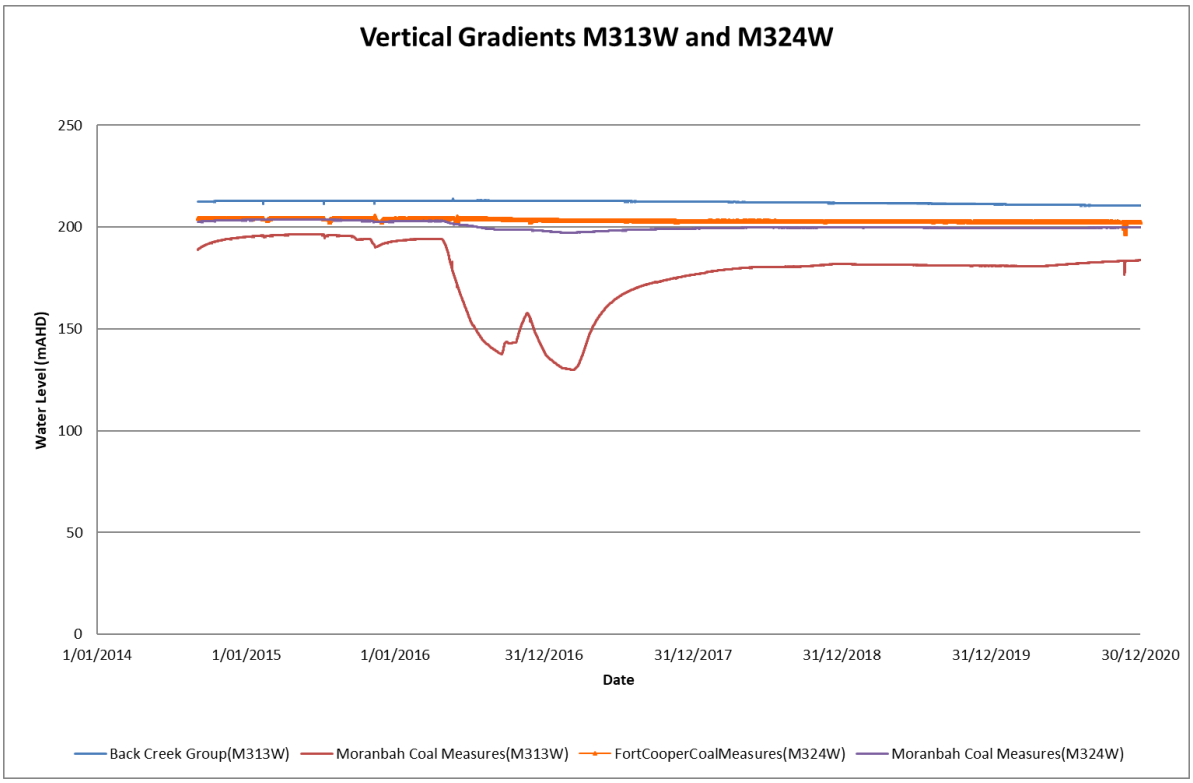


Figure 18: Site 2 - Review of Vertical Gradients (M324W and M313W)

4.2.3.1 Site 3

Figure 19 shows the graphically displayed vertical gradients for Site 3 (MB1) and based on the presented data, a decrease in water levels in the Moranbah Coal Measures is visible, with a smaller decrease seen in the Fort Cooper Coal Measures. Prior to this decrease, the Fort Cooper Coal Measures displayed similar water levels to the Quaternary Alluvium. This decline in water levels can be attributed to the workover conducted on MB1 to equip the borehole for multi-zone monitoring. During the workover process, a slug of water was introduced to 'kill' the well and due to the low permeability of the FCCM and MCM, a decline in water level was seen. As of the end of 2020, the water levels in all three zones are stabilising, with the MCM zone displaying an increase in water levels.

The sharp pressure increases in the data can be attributed to sampling events of MB1, where the pressure is bled off the borehole during sampling.

Ongoing monitoring at this site will provide further information on the interconnectivity of aquifers at these sites.

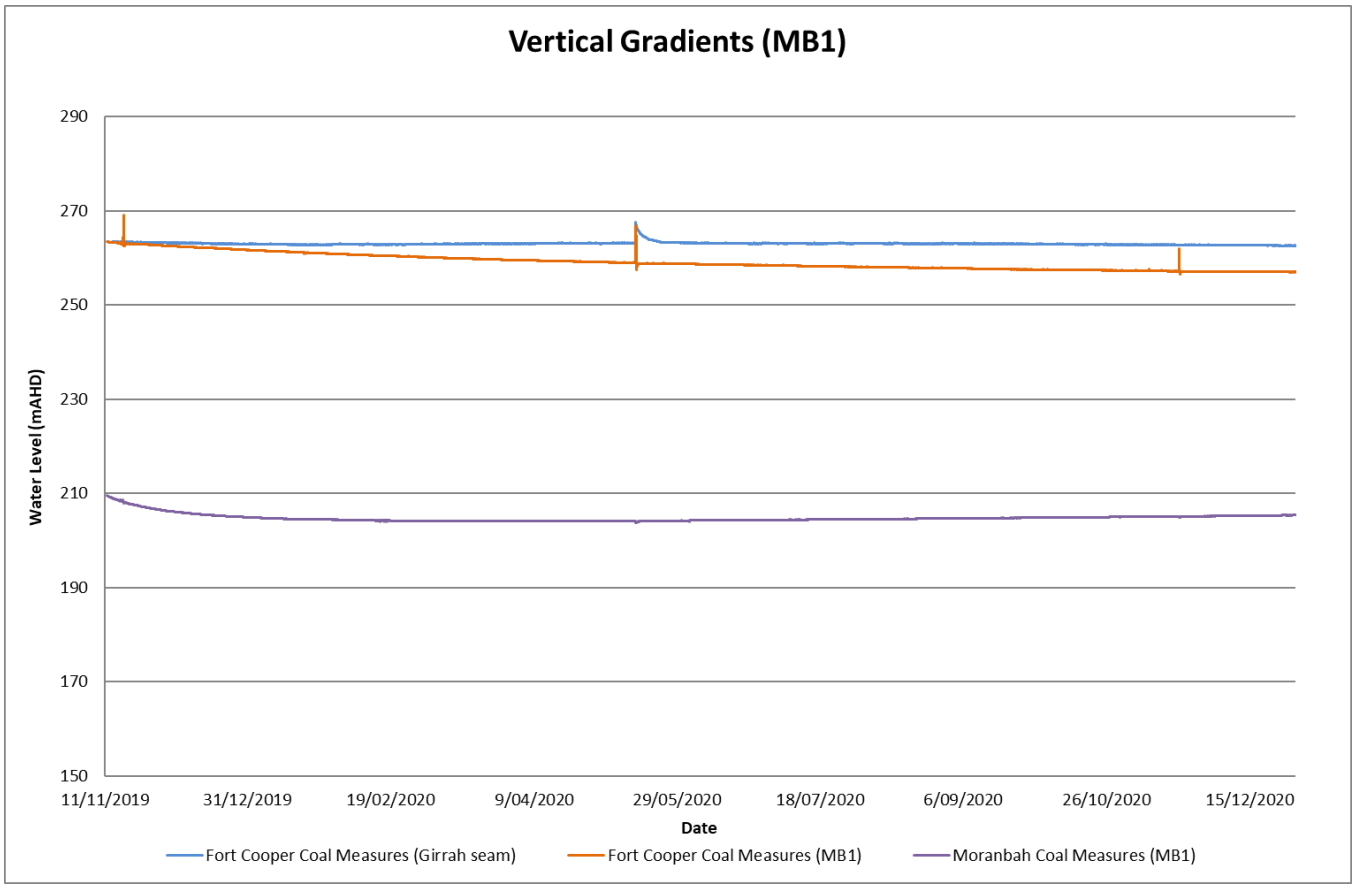


Figure 19: Site 3 - Review of Vertical Gradients (MB1)

5 GROUNDWATER QUALITY MONITORING

Groundwater quality is monitored in eight shallow groundwater monitoring bores. Monitoring has been undertaken since June 2012 in seven of the shallow groundwater monitoring bores and since May 2016 from the other remaining monitoring bore. It should be noted that one additional shallow groundwater monitoring bore (AN021F) exists but has not been able to be sampled due to the low water volume in the bore casing. An adjacent bore, AN020F, is drilled and completed into the Rewan Formation, and is the bore which has only been sampled since 13 May 2016 (as it is a replacement for AN021F).

Groundwater quality monitoring was also undertaken in four deep groundwater monitoring bores that were completed in July 2014, two additional deep groundwater monitoring bores that were completed in November 2015 and one more recent deep groundwater monitoring bore that was completed in August 2016.

As a part of commencement of the BGP, additional monitoring sites have been incorporated in the monitoring network. These sites (MB1 and GW007B) are located in PL 486. These bores have been added to the MGP network for analysis.

As per the 2018 Bowen Annual Review, M134GM replaced M162V for the purpose of water quality monitoring from November 2017.

The groundwater quality monitoring results are shown in Appendix B. The primary purpose of groundwater quality monitoring is to identify changes in background water quality. A summary of these results (2012 to 2020) are provided in the following sections.

5.1 Shallow aquifer water quality

Table 9 provides a summary of water quality results obtained from bores targeting the shallow aquifers (M339W, M225W, M340W, M230W, M250W, M224W, M222W and AN020F). This provides an indication of water quality ranges for each parameter analysed based on aquifer type. Results for some parameters between different monitoring locations in the Tertiary Basalt show high degree of variation which is likely to be attributable to the spatial heterogeneity of that hydrogeological system. Review of this data indicates that there are no notable trends. As displayed by the groundwater level data in Section 4.2.1 , recharge by rainfall or streams occurs to shallow aquifers and is likely to result in variations in some parameters at the same monitoring location as shown in the table below. In general, this data shows that:

- Groundwater quality of the quaternary alluvium varies from brackish to saline;
- Groundwater quality of the tertiary basalt aquifer varies from brackish to saline;
- Groundwater quality of the tertiary sediment aquifer is fresh to brackish;
- Groundwater quality of the weathered coal measures is brackish; and
- Groundwater quality of the Rewan Formation is brackish.

Table 9: Background Water Quality - Shallow Monitoring Bores

Parameter	Units	Quaternary Alluvium		Tertiary Basalt		Tertiary Sediment		Weathered Coal Measures		Rewan Formation	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Field pH		5.73	7.48	6.28	8.49	5.42	7.76	6.09	8.16	6.2	7.58
Electrical Conductivity	µS/cm	4240	31600	5300	42769	2170	2650	9090	11000	10300	11200
Total Dissolved Solids	mg/L	2360	27000	3000	29000	1300	1620	5190	9600	6210	7310
Hydroxide Alkalinity (OH-) as CaCO3	mg/L	<1	<5	<1	<5	<1	<5	<1	<5	<1	<1
Carbonate Alkalinity as CaCO3	mg/L	<1	<5	<1	94	<1	<5	<1	<5	<1	<1
Bicarbonate Alkalinity as CaCO3	mg/L	101	360	380	827	53	116	261	457	5	126
Total Alkalinity as CaCO3	mg/L	101	360	380	827	53	116	261	457	5	126
Sulphate, SO4	mg/L	541	6200	60	1140	54	106	78	177	<1	1
Chloride, Cl	mg/L	1020	14000	1490	17000	660	794	3140	4100	3750	4030
Calcium - Dissolved	mg/L	172	1000	55	204	12	20	290	440	51	460
Magnesium - Dissolved	mg/L	107	1400	85	792	38	52	340	506	174	203
Sodium - Dissolved	mg/L	543	6200	891	13000	344	510	932	1400	1450	1650
Potassium - Dissolved	mg/L	5	17	12	150	9	13	9	14	21	29
Arsenic-Dissolved	mg/L	<0.001	0.008	<0.001	0.002	<0.001	<0.01	<0.001	0.011	<0.001	<0.001
Beryllium-Dissolved	mg/L	<0.00001	0.193	<0.0005	<0.005	<0.0005	<0.001	<0.000001	<0.001	<0.001	<0.001
Barium-Dissolved	mg/L	0.045	0.2	0.05	0.283	0.047	0.11	0.184	3.9	3.42	3.88
Cadmium-Dissolved	mg/L	<0.0005	0.0002	<0.0001	0.0012	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium-Dissolved	mg/L	<0.001	0.015	<0.001	0.01	0.001	0.076	<0.001	0.002	<0.001	<0.001
Cobalt-Dissolved	mg/L	<0.001	0.027	<0.001	0.005	<0.0001	0.005	<0.001	0.002	<0.001	0.001
Copper-Dissolved	mg/L	<0.005	0.017	<0.001	0.07	<0.001	0.005	<0.001	0.036	<0.001	0.005
Lead-Dissolved	mg/L	<0.001	<0.01	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese-Dissolved	mg/L	0.313	8.1	<0.005	0.611	0.007	0.095	1.1	1.86	1.17	1.92
Molybdenum	mg/L	0.001	0.003	0.002	0.008	<0.001	0.002	0.002	0.004	<0.001	0.007
Nickel-Dissolved	mg/L	0.004	0.17	0.005	0.253	0.006	0.088	<0.001	0.125	<0.001	0.006
Selenium	mg/L	<0.01	<0.05	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	mg/L	3.19	14	1.52	8.98	0.686	0.725	6.67	8.96	11	11.3
Vanadium-Dissolved	mg/L	<0.001	0.002	<0.001	0.042	<0.001	<0.01	<0.001	<0.01	<0.01	<0.01
Zinc-Dissolved	mg/L	0.008	0.302	<0.005	0.185	<0.005	0.131	<0.005	0.115	<0.005	<0.005
Boron	mg/L	0.13	0.39	0.42	2.96	0.61	0.76	0.3	0.34	0.13	0.2
Iron	mg/L	0.2	10.1	<0.05	0.43	<0.05	0.43	11	21.1	1.68	14.3
Mercury-Dissolved	mg/L	<0.00005	<0.0001	0.00008	0.001	<0.00005	<0.0001	<0.0001	<0.00005	<0.0001	<0.0001
Fluoride, F	mg/L	0.2	0.9	0.09	2	0.13	0.6	0.4	1	<0.1	<0.1
Phosphate as P in water	mg/L	0.007	0.79	0.026	12.6	0.01	1.3	0.11	2.09	<0.01	0.11

5.2 Deep aquifer water quality

Table 10 provides a summary of water quality results obtained from bores targeting the deep aquifers (M313W, M314W, M324W, M325W, AN019F, GR067V, M162V, M134GM, MB1-D and GW007B. This provides an indication of water quality ranges for each parameter analysed based on aquifer type. Results for some parameters between different monitoring locations show high degree of variation which is likely to be attributable to the spatial heterogeneity and low permeability of the hydrogeological system. In addition to this, as displayed by the groundwater level data, groundwater recovery for some sites is slow and this is likely to result in variations in some parameters at the same monitoring location. Overall, a review of this data indicates that there are no notable trends. In general, this data shows that:

- Groundwater quality of the Fort Cooper Coal Measures aquifer is fresh to brackish; and
- Groundwater quality of the Moranbah Coal Measures is fresh to brackish.

Table 10: Background Water Quality – Deep Monitoring Bores

Parameter	Fort Cooper Coal Measures		Moranbah Coal Measures	
	Min	Max	Min	Max
pH	6.79	11.8	7.27	9.42
EC uS/cm (laboratory)	1170	11100	1710	16000
TDS mg/L (laboratory)	707	9910	1160	9810
Bicarbonate Alkalinity as $CaCO_3$ (mg/L)	<1	456	<1	<1
Total Alkalinity as $CaCO_3$ (mg/L)	<1	135	<1	456
Sulphate as SO_4 (mg/L)	<1	1380	159	2310
Chloride (mg/L)	225	1380	159	2420
Calcium (mg/L)	<1	68	<1	134
Magnesium (mg/L)	188	4920	198	5770
Sodium (mg/L)	2	276	7	209
Potassium (mg/L)	<1	256	<1	62
Arsenic mg/L (dissolved)	199	2590	212	3490
Barium mg/L (dissolved)	12	73	9	1450
Beryllium mg/L (dissolved)	<0.001	0.005	<0.001	0.013
Cobalt mg/L (dissolved)	<0.001	<0.001	<0.001	<0.001
Chromium mg/L (dissolved)	0.005	12.2	0.236	23
Copper mg/L (dissolved)	<0.001	<0.001	<0.001	0.001
Manganese mg/L (dissolved)	<0.001	0.004	<0.001	0.018
Molybdenum mg/L	<0.001	0.004	<0.001	0.01
Nickel mg/L (dissolved)	<0.001	0.582	<0.001	7.08
Selenium mg/L	<0.001	0.459	<0.001	2.19
Lead mg/L (dissolved)	<0.001	0.304	0.008	0.446
Strontium mg/L	0.006	0.114	0.001	0.082
Vanadium mg/L (dissolved)	<0.001	0.02	<0.001	0.032
Zinc mg/L (dissolved)	<0.01	<0.01	<0.01	<0.01
Boron mg/L	0.639	8.18	1.18	10.8
Iron mg/L	<0.01	<0.01	<0.01	0.02
Fluoride (mg/L)	<0.005	2.16	<0.005	0.568
Phosphate as P (mg/L)	0.24	1.17	0.46	2.4

6 SPRINGS AND GROUNDWATER DEPENDANT ECOSYSTEMS

As outlined in the 2019 Bowen UWIR, no relevant springs or Groundwater Dependent Ecosystems (GDE's) have been identified in the MGP or BGP areas.

7 CONCLUSION

Key findings of the 2021 UWIR annual review for the water production are:

MGP:

- Based on the observed water produced since the 2019 Bowen UWIR, there has been 6.6 ML less water produced than was forecasted in the 2019 UWIR;
- The updated water production forecast is 2.6% less than the modelled water production to the end of 2021.Given the updated water production forecast is less than what was modelled in the 2019 UWIR, the predicted impacts are expected to be less than originally modelled, an update of the of the 2019 UWIR is not proposed. Accordingly, a material change to the Immediately Impacted Area (IAA) or the Long-Term Affected Area (LAA) is not expected; and
- The maps prepared under s.376(1)(b)(iv and v) do not require updating as there has not been a material change in the information or predictions used to prepare the maps.

BGP:

- Water production is yet to commence for PL486. The updated water production forecast is 100% less than modelled water production up to the end of 2021. As a result, there is no material change in the information or predictions made in the 2019 Bowen UWIR. Based on this, no change is proposed to the modelling undertaken for the 2019 Bowen UWIR;
- Three production testing wells in ATP 1103 were active in 2020 (RH098A, RH099A and RH100A), with a combined water production of 2.9 ML for the annual review period (a total of 4.9 ML since the 2019 Bowen UWIR). This amount of water produced is below the Peak Downs reference pilot site. Therefore, any IAA or LAA arising from production testing wells in the 2021 annual review data capture period will be smaller than that associated with the reference pilot site;
- No landholder bores are located within the 1-kilometre IAA radius from any production testing wells. Given the updated water production forecast is less than what was modelled in the 2019 UWIR, the predicted impacts are expected to be less than originally modelled, an update of the of the 2019 UWIR is not proposed; and
- The maps prepared under s.376(1)(b)(iv and v) do not require updating as there has not been a material change in the information or predictions used to prepare the maps.

As identified above, there is no material increase in observed and predicted water production for the MGP or BGP, therefore the modelling conducted in the 2019 UWIR overestimates groundwater impacts and an update of the 2019 UWIR is not proposed.

Key findings of the 2021 annual review for water levels monitoring are:

- There is no apparent influence of CSG production to the Quaternary alluvium, weathered Tertiary basalt, Tertiary sediment, weathered Fort Cooper coal measures and Rewan aquifers in which these bores are installed.

Key findings of the 2021 annual review for water quality monitoring are:

- A review of this data indicates that there are no notable trends for both the shallow and deep aquifers.

□□□□□D□□B□□□ □□□R□□□□□□R□□□□□□□

□□□□□□ □B□R□□□

Bore Name	SWL (mAHD)																						
	9/06/2012	13/12/2012	8/04/2013	25/05/2013	6/08/2013	6/12/2013	5/05/2014	19/08/2014	5/12/2014	11/03/2015	17/05/2015	27/07/2015	13/11/2015	2/03/2016	13/05/2016	29/08/2016	15/11/2016	15/06/2017	12/11/2017	1/06/2018	17/11/2018	24/05/2019	12/11/2019	22/11/2020
M339W	200.426	200.456	200.43	200.451	200.462	200.546	200.49		200.56	200.533	200.416	200.398	200.556	200.466	200.456	200.426	200.500	200.507	200.498	200.520	200.600	200.620	200.660	200.750
M225W	206.298	206.641	206.737	206.8	207.455	207.152	207.11		207.27	207.349	207.257	207.23	207.402	207.215	207.245	207.248	207.316	207.54	207.685	207.75	207.9		207.78	207.43
M340W	207.621	208.973	208.118	208.216	208.261	208.507	208.6		208.7	208.771	208.753	208.805	208.918	208.869	208.9	208.761	205.946	203.032	dry					
M230W	208.495	208.705	208.715	208.837	208.865	209.062	209.07		209.2	209.204	209.106	209.058	209.145	208.884	208.922	208.863	208.992	208.629	208.591	208.214	207.7	206.94	205.95	203.17
GW004A																							235.162	234.692
GW007A																							dry	
M250W	233.288	233.248	233.238	233.232	233.248	233.308	233.26		233.33	233.289	233.25	233.221	233.25	233.243	233.258	233.328	233.237	233.283	233.273	233.29	233.32	233.34	233.34	
AN021F															237.06		242.34		238.47	239.06	239.52		240.52	241.52
M224W	211.675	211.365	211.45	211.705	211.42	211.11	210.89	210.65	210.49	210.561	210.419	210.277	209.982	210.02	209.969		209.852	210.354	210.355	210.08	209.69	209.57	209.36	208.96
M222W	202.414	202.974	203.209		203.819	204.014	204.3	204.65	204.95	205.21	205.44	205.54	205.994	205.929	205.969	206.014	206.014	206.149	206.301	206.3	206.28	206.22	206.22	206.22
MB1S																							263.51	262.72
GW004B																							232.087	230.952
AEN1214																								215.12
AEN1234																								185.44
AEN1063																								143.12
MB12																				298.54	286.88	286.31	294.26	296.01
AN020F														238.37	238.366	238.48	238.44		237.18	238.61	238.39	238.36	238.36	237.99

□

Monitoring Bore ID	Sample Date	Field pH	Electrical Conductivity	Total Dissolved Solids (grav)	Hydroxide Alkalinity (OH-) as CaCO3	Carbonate Alkalinity as CaCO3	Bicarbonate Alkalinity as CaCO3	Total Alkalinity as CaCO3	Sulphate, SO4	Chloride, Cl	Calcium - Dissolved	Magnesium - Dissolved	Sodium - Dissolved	Potassium - Dissolved	Arsenic- Dissolved	Beryllium- Dissolved	Barium- Dissolved
			µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
M339W	11/12/2012	6.46	38000	26000	<5	<5	680	680	980	15000	150	670	10000	110	<0.001	<0.0005	0.056
M339W	4/04/2013	6.28	36000	22000	<5	<5	690	690	830	14000	160	700	9700	120	<0.001	<0.0005	0.057
M339W	21/05/2013	8.09	37000	29000	<5	<5	680	680	1100	17000	150	710	10000	120	<0.001	<0.0005	0.067
M339W	7/08/2013	6.42	37000	25000	<5	<5	660	660	990	15000	190	670	13000	150	<0.002	<0.0005	0.061
M339W	5/12/2013	6.6	39000	28000	<5	<5	660	660	1100	16000	160	740	11000	110	<0.001	<0.0005	0.055
M339W	11/05/2014	6.6	37900	24600	<1	<1	698	698	1020	13800	150	722	7740	100			
M339W	9/12/2014	6.46	39300	25400	<1	<1	706	706	893	13700	158	780	8220	138			
M339W	10/03/2015	6.53	39000	27100	<1	<1	644	644	932	13900	183	682	8360	98	<0.005	<0.005	0.058
M339W	16/05/2015	6.67	37500	24200	<1	<1	647	647	1140	12200	167	668	7770	82	<0.001	<0.001	0.124
M339W	27/07/2015	6.53	38200	25400	<1	<1	658	658	1020	13500	180	676	7600	90	<0.001	<0.001	0.051
M339W	16/11/2015	6.43	32300	21200	<1	<1	714	714	987	12700	147	669	7170	81	<0.005	<0.005	0.053
M339W	2/03/2016	7.56	39800	21200	<1	<1	712	712	1000	13400	160	747	8710	104	<0.001	<0.001	0.050
M339W	13/05/2016		39000	24400	<1	<1	681	681	1020	13000	178	712	7850	89	0.001	<0.001	0.055
M339W	29/08/2016	8.37	41300	28200	<1	43	714	757	993	12600	170	688	7790	93	<0.005	<0.005	0.058
M339W	15/11/2016	7.13	37100	22900	<1	<1	652	652	1050	12600	171	743	8440	92	<0.001	<0.001	0.055
M339W	13/06/2017		38600	25100	<1	<1	726	726	964	13500	186	780	9040	105			
M339W	12/11/2017	6.99	39800	27100	<1	<1	708	708	923	13700	204	792	9570	102	<0.005	<0.005	0.062
M339W	1/06/2018	6.58	39300		<1	<1	644	644	974	12900	181	772	8990	97			
M339W	17/11/2018	6.51	42769	26800	<1	<1	661	661	916	11600	174	750	7800	96	<0.005	<0.005	0.057
M339W	27/05/2019	6.47	37398	26200	<1	<1	632	632	958	13600	174	769	8370	95			
M339W	12/11/2019	6.69	38760	23400	<1	<1	669	669	936	13800	142	680	7860	88	<0.005	<0.005	0.052
M339W	22/11/2020	6.73	38400	26800	<1	<1	682	682	944	14000	154	708	8150	91			0.058
M225W	3/04/2013	7.54	28000	17000	<5	<5	810	810	710	11000	150	510	7200	84	<0.001	<0.0005	0.063
M225W	21/05/2013	6.53	28000	21000	<5	<5	790	790	660	10000	150	520	7500	82	0.001	<0.0005	0.140
M225W	8/08/2013	6.59	29000	20000	<5	<5	780	780	700	11000	160	480	7500	75	<0.001	<0.0005	0.120
M225W	5/12/2013	6.84	30000	21000	<5	<5	780	780	780	11000	180	490	9500	95	<0.001	<0.0005	0.120
M225W	6/05/2014	6.98	29900	19400	<1	<1	745	745	369	9940	142	495	5440	72			
M225W	5/12/2014	6.73	30500	20100	<1	<1	808	808	617	9880	151	523	6450	76			
M225W	11/03/2015	6.82	30100	20000	<1	<1	716	716	827	10200	163	508	6600	75	<0.005	<0.005	0.075
M225W	17/05/2015	6.89	30200	19800	<1	<1	780	780	884	9850	161	518	6430	64	0.001	<0.001	0.112
M225W	28/07/2015	6.96	28700	19300	<1	<1	790	790	735	9660	157	478	5670	65	0.001	<0.001	0.089
M225W	16/11/2015	6.38	23700	17400	<1	<1	826	826	738	9870	134	485	5460	59	<0.005	<0.005	0.055
M225W	2/03/2016	7.71	30500	19400	<1	<1	817	817	721	10300	153	541	6530	76	<0.001	<0.001	0.053
M225W	13/05/2016	7.57	29600	18400	<1	<1	779	779	752	9390	158	532	6570	66	<0.001	<0.001	0.062
M225W	29/08/2016	7.45	29600	17900	<1	<1	799	799	727	9750	158	532	6220	68	<0.001	<0.001	0.065
M225W	15/11/2016	7.31	30200	19800	<1	<1	778	778	711	9620	169	567	6560	72	<0.001	<0.001	0.068
M225W	13/06/2017		29900	18300	<1	<1	827	827	786	10800	150	492	6780	66			
M225W	12/11/2017	7.15	30700	20100	<1	<1	814	814	691	10400	144	507	5930	64	<0.001	<0.001	0.060
M225W	31/05/2018	7.16	30100	19200	<1	<1	701	701	701	9900	169	578	6960	70			
M225W	21/11/2018	6.74	29700	19000	<1	<1	748	748	723	10200	159	566	6470	68	<0.005	<0.005	0.103
M225W	25/05/2019	6.59	29500	19500	<1	<1	738	738	745	10700	159	541	6250	70			
M225W	7/11/2019	6.91	30400	21800	<1	<1	733	733	715	10200	149	566	6670	71	<0.005	<0.005	0.067
M225W	19/11/2020	6.81	29700	20000	<1	<1	758	758	746	10600	179	518	6130	68	0	0	0
M340W	11/12/2012	6.6	8600	5200	<5	<5	620	620	240	2900	57	110	2100	25	<0.001	<0.0005	0.056
M340W	4/04/2013	6.3	8300	5200	<5	<5	620	620	230	2600	62	120	1900	32	<0.001	<0.0005	0.056
M340W	22/05/2013	6.81	8400	5000	<5	<5	610	610	240	2700	59	120	1900	25	<0.001	<0.0005	0.057
M340W	7/08/2013	6.63	8600	5000	<5	<5	620	620	230	2700	55	110	2000	26	<0.001	<0.0005	0.061
M340W	5/12/2013	6.63	9100	5700	<5	<5	610	610	260	2800	56	110	2200	27	<0.001	<0.0005	0.058
M340W	10/05/2014	6.74	10000	6500	<1	<1	661	661	246	3150	71	141	1920	25			
M340W	8/12/2014	6.69	11100	6390	<1	<1	708	708	257	3400	85	172	2050	33			
M340W	12/03/2015	6.81	11400	6500	<1	<1	689	689	269	3760	102	174	2240	32	<0.001	<0.001	0.068
M340W	17/05/2015	6.82	11700	6900	<1	<1	679	679	383	3740	96	179	2060	27	<0.001	<0.001	0.194
M340W	28/07/2015	6.68	11400	6280	<1	<1	668	668	319	3670	100	177	2120	29	<0.001	<0.001	0.113
M340W	16/11/2015	6.38	10700	7320	<1	<1	727	727	322	3850	89	193	2180	28	<0.001	<0.001	0.057
M340W	2/03/2016	8.43	12600	6400	<1	43	681	725	320	4060	101	203	2480	33	<0.001	<0.001	0.060
M340W	13/05/2016	7.67	12400	7140	<1	<1	693	693	342	3790	100	200	2310	30	<0.001	<0.001	0.070
M340W	29/08/2016	8.49	13000	7250	<1	94	636	730	345	3780	107	198	2340	30	<0.001	<0.001	0.073
M340W	15/11/2016	7.44	13100	7430	<1	<1	668	668	371	4310	109	216	2420	31	<0.001	<0.001	0.075
M340W	13/06/2017		11300	6590	<1	<1	651	651	353	3690	90	180	2180	27			
M230W	11/12/2012	7.15	5600	3300	<5	<5	420	420	64	1600	55	93	1200	18	0.002	<0.0005	0.150
M230W	3/04/2013	6.66	5400	3200	<5	<5	420	420	66	1600	60	96	1000	19	0.002	<0.0005	0.170
M230W	21/05/2013	7.01	5300	3300	<5	<5	410	410	60	1700	60	96	1100	18	0.002	<0.0005	0.180
M230W	7/08/2013	7.05	5600	3000	<5	<5	400	400	77	1700	58	93	1100	16	0.002	<0.0005	0.180
M230W	7/12/2013	6.96	5900	3700	<5	<5	390	390	83	1700	56	85	1200	15	0.002	<0.0005	0.180
M230W	11/05/2014	6.99	6010	3910	<1	<1	426	426	82	1660	67	100	1040	14			
M230W	5/12/2014	7.05	6100	3120	<1	<1	418	418	73	1490	70	103	970	17			
M230W	12/03/2015	7	6080	3360	<1	<1	410	410	69	1730	74	100	1030	16	0.002	<0.001	0.195
M230W	17/05/2015	7	6180	3580	<1	<1	407	407	97	1550	75	106	985	14	0.002	<0.001	0.283
M230W	28/07/2015	7.05	6000	3210	<1	<1	404	404	87	1500	74	107	1050	16	0.002	<0.001	0.237
M230W	15/11/2015	6.62	6260	3440	<1	<1	419	419	82	1840	69	101	891	12	0.002	<0.001	0.175
M230W	2/03/2016	7.82	6350	3350	<1	<1	431	431	84	1760	68	104	995	17	0.001	<0.001	0.164
M230W	13/05/2016	7.78	6120	3500	<1	<1	419	419	80	1760	72	110	1050	16	0.001	<0.001	0.184
M230W	29/08/2016	7.48	6130	3450	<1	<1	417	417	79	1680	76	111	1050	18	0.001	<0.001	0.186
M230W	15/11/2016	7.51	6220	3500	<1	<1	414	414	83	1750	68	117	1100	15	0.002	<0.001	0.186
M230W	13/06/2017		6270	3470	<1	<1	442	442	78	1870	65	110	1100	15			
M230W	12/11/2017	7.5	6400	3710	<1	<1	420	420	79	1820	70	114	1070	15	0.002	<0.001	0.206
M230W	1/06/2018	6.95	6860	3960	<1	<1	380	380	99	1920	78	121	1170	17			
M230W	21/11/2018	6.83	7260	4140	<1	<1	401	401	104	2140	98	158	1300	17	0.002	<0.001	0.207
M230W	25/05/2019	6.74	7450	4410	<1	<1	397	397	117	2480	101	163	1350	18			
M230W	10/11/2019	6.88	7420	4770	<1	<1	403	403	110	2330	93	150	1260	18	0.002	<0.001	0.206
M230W	1/11/2020	6.9	7670	4630	<1	<1	416	416	110	2520	109	159	1280	18			
M250W	13/12/2012	5.42	2400	1400	<5	<5	61	61	54	700	14	39	380	11	<0.001	<0.0005	0.1
M250W	6/04/2013	5.77	2400	1600	<5	<5	69	69	69	660	17	45	490	13	<0.001	<0.0005	0.11
M250W	25/05/2013	5.86	2500	1600	<5	<5	67	67	83	730	18	46	510	13	<0.001	<0.0005	0.1
M250W	6/08/2013	5.82	2300	1300	<5	<5	72	72	81	730	19	43	450	11	<0.001	<0.0005	0.1
M250W	5/12/2013	5.92	2500	1600	<5	<5	60	60	84	710	14	39	480	12	<0.001	<0.0005	0.083
M250W	9/05/2014	5.64	2440	1590	<1	<1	76	76	76	682	13	43	393	12			
M250W	7/12/2014	5.65	2530	1380	<1	<1	58	58	76	717	13	45	432	11			
M250W	10/03/2015	5.5	2540	1580	<1	<1	58	58	92	768	19	42	420	10	<0.001	<0.001	0.07
M250W	18/05/2015	5.75	2560	1420	<1	<1	55	55	92	763	17	44	398	10	<0.001	<0.001	0.07
M250W	29/07/2015	5.48	2430	1430	<1	<1	59	59	89	729	15	44	387	11	<0.001	<0.001	0.078
M250W	16/11/2015	5.72	2170	1300	<1	<1	72	72	76	664	12	38	344	9	<0.001	<0.001	0.061
M250W	2/03/2016	6.54	2650	1490	<1	<1	53	53	92	787	15	45	408	12	<0.001	<0.001	0.047
M250W	13/05/2016	6.74	2620	1530	<1	<1	116	116	95	774	18	52	461	11	<0.01	<0.001	<0.001
M250W	29/08/2016	7.76	2600	1440	<1	<1	64	64	81	678	14	44	396	10	<0.001	<0.001	0.055
M250W	15/11/2016	6.36	2460	1400	<1	<1	60	60	86	715	12	46	411	10	<0.001	<0.001	0.05
M250W	18/06/2017		2450	1360			63	63	80	708	12	42	402	10			
M250W	13/11/2017	7.23	2650	1620			55	55	106	794	20	50	465	11	<0.001	<0.001	0.072
M250W	2/06/2018	5.8	2530					55	77	708	15	48	440	10			
M250W	22/11/2018	5.66	2510	1520	<1	<1	62	62	89	746	15	48	420	11	<0.001	<0.001	0.057
M250W	26/05/2019	5.45	2480	1400	<1	<1	58	58	88	790	16	48	407	11			
M250W	7/11/2019	5.93	2510	1560	<1	<1	59	59	87	744	20	46	414	11	<0.001	<0.001	0.059
M250W	7/11/2019	5.93	2510	1560	<1	<1	59	59	87	744	20	46	414	11	<0.001	<0.001	0.059
M222W	16/06/2012	6.43	9520	6690	<1	<1	457	457	85	3140	326	355	1120	14	0.003	<0.000001	3.9
M222W	14/12/2012	6.52	9300	6500	<5	<5	420	420	78	3500	290	340	1000	14	<0.001	<0.0005	1.2
M222W	5/04/2013	6.22	9100	6500	<5	<5	300	300	140	4100	320	440	1100	14	<0.001	<0.0005	0.26
M222W	26/05/2013	6.67	9400	7500	<5	<5	290	290	100	3200	350	450	1100	14	0.001	<0.0005	0.24
M222W	9/08/2013	6.17	9200	6200	<5	<5	310	310	110	3400	340	400	1100	11	0.003	<0.0005	0.23
M222W	6/12/2013	6.26	9700	9600	<5	<5	300	300	130	3300	440	380	1400	12	0.006	<0.0005	0.24
M222W	10/05/2014	6.16	9480	6160	<1	<1	316	316	129	3420	363	428	1010	10			
M222W	19/08/2014	6.81	9090	8950	<1	<1	275	275	128	3450	365	448	1020	12			
M222W	4/12/2014	6.25	10200	7520	<1	<1	303	303	116	3330	361	451	1080	12			
M222W	11/03/2015	6.55	10000	6810	<1	<1	295	295	122	3450	395	395	999	10	0.003	<0.001	0.248
M222W	17/05/2015	6.32	9890	7160	<1	<1	304	304	165	3480	374	426	943	9	0.011	<0.001	0.202
M222W	27/07/2015	6.23	9670	6150	<1	<1	290	290	129	3420	385	434	956	10	0.004	<0.001	0.226
M222W	17/11/2015	6.1	10200	6820	<1	<1	296	296	124	3560	352	376	932	10	0.004	<0.001	0.22
M222W	2/03/2016	7.19	10700	5190	<1	<1	318	318	118	3560	342	434	1040	12	0.003	<0.001	0.219
M222W	13/05/2016	7.22	9890	5740	<1	<1	282	282	177	3340	376	456	1040	10	0.009	<0.001	0.201
M222W	29/08/2016	8.16	10400	7370	<1	<1	280	280	155	3170	414	474	1080	10	0.01	<0.001	0.184
M222W	15/11/2016	6.62	10300	6300	<1	<1	292	292	140	3660	407	492	1170	11	0.005	<0.001	0.252
M222W	13/06/2017		10600	6320			310	310	145	3920	379	448	1140	11			
M222W	7/11/2017	6.82	10600	6800			271	271	126	3670	399	466	1080	10	0.005	<0.001	0.288
M222W	29/05/2018	6.29	11000					286	131	4020	417	478	1170	12			
M222W	18/11/2018	6.19	11000	6970	<1	<1	282	282	130	3630	406	494	1080	11	0.004	<0.001	0.268
M222W	24/05/2019	6.09	10700	7230	<1	<1	261	261	159	4000	432	506	1180	10			
M222W	10/11/2019	6.09	10700	8400	<1	<1	275	275	161	3780	404	470	1110	11	0.007	<0.001	0.248
M222W	20/11/2020	6.3	11100	8600	<1	<1	292	292	155	4090	448	513	1200	11			
M224W	16/06/2012	6.22	29500	22300	<1	<1	355	355	1600	9560	831	1260	4170	11	<0.050	<0.00001	0.078
M224W	15/12/2012	6.24	28000	22000	<5	<5	340	340	1500	14000	780	1100	4500	13	0.003	<0.0005	0.11
M224W	7/04/2013	5.73	25000	20000	<5	<5	360	360	1300	11000	740	1000	4300	16	0.002	<0.0005	0.2
M224W	25/05/2013	6.11	18000	14000	<5	<5	220	220	880	6200	610	680	2600	17	0.004	<0.0005	0.14
M224W	6/08/2013	6.07	23000	17000	<5	<5	240	240	1200	9100	840	980	4500	12	0.005	<0.0005	0.13
M224W	6/12/2013	6.15	28000	27000	<5	<5	280	280	6200	11000	1000	1400	6200	13	0.007	<0.0005	0.13
M224W	10/05/2014	6.24	27200	17700	<1	<1	253	253	1250	10200	779	1080	3690	11			
M224W	19/08/2014	6.34	27600	21000	<1	<1	192	192	1060	10800	822	1300	4590	13			
M224W	4/12/2014	6.14	31600	22900	<1	<1	186	186	842	9710	764	1320	4080	13			
M224W	12/03/2015	6.46	22900	16500	<1	<1	174	174	710	8850	661	842	3240	10	0.004	<0.001	0.157
M224W	17/05/2015	6.36	21000	16800	<1	<1	184	184	978	7200	640	768	2760	8	0.006	<0.001	0.164
M224W	27/07/2015	6.13	24700	17100	<1	<1	188	188	948	8670	712	984	3390	9	0.008	<0.001	0.157
M224W	17/11/2015	6.13	27700	17500	<1	<1	158	158	890	9930	613	870	3320	7	0.008	<0.001	0.163
M224W	2/03/2016	7.38	10800	5950	<1	<1	128	128	656	3350	316	360	1600	6	0.005	<0.001	0.065
M224W	13/05/2016	7.48	17900	11100	<1	<1	202	202	799	5860	512	664	2680	9	0.008	<0.001	0.159
M224W	29/08/2016	7.21	4240	2360	<1	<1	101	101	541	1020	172	107	543	5	0.003	<0.001	0.06
M224W	15/11/2016	6.77	17700	11700	<1	<1	192	192	802	6210	570	696	2650	8	0.008	<0.001	0.182
M224W	13/06/2017		17600	11000	<1	<1	238	238	1070	6490	676	630	2400	9			
M224W	07/11/2017	6.97	20400	14100	<1	<1	232	232	1000	7120	774	778	2650	10	<0.001	0.193	<0.001
M224W	29/05/2018	6.28	27200					304	1240	10100	870	1090	4100	10			
M224W	18/11/2018	6.33	5490	3630	<1	<1	141	141	574	1270	264	137	669	5	<0.001	<0.001	0.045
M224W	24/05/2019	6.53	12800	8730	<1	<1	152	152	907	4490	448	440	1960	6			
M224W	10/11/2019	6.12	18400	15200	<1	<1	141	141	644	6430	426	628	2760	6	0.006	<0.001	0.126
M224W	20/11/2020	6.13	20100	15600	<1	<1	137	137	575	7590	413	670	2980	5			
AN020F	13/05/2016	6.2	10800	6210	<1	<1	22	22	<1	3750	429	178	1550	29	<0.001	<0.001	3.72
AN020F	15/11/2016	6.32	10600	7210	<1	<1	21	21	1	4030	439	174	1450	26	<0.001	<0.001	3.62
AN020F	15/11/2017	7.39	10900	7010	<1	<1	47	47	<1	3790	456	182	1650	29	<0.001	<0.001	3.42
AN020F	15/11/2018	7.05	11200	7280	<1	<1	126	126	<1	3800	460	203	1460	24	<0.001	<0.001	3.88
AN020F	11/11/2019	7.58	10400	7310	<1	<1	20	20	<1	3830	457	174	1580	29	<0.001	<0.001	3.66
AN020F	21/11/2020	7.03	10300	8090	<1	<1	5	5	<1	3990	51	<1	2160	21	0	0	5.34

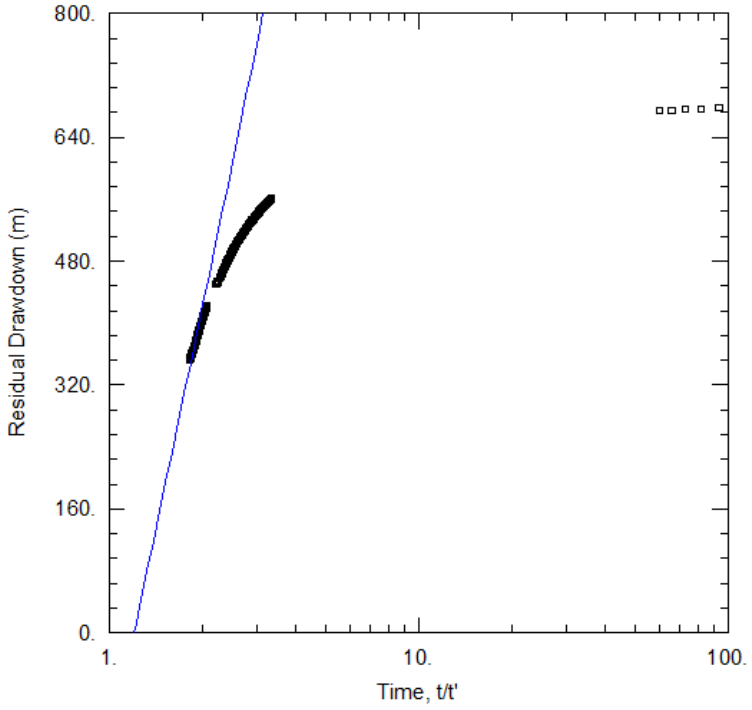
Monitoring Bore ID	Sample Date	Cadmium- Dissolved	Chromium- Dissolved	Cobalt- Dissolved	Copper- Dissolved	Lead- Dissolved	Manganese- Dissolved	Molybdenum	Nickel- Dissolved	Selenium - Dissolved	Strontium	Vanadium- Dissolved	Zinc- Dissolved	Boron - Dissolved	Iron - Dissolved	Mercury- Dissolved	Fluoride, F	Phosphate as P in water
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
M339W	11/12/2012	0.0004	0.006	<0.001	0.007	<0.001	0.016		0.018			0.003	0.05			0.00008	0.45	0.1
M339W	4/04/2013	0.0003	0.007	<0.001	0.005	<0.001	0.013		0.027			0.003	0.039			<0.00005	0.44	0.11
M339W	21/05/2013	0.0005	0.004	<0.001	0.059	<0.001	0.012		0.014			0.003	0.068			0.00009	0.33	0.026
M339W	7/08/2013	0.0004	0.003	<0.001	0.004	<0.001	0.007		0.014			0.003	0.078			<0.00005	0.29	0.19
M339W	5/12/2013	0.0005	0.006	<0.001	0.007	<0.001	0.007		0.015			0.003	0.06			<0.00005	0.37	0.085
M339W	11/05/2014				<0.05		<0.01						<0.05			<0.0001		0.26
M339W	9/12/2014				<0.005		<0.005						0.04			<0.0001	0.4	0.08
M339W	10/03/2015		<0.005	<0.005	<0.005	<0.005	0.009		0.026			<0.05	0.053				0.8	
M339W	16/05/2015	0.0007	0.002	<0.001	0.009	<0.001	0.009		0.012			<0.01	0.128			0.0008	0.4	
M339W	27/07/2015	0.0004	<0.001	<0.001	0.001	<0.001	0.003		0.012			<0.01	0.016			0.001	0.5	
M339W	16/11/2015	<0.0005	<0.005	<0.005	0.01	<0.005	<0.005		0.014			<0.05	0.149			0.0006	0.4	0.1
M339W	2/03/2016		0.007	<0.001	0.002	<0.001	0.002		0.014			<0.01	0.046				0.4	0.24
M339W	13/05/2016		0.01	<0.001	0.008	<0.001	0.005	0.003	0.014	0.01	8.48	<0.01	0.051	2.58	<0.05	<0.0001	0.4	0.62
M339W	29/08/2016		0.01	<0.005	0.005	<0.005	<0.005	<0.005	0.014	<0.05	8.98	<0.05	0.027	2.66	<0.05		0.5	0.07
M339W	15/11/2016	0.0001	0.002	<0.001	<0.001	<0.001	0.006	0.003	0.014	<0.01	8.36	<0.01	0.021	2.42	<0.05	<0.0001	0.5	0.15
M339W	13/06/2017				0.006		<0.005						<0.025	2.74	<0.05	<0.0001	0.5	
M339W	12/11/2017		0.008	<0.005		<0.005	<0.005	<0.005	0.015	<0.05		<0.05	<0.025	2.96	0.06		0.4	0.07
M339W	1/06/2018				<0.005		<0.005						<0.025	2.66	<0.05	0.001	0.4	0.09
M339W	17/11/2018		0.01	<0.005	<0.005	<0.005	<0.005	<0.005	0.013	<0.05		<0.05	<0.025	2.36	<0.05		0.09	
M339W	27/05/2019				<0.005		<0.005						0.029	2.91	<0.05	0.0009	<0.05	
M339W	12/11/2019		0.009	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.05		<0.05	0.047	2.81	<0.05		0.11	
M339W	22/11/2020		0.01		0.009		<0.005	<0.005	0.013	<0.05		<0.05	0.03	2.64	<0.05	0.0005	0.4	0.15
M225W	3/04/2013	0.0006	0.003	<0.001	0.01	<0.001	0.011		0.025			0.015	0.042			<0.00005	0.48	0.2
M225W	21/05/2013	0.0006	0.002	0.001	0.01	<0.001	0.21		0.034			0.009	0.053			<0.00005	0.37	0.11
M225W	8/08/2013	0.001	0.002	0.001	0.03	<0.001	0.18		0.068			0.013	0.036			<0.00005	0.32	0.19
M225W	5/12/2013	0.0007	0.002	0.002	0.009	<0.001	0.35		0.056			0.009	0.031			<0.00005	0.37	0.11
M225W	6/05/2014				<0.05		<0.01						0.059			<0.0001		0.1
M225W	5/12/2014				0.028		0.004						0.058			0.0001	0.5	0.27
M225W	11/03/2015		<0.005	<0.005	<0.005	<0.005	0.009		0.026			<0.05	0.096				0.8	
M225W	17/05/2015	0.0012	0.001	<0.001	0.022	<0.001	0.161		0.048			0.01	0.029			<0.0001	0.4	
M225W	28/07/2015	0.0006	<0.001	<0.001	0.011	<0.001	0.033		0.016			0.01	0.018			<0.0001	0.6	
M225W	16/11/2015	0.0006	<0.005	<0.005	0.012	<0.005	<0.005		0.022			<0.05	0.099			0.0001	0.6	0.18
M225W	2/03/2016		0.002	<0.001	0.02	<0.001	0.001		0.012			0.01	0.035				0.5	0.25
M225W	13/05/2016	0.0005	0.002	<0.001	0.006	<0.001	0.01	0.004	0.028	<0.01	4.25	0.01	0.036	2.48	<0.05	<0.0001	0.5	0.13
M225W	29/08/2016		0.002	<0.001	0.012	<0.001	0.006	0.004	0.022	<0.01	4.58	0.01	0.038	2.1	<0.05		0.6	0.22
M225W	15/11/2016	0.0006	0.002	<0.001	0.006	<0.001	0.008	0.006	0.058	<0.01	4.93	0.01	0.062	2.32	<0.05	0.0002	0.7	0.12
M225W	13/06/2017				0.013		0.005						0.018	1.92	<0.05	<0.0001	0.4	0.43
M225W	12/11/2017		0.003	<0.001		<0.001	0.008	0.004	0.253	<0.01		0.01	0.015	1.95	<0.05		0.5	0.17
M225W	31/05/2018				0.012		0.027						<0.025	2.07	<0.05	<0.0001	0.6	0.1
M225W	21/11/2018		<0.005	<0.005	0.07	<0.005	<0.005	<0.005	0.016	<0.05		<0.05	0.046	2.02	<0.05	0.0001	0.5	0.14
M225W	25/05/2019				0.041		0.022						0.031	1.98	0.08	0.0001	0.5	0.09
M225W	7/11/2019		<0.005	<0.005	<0.005	<0.005	0.008	<0.005	0.011	<0.05		<0.05	0.11	2.24	<0.05		0.5	0.09
M225W	19/11/2020	0	0	0	0.022	0	0.062	0	0	0	0	0	0.045	1.81	0	0	0.5	0.18
M340W	11/12/2012	0.0002	<0.001	0.0002	0.005	<0.001	0.1		0.012			0.003	0.035			<0.00005	0.45	0.1
M340W	4/04/2013	<0.0001	<0.001	0.002	0.004	<0.001	0.085		0.014			0.002	0.028			<0.00005	1.6	0.077
M340W	22/05/2013	<0.0001	<0.001	0.002	0.005	<0.001	0.086		0.007			0.002	0.036			<0.00005	1.4	0.055
M340W	7/08/2013	<0.0001	<0.001	0.002	0.002	<0.001	0.095		0.006			0.001	0.037			<0.00005	1.3	0.1
M340W	5/12/2013	<0.0001	<0.001	0.002	<0.001	<0.001	0.1		0.013			0.001	0.021			<0.00005	1.5	0.063
M340W	10/05/2014				0.007		0.075						0.041			<0.0001		0.12
M340W	8/12/2014				0.008		0.081						0.076			<0.0001	1.8	0.08
M340W	12/03/2015		<0.001	0.002	0.003	<0.001	0.058		0.022			<0.01	0.013				1.7	
M340W	17/05/2015	<0.0001	<0.001	0.001	0.024	<0.001	0.051		0.009			<0.01	0.185			<0.0001	1.6	
M340W	28/07/2015	<0.0001	<0.001	<0.001	0.011	<0.001	0.049		0.038			<0.01	0.06			<0.0001	1.9	
M340W	16/11/2015	<0.0001	0.001	0.001	0.018	<0.001	0.047		0.01			<0.01	0.098			<0.0001	1.6	0.04
M340W	2/03/2016		<0.001	0.002	0.002	<0.001	0.044		0.01				0.018				2.0	0.08
M340W	13/05/2016	<0.0001	<0.001	0.001	0.012	<0.001	0.034	0.004	0.005	<0.01	2.95	<0.01	0.132	2.26	<0.05	<0.0001	1.8	0.05
M340W	29/08/2016		0.001	0.003	0.002	<0.001	0.06	0.004	0.008	<0.01	3.32	<0.01	0.005	1.83	<0.05		2.0	0.05
M340W	15/11/2016	<0.0001	0.002	0.002	<0.001	<0.001	0.056		0.006	<0.01		<0.01	0.014	2.14		<0.0001	1.6	0.08
M340W	13/06/2017				<0.001		0.611						<0.005	1.75	<0.05	<0.0001	1.9	12.6
M230W	11/12/2012	<0.0001	<0.001	<0.001	0.001	<0.001	0.097		0.005			<0.001	0.014			<0.00005	0.79	0.67
M230W	3/04/2013	<0.0001	<0.001	0.002	0.002	<0.001	0.26		0.01			<0.001	0.027			<0.00005	0.76	0.16
M230W	21/05/2013	<0.0001	<0.001	0.002	0.004	<0.001	0.18		0.014			<0.001	0.021			<0.00005	0.54	0.094
M230W	7/08/2013	<0.0001	<0.001	<0.001	0.003	<0.001	0.091		0.01			<0.001	0.033			<0.00005	0.46	0.27
M230W	7/12/2013	<0.0001	<0.001	0.002	0.003	<0.001	0.16		0.008			<0.001	0.017			<0.00005	0.63	0.11
M230W	11/05/2014				0.003		0.212						0.037			<0.0001		0.17
M230W	5/12/2014				0.001		0.317						0.06			<0.0001	0.7	0.3
M230W	12/03/2015		<0.001	0.003	0.001	<0.001	0.251		0.131			<0.01	0.013				0.8	
M230W	17/05/2015	<0.0001	<0.001	0.003	0.002	<0.001	0.243		0.01			<0.01	0.024			<0.0001	0.6	
M230W	28/07/2015	<0.0001	<0.001	0.001	0.004	<0.001	0.146		0.012			<0.01	0.049			<0.0001	0.7	
M230W	15/11/2015	<0.0001	0.002	<0.001	0.002	<0.001	0.046		0.06			<0.01	0.068			<0.0001	0.8	0.17
M230W	2/03/2016		<0.001	0.001	0.002	<0.001	0.035		0.006			0.042	<0.01				0.7	0.19
M230W	13/05/2016	<0.0001	<0.001	<0.001	0.001	<0.001	0.04	0.006	0.021	<0.01	1.52	<0.01	0.024	0.6	<0.05	<0.0001	0.7	0.1
M230W	29/08/2016		<0.001	<0.001	0.007	<0.001	0.027	0.008	0.039	<0.01	1.68	<0.01	0.026	0.42	<0.05		0.7	0.1
M230W	15/11/2016	<0.0001	<0.001	<0.001	0.002	<0.001	0.097	0.008	0.026	<0.01	1.71	<0.01	0.036	0.47	<0.05	<0.0001	0.6	0.08
M230W	13/06/2017				0.001		0.451						0.014	0.45	0.36	<0.0001	0.8	0.18
M230W	12/11/2017		<0.001	0.005		<0.001	0.203	0.005	0.014	<0.01		<0.01	0.065	0.47	<0.05		0.7	0.23
M230W	1/06/2018				0.001		0.188						0.012	0.44	0.43	<0.0001	0.7	0.17
M230W	21/11/2018		<0.001	0.003	<0.001	<0.001	0.186	0.003	0.009	<0.01		<0.01	0.047	0.48	<0.05	<0.0001	0.7	0.12
M230W	25/05/2019				0.001		0.213						0.012	0.56	0.39	<0.0001	0.7	0.14
M230W	10/11/2019		<0.001	0.004	<0.001	<0.001	0.186	0.002	0.015	<0.01		<0.01	0.016	0.52	0.29		0.7	0.13
M230W	1/11/2020				<0.001		0.204						0.017	0.44	<0.05	<0.0001	0.6	0.14
M250W	13/12/2012	<0.0001	0.002	<0.001	0.002	<0.001	0.027		0.008			<0.001	0.023			<0.00005	0.18	0.012
M250W	6/04/2013	<0.0001	0.001	<0.001	0.002	<0.001	0.054		0.014			<0.001	0.02			<0.00005	0.14	0.01
M250W	25/05/2013	<0.0001	0.003	<0.001	0.004	<0.001	0.015		0.007			<0.001	0.018			<0.00005	0.14	0.012
M250W	6/08/2013	<0.0001	0.002	<0.001	0.002	<0.001	0.007		0.006			<0.001	0.016			<0.00005	0.13	0.079
M250W	5/12/2013	<0.0001	0.002	<0.001	0.001	<0.001	0.019		0.01			<0.001	0.014			<0.00005	0.14	<0.005
M250W	9/05/2014				0.004		0.018						0.019			<0.0001		1.3
M250W	7/12/2014				<0.001		0.017						<0.005			<0.0001	0.2	0.08
M250W	10/03/2015		0.003	<0.001	<0.001	<0.001	0.013		0.01			<0.01	0.018				0.6	
M250W	18/05/2015	<0.0001	0.002	0.001	<0.001	<0.001	0.015		0.011			<0.01	0.019				0.2	
M250W	29/07/2015	<0.0001	0.003	0.001	<0.001	<0.001	0.028		0.01			<0.01	0.106			<0.0001	0.2	
M250W	16/11/2015	<0.0001	0.001	0.004	0.005	<0.001	0.076		0.048			<0.01	0.131			<0.0001	0.2	0.4
M250W	2/03/2016		0.002	<0.001	0.001	<0.001	0.014		0.01			<0.01	0.048				0.2	0.16
M250W	13/05/2016		0.076	<0.0001	0.002	<0.001	0.011	<0.001	0.009	<0.01	0.725	<0.01	0.016	0.76	0.05	<0.0001	0.2	0.91
M250W	29/08/2016		0.002	0.001	0.001	<0.001	0.012	<0.001	0.01	<0.01	0.686	<0.01	0.008	0.61	<0.05		0.2	0.51
M250W	15/11/2016	<0.0001	0.002	0.001	<0.001	<0.001	0.012	<0.001	0.008	<0.01	0.698	<0.01	0.032	0.73	<0.05	<0.0001	0.2	0.47
M250W	18/06/2017				0.001		0.014						0.021	0.67	<0.05	<0.0001	0.2	0.44
M250W	13/11/2017		0.002	0.005	0.002	<0.001	0.095	0.002	0.043	<0.01		<0.01	0.111	0.7	<0.05		0.3	0.62
M250W	2/06/2018				<0.001		0.014						0.006	0.73	0.43	<0.0001	0.2	0.63
M250W	22/11/2018		0.002	0.001	0.001	<0.001	0.016	<0.001	0.01	<0.01		<0.01	0.072	0.68	<0.05	<0.0001	0.2	0.77
M250W	26/05/2019				0.001		0.021						0.031	0.74	<0.05	<0.0001	0.2	0.23
M250W	7/11/2019		0.002	0.004	<0.001	<0.001	0.043	0.001	0.088	<0.01		<0.01	0.035	0.74	<0.05		0.2	0.03
M250W	7/11/2019		0.002	0.004	<0.001	<0.001	0.043	0.001	0.088	<0.01		<0.01	0.035	0.74	<0.05		0.2	0.03
M222W	16/06/2012	<0.0001	0.002	0.002	0.002	<0.001	1.17		0.125			<0.01	0.041			<0.0001	0.6	
M222W	14/12/2012	<0.0001	<0.001	0.002	0.003	<0.001	1.3		0.005			<0.001	0.043			<0.00005	0.48	<0.005
M222W	5/04/2013	<0.0001	<0.001	<0.001	0.002	<0.001	1.1		0.019			<0.001	0.037			<0.00005	0.68	<0.005
M222W	26/05/2013	<0.0001	<0.001	<0.001	0.002	<0.001	1.3		0.004			<0.001	0.007			<0.00005	0.47	<0.005
M222W	9/08/2013	<0.0001	<0.001	<0.001	0.001	<0.001	1.2		<0.001			<0.001	0.011			<0.00005	0.44	<0.005
M222W	6/12/2013	<0.0001	<0.001	<0.001	0.002	<0.001	1.7		0.001			<0.001	0.018			<0.00005	0.59	<0.005
M222W	10/05/2014				0.004		1.35						0.019			<0.0001		2.09
M222W	19/08/2014				0.001		1.54						0.036			<0.0001	0.4	0.18
M222W	4/12/2014				<0.001		1.45						0.115			<0.0001	0.8	0.74
M222W	11/03/2015		<0.001	<0.001	<0.001	<0.001	1.27		<0.001			<0.01	0.02				1	
M222W	17/05/2015	<0.0001	<0.001	<0.001	<0.001	<0.001	1.57		0.002			<0.01	0.021			<0.0001	0.7	
M222W	27/07/2015	<0.0001	<0.001	<0.001	<0.001	<0.001	1.28		0.007			<0.01	<0.005			<0.0001	0.8	
M222W	17/11/2015	<0.0001	<0.001	<0.001	0.001	<0.001	1.37		<0.001			<0.01	0.074			<0.0001	0.9	0.53
M222W	2/03/2016		0.002	<0.001	<0.001	<0.001	1.27		0.017			<0.01	0.043				0.8	0.11
M222W	13/05/2016	<0.0001	<0.001	<0.001	<0.001	<0.001	1.59	0.004	<0.001	<0.01	6.67	<0.01	<0.005	0.33	17.6	<0.0001	0.7	0.43
M222W	29/08/2016		<0.001	<0.001	<0.001	<0.001	1.86	0.004	0.003	<0.01	8.96	<0.01	<0.005	0.32	21.1		0.8	0.55
M222W	15/11/2016	<0.0001	<0.001	<0.001	<0.001	<0.001	1.59	0.003	0.002	<0.01	8.73	<0.01	0.015	0.34	13.6	<0.0001	0.8	0.19
M222W	13/06/2017				<0.001		1.55						<0.005	0.33	11.4	<0.0001	0.7	0.32
M222W	7/11/2017		<0.001	<0.001	<0.001	<0.001	1.63	0.002	0.001	<0.01		<0.01	<0.005	0.3	14.5		0.8	0.43
M222W	29/05/2018				0.002		1.63						<0.005	0.32	15.5	<0.0001	0.7	0.46
M222W	18/11/2018		<0.001	<0.001	<0.001	<0.001	1.48	0.002	<0.001	<0.01		<0.01	<0.005	0.34	11		0.6	0.12
M222W	24/05/2019				0.036		1.65						0.069	0.32	18.6	<0.0001	0.7	0.39
M222W	10/11/2019		<0.001	<0.001	0.014	<0.001	1.56	0.003	0.028	<0.01		<0.01	0.059	0.32	17.1		0.7	0.41
M222W	20/11/2020				<0.001		1.72						0.013	0.33	0.05	<0.0001	0.7	0.67
M224W	16/06/2012	<0.0050	<0.010	0.011	<0.00005	<0.010	7.75		<0.00005			<0.10	0.06			<0.0001	0.9	
M224W	15/12/2012	<0.0001	<0.001	0.012	<0.001	<0.001	7.8		0.023			0.001	0.009			<0.00005	0.74	0.03
M224W	7/04/2013	0.0002	<0.001	0.015	<0.001	<0.001	8.1		0.04			<0.001	0.024			<0.00005	0.45	<0.005
M224W	25/05/2013	<0.0001	<0.001	0.007	<0.001	<0.001	4.8		0.083			0.002	0.008			<0.00005	0.23	<0.005
M224W	6/08/2013	<0.0001	<0.001	0.01	<0.001	<0.001	6.8		0.018			<0.001	0.027			<0.00005	0.37	0.052
M224W	6/12/2013	<0.0001	<0.001	0.012	<0.001	<0.001	8		0.015			<0.001	0.021			<0.00005	0.51	0.007
M224W	10/05/2014				<0.05		7.57						0.056			<0.0001		0.3
M224W	19/08/2014				<0.001		7.98						0.302			<0.0001	0.4	0.79
M224W	4/12/2014				<0.001		6.83						0.067			<0.0001	0.4	0.17
M224W	12/03/2015		<0.001	0.016	0.006	<0.001	4.4		0.119			<0.01	0.044				0.6	
M224W	17/05/2015	<0.0001	<0.001	0.021	0.001	<0.001	4.59		0.025			<0.01	0.05			<0.0001	0.3	
M224W	27/07/2015	0.0001	<0.001	0.019	0.003	<0.001	4.51		0.17			<0.01	0.059			<0.0001	0.5	
M224W	17/11/2015	<0.0001	<0.001	0.027	<0.001	<0.001	3.78		0.014			<0.01	0.101			<0.0001	0.4	0.11
M224W	2/03/2016		<0.001	0.009	0.002	<0.001	1.36		0.021			<0.01	0.037				0.4	0.06
M224W	13/05/2016	<0.0001	<0.001	0.011	0.005	<0.001	3.42	0.001	0.007	<0.01	11.4	<0.01	0.176	0.34	4.8	<0.0001	0.4	<0.05
M224W	29/08/2016		<0.001	0.005	<0.001	<0.001	0.834	0.001	0.004	<0.01	3.19	<0.01	0.037	0.13	0.2		0.2	0.09
M224W	15/11/2016	<0.0001	<0.001	0.017	<0.001	<0.001	3.75	0.002	0.02	<0.01	14	<0.01	0.21	0.24	5.39	<0.0001	0.4	0.07
M224W	13/06/2017				<0.001		4.04						0.052	0.22	7.91	<0.0001	0.3	0.08
M224W	07/11/2017		0.015	<0.001		<0.001	4.94	0.003	0.042	<0.01	<0.01	<0.01	0.044	0.22	10.1		0.4	0.3
M224W	29/05/2018				0.002		6.72						0.062	0.34	7.2	<0.0001	0.5	0.22
M224W	18/11/2018		<0.001	0.003	0.017	<0.001	0.313	<0.001	0.014	<0.01		<0.01	0.103	0.16	0.52		0.2	0.03
M224W	24/05/2019				0.001		1.68						0.032	0.29	1.12	<0.0001	0.4	0.13
M224W	10/11/2019		<0.001	0.026	0.002	<0.001	1.58	0.001	0.045	<0.01		<0.01	0.059	0.39	4.43		0.3	<0.05
M224W	20/11/2020				<0.001		1.64						0.042	0.39	0.2	<0.0001	0.3	0.09
AN020F	13/05/2016	<0.0001	<0.001	0.001	<0.001	<0.001	1.92	<0.001	<0.001	<0.01	11.3	<0.01	<0.005	0.14	14.3	<0.0001	<0.1	<0.01
AN020F	15/11/2016		<0.001	<0.001	<0.001	<0.001	1.85	0.001	0.001	<0.01	11	<0.01	<0.005	0.19	8.25		<0.1	<0.05
AN020F	15/11/2017		<0.001	<0.001	<0.001	<0.001	1.17	0.005	0.006	<0.01		<0.01	<0.005	0.14	5.01		<0.1	0.11
AN020F	15/11/2018		<0.001	<0.001	0.001	<0.001	1.19	0.007	0.001	<0.01		<0.01	<0.005	0.2	5.36		<0.1	<0.01
AN020F	11/11/2019		<0.001	<0.001	0.005	<0.001	1.42	0.002	0.002	<0.01		<0.01	<0.005	0.13	1.68		<0.1	<0.01
AN020F	21/11/2020				<0.001		2.28	0.002					0.006	0.16	2.99	<0.0001	<0.1	0.01

D□□□M□ □□□□R□□ □□

Monitoring Bore ID	Sample Date	Field pH	Electrical Conductivity µS/cm	Total Dissolved Solids (grav) mg/L	Hydroxide Alkalinity (OH-) as CaCO3 mg/L	Carbonate Alkalinity as CaCO3 mg/L	Bicarbonate Alkalinity as CaCO3 mg/L	Total Alkalinity as CaCO3 mg/L	Sulphate, SO4 mg/L	Chloride, Cl mg/L	Calcium - Dissolved mg/L	Magnesium - Dissolved mg/L	Sodium - Dissolved mg/L	Potassium - Dissolved mg/L	Arsenic-Dissolved mg/L	Beryllium-Dissolved mg/L	Barium-Dissolved mg/L	Cadmium-Dissolved mg/L	Chromium-Dissolved mg/L	Cobalt-Dissolved mg/L	Copper-Dissolved mg/L	Lead-Dissolved mg/L	Manganese-Dissolved mg/L	Molybdenum mg/L	Nickel-Dissolved mg/L	Selenium mg/L	Strontium mg/L	Vanadium-Dissolved mg/L	Zinc-Dissolved mg/L	Boron mg/L	Iron mg/L	Mercury-Dissolved mg/L	Fluoride, F mg/L	Phosphate as P in water mg/L
M313W	25/07/2014	9.42	1710	1160	<1	51	283	334	12	252	7	<1	319	98	0.004	<0.001	0.843		0.018	0.01	2.12	2.19	0.429		0.032			0.02	0.568				0.6	2.28
M313W	13/02/2015	8.12	6940	4110	<1	<1	781	781	4	1810	26	5	1420	126	<0.001	<0.001	4.88		<0.001	<0.001	0.055	<0.001	0.139		0.004			<0.01	<0.005				2.4	2.32
M313W	11/11/2015	8.3	6890	3870	<1	<1	666	667	2	1910	22	4	1250	56	<0.001	<0.001	2.8		<0.001	<0.001	0.002	<0.001	0.099		0.002			<0.01	<0.005				2.4	0.87
M313W	30/05/2016	8.48	4570	2420	<1	41	443	484	2	1130	10	1	1000	60	<0.001	<0.001	1.23	<0.001	<0.001	<0.001	<0.001	<0.001	0.04	0.017	<0.001	<0.01	1.39	<0.01	0.008	0.5	0.28			0.16
M313W	15/11/2016	7.8	5620	2950	<1	<1	634	634	<1	1420	20	3	1170	62	0.002	<0.001	2.63	<0.001	<0.001	<0.001	0.002	<0.001	0.077	0.035	0.003	<0.01	3.02	<0.01	0.018	0.95	1.08		2.3	0.89
M313W	19/11/2017	8.59	6020	3320	<1	48	587	636	<1	1720	24	4	1370	60	0.003	<0.001	2.54		<0.001	<0.001	<0.001	<0.001	0.071	0.035	0.002	<0.01		<0.01	<0.005	0.92	0.57		2	0.83
M313W	16/11/2018	8.05	5840	3210	<1	4	621	625	<1	1350	24	4	1200	61	0.003	<0.001	2.25		<0.001	<0.001	0.002	<0.001	0.106	0.039	0.002	<0.01		<0.01	<0.005	0.81	1.07		1.9	
M313W	14/11/2019	7.99	6030	3360	<1	<1	621	621	2	1600	20	4	1260	55	0.003	<0.001	2.42		<0.001	<0.001	<0.001	<0.001	0.088	0.041	0.002	<0.01		<0.01	<0.005	0.88	0.45		2.1	
M313W	23/11/2020	8.23	6020	3390	<1	<1	648	648	1	1700	26	5	1520	67	0.003	<0.001	2.85		<0.001	<0.001	<0.001	<0.001	0.082	0.055	0.003	<0.01		<0.01	<0.005	1.31	1.4		2.2	0.65
M314W	24/07/2014	8.57	5090	4790	<1	9	1210	1220	134	198	46	1	212	1450	0.013	<0.001	0.575		0.015	0.005	7.08	0.562	0.446		0.018			<0.01	0.472				0.4	65.6
M314W	13/02/2015	8.04	7150	5470	<1	<1	1180	1180	69	1370	29	6	1040	795	0.004	<0.001	1.37		<0.001	0.002	0.995	<0.001	0.141		0.01			<0.01	<0.005				0.9	20.6
M314W	13/11/2015	8.01	8210	5280	<1	<1	836	836	2	2190	17	5	1420	335	0.003	<0.001	1.31		<0.001	<0.001	0.031	<0.001	0.14		0.013			<0.01	0.011				1.1	17.4
M314W	30/05/2016	8.6	8500	4880	<1	49	767	817	<1	2370	22	6	1640	326	0.003	<0.001	5.21	<0.001		<0.001	0.022	<0.001	0.028	0.053	0.001	<0.01	5.5	<0.01	0.01	0.87	0.1	0.87		9.67
M314W	15/11/2016	8.88	8180	4810	<1	108	827	934	<1	2290	19	6	1500	404	0.004	<0.001	3.88	<0.001	<0.001	<0.001	0.03	<0.001	0.036	0.062	0.002	<0.01	3.67	<0.01	0.009	0.9	0.21		1.3	12.1
M314W	18/11/2017	8.9	8300	4860	<1	169	908	1080	<1	2190	17	5	1880	543	0.004	<0.001	2.91		<0.001	<0.001	0.024	<0.001	0.053	0.068	0.002	<0.01		<0.01	<0.005	0.76	0.18		1.2	14.2
M314W	20/11/2018	8.72	8010	4910	<1	142	892	1030	<1	2010	15	5	1530	459	0.005	<0.001	2.86		<0.001	<0.001	0.024	<0.001	0.057	0.078	0.002	<0.01		<0.01	<0.005	0.81	0.29		1.2	
M314W	16/11/2019	8.59	7910	4900	<1	86	991	1080	2	1860	8	4	1460	465	0.005	<0.001	2.43		<0.001	<0.001	0.024	<0.001	0.068	0.082	0.003	<0.01		<0.01	<0.005	0.77	0.33		1.3	
M314W	24/11/2020	8.64	7880	4510	<1	37	1010	1050	5	2130	10	4	1610	506	0.006	<0.001	2.82		<0.001	<0.001	0.021	<0.001	0.073	0.089	0.003	<0.01		<0.01	<0.005	0.91	0.59		1.3	14.5
M324W	26/07/2014	9.17	1170	707	<1	48	177	225	24	188	26	5	199	31	0.005	<0.001	0.31		0.004	0.004	0.582	0.459	0.304		0.008			<0.01	0.427				1	2.01
M324W	13/02/2015	8.83	2660	1540	<1	105	615	720	1	505	7	2	627	29	<0.001	<0.001	0.482		<0.001	<0.001	<0.001	<0.001	0.018		0.002			<0.01	0.093				3.7	0.88
M324W	30/05/2016	8.57	2750	1390	<1	64	624	688	6	522	6	1	599	12	<0.001	<0.001	0.921	<0.001	<0.001	<0.001	<0.001	<0.001	0.025	0.02	<0.001	<0.01	0.889	<0.01	0.006	0.76	0.22			0.46
M324W	15/11/2016	8.58	2650	1540	<1	59	635	694	<1	503	5	1	612	12	0.001	<0.001	0.738	<0.001	<0.001	<0.001	<0.001	<0.001	0.009	0.024	<0.001	<0.01	0.807	<0.01	0.01	0.78	0.13		4.5	0.44
M324W	19/11/2017	8.86	2740	1300	<1	104	568	672	<1	536	4	1	666	13	0.001	<0.001	0.572		<0.001	<0.001	<0.001	<0.001	0.006	0.027	<0.001	<0.01		<0.01	<0.005	0.72	<0.05		3.9	0.57
M324W	16/11/2018	8.66	2740	1520	<1	86	565	651	<1	507	3	1	579	13	0.001	<0.001	0.555		<0.001	<0.001	0.001	<0.001	0.006	0.031	<0.001	<0.01		<0.01	<0.005	0.74	0.12		3.8	
M324W	14/11/2019	8.7	2690	1530	<1	74	571	645	1	524	2	<1	595	12	0.001	<0.001	0.56		<0.001	<0.001	<0.001	0.001	0.005	0.03	<0.001	<0.01		<0.01	<0.005	0.72	0.2		4.3	
M324W	23/11/2020	8.99	2590	1480	<1	92	556	648	<1	566	1	1	748	15	0.001	<0.001	0.584		<0.001	<0.001	0.002	0.002	0.005	0.044	<0.001	<0.01		<0.01	0.005	0.99	0.22		4.3	0.57
M325W	13/02/2015	8.55	3410	2260	<1	14	252	297	68	906	2	<1	709	73	0.002	<0.001	0.005		<0.001	0.003	0.016	<0.001	0.009		0.009			<0.01	0.024				0.7	0.56
M325W	13/11/2015	8.13	5000	2730	<1	<1	450	450	4	1400	8	1	919	40	0.001	<0.001	0.252		<0.001	0.002	<0.001	<0.001	0.086		<0.001			<0.01	<0.005				1.1	0.45
M325W	30/05/2016	8.74	6150	3310	<1	75	370	446	1	1600	6	<1	1250	39	0.002	<0.001	0.384	<0.001	<0.001	<0.001	0.008	<0.001	0.057	0.114	0.002	<0.01	0.639	<0.01	0.009	1.17	0.24			0.4
AN019F	10/11/2015	11.8	10200	5430	456	82	<1	539	33	2920	154	<1	1620	19	0.002	<0.001	2.79		<0.001	<0.001	0.006	<0.001	<0.001		0.007			<0.01	0.01				0.8	0.04
AN019F	30/05/2016	11.6	10800	5970	410	100	<1	510	38	3180	168	<1	1840	29	0.004	<0.001	3.25	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.056	0.008	<0.01	8.18	<0.01	<0.005	0.42	<0.05	0.42		0.05
AN019F	15/11/2016	11.8	11100	6140	428	125	<1	553	37	3400	162	<1	1970	28	0.004	<0.001	2.65	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.036	0.006	<0.01	5.92	<0.01	0.014	0.46	<0.05		0.7	<0.05
AN019F	15/11/2017	11.1	10700	5890	123	135	<1	258	35	3340	104	<1	2330	27	0.004	<0.001	2.4		<0.001	<0.001	<0.001	<0.001	<0.001	0.027	0.003	<0.01		<0.01	0.006	0.45	<0.05		0.7	0.13
AN019F	11/11/2019	11.41	10700	6550	195	125	<1	319	32	3540	82	<1	2280	23	0.004	<0.001	2.34		<0.001	<0.001	<0.001	<0.001	<0.001	0.024	0.002	<0.01		<0.01	<0.005	0.57	<0.05		0.8	
AN019F	21/11/2020	11.37	10800	5750	230	61	<1	291	29	3670	63	<1	2590	24	0.004	<0.001	2.86		<0.001	<0.001	<0.001	<0.001	<0.001	0.03	0.002	<0.01		<0.01	<0.005	0.75	<0.05		0.8	0
GR067V	30/08/2016	9.05	7020	4000	<1	407	1550	1960	19	1180	7	1	1580	14	0.003	<0.001	1.48	0.001	0.001	<0.001	0.002	<0.001	0.11	0.032	0.006	<0.01	1.18	<0.01	0.011	0.81	1.56			0.6
GR067V	15/11/2016	8.12	7850	4640	<1	<1	2310	2310	3	1260	15	3	1850	13	0.003	<0.001	4.94	0.001	0.001	<0.001	<0.001	<0.001	0.024	0.024	0.001	<0.01	3.72	<0.01	0.018	1.17	0.68		1.8	0.3
GR067V	19/11/2017	8.72	8210	4910	<1	238	2120	2360	4	1440	19	3	2190	12	0.003	<0.001	3.83		<0.001	<0.001	<0.001	<0.001	0.008	0.019	<0.001	<0.01		<0.01	0.008	1.03	0.16		1.7	0.3
GR067V	23/11/2018	8.46	8340	6020	<1	456	1950	2410	7	1460	18	3	2050	12	0.002	<0.001	4.44		<0.001	<0.001	<0.001	<0.001	0.008	0.023	<0.001	<0.01		<0.01	0.008	1.18	0.22		2	
GR067V	16/11/2019	8.19	7950	4950	<1	47	2380	2420	7	1350	7	3	2040	9	0.002	<0.001	3.23		<0.001	<0.001	<0.001	<0.001	0.009	0.019	<0.001	<0.01		<0.01	0.005	1.28	0.29		2	
GR067V	24/11/2020	8.73	7980	5040	<1	111	2240	2350	12	1520	7	3	1860	10	0.003	<0.001	5.28		<0.001	<0.001	<0.001	<0.001	0.014	0.03	<0.001	<0.01		<0.01	<0.005	1.56	0.54		2.2	0.44
M162V	14/11/2015	8.44	11500	6970	<1	38	1060	1090	3	3640	10	6	2370	12	<0.001	<0.001	0.236		<0.001	<0.001	<0.001	<0.001	0.092		<0.001			<0.01	<0.005				1.9	1.13
M162V	30/05/2016	7.91	12700	7250	<1	<1	1050	1050	2	4040	56	19	2590	12	<0.001	<0.001	11	<0.001	<0.001	<0.001	0.01	<0.001	0.063	0.002	0.001	<0.01	10.8	<0.01	0.16	2.4	3			<0.05
M162V	15/11/2016	7.7	12300	6660	<1	<1	1060	1060	<1	3870	69	18	2670	12	<0.001	<0.001	9.93	<0.001	<0.001	<0.001	<0.001	<0.001	0.034	0.001	<0.001	<0.01	9.77	<0.01	0.032	2.02	2.19		2.6	0.03
M134W	14/11/2017	8.1	15600	9810	<1	<1	168	168	<1	5770	209	62	3490	12	<0.001	<0.001	23		<0.001	<0.001	<0.001	<0.001	0.064	0.001	<0.001	<0.01		<0.01	0.009	0.46	0.40		0.5	0.04
M134W	215/11/2018	7.3	16000	9710	<1	<1	159	159	<1	5310	182	61	2990	12	<0.001	<0.001	20.3		<0.001	<0.001	0.002	<0.001	0.063	0.001	<0.001	<0.01		<0.01	0.011	0.48	0.3		0.5	
M134W	14/11/2019	7.27	15500	9670	<1	<1	162	162	1	5460	134	58	3200	12	0.002	<0.001	20.2		<0.001	0.005	<0.001	<0.001	0.098	0.007	0.02	<0.01		<0.01	0.02	0.47	1.18		0.5	0.04
M134W	24/11/2020	7.73	15500	9430	<1	<1	166	166	0	5850	114	55	3100	11					<0.001				0.068						0.011	0.49	0.45	<0.0001	0.6	0.06
MB1-D	17/11/2019	7.95	8790	5110	<1	<1	817	817	<1	2250	14	12	1900	16	0.002	<0.001	4.29		<0.001	0.001	0.005	0.008	0.049	0.018	0.036	<0.01		<0.01	0.045	1.04	1.53		2.2	0.45
MB1-D	20/11/2020	8.26	9380	5460	<1	<1	1600	1600	0	2560	14	10	2410	24	0.003	0	4.12		<0.001	<0.001	0.002	0.006	0.015	0.017	0.032	<0.01		<0.01	0.024	1.68	1.14	<0.0001	2	0.97
GW007B	15/11/2019	6.79	15700	9910	<1	<1	1380	1380	<1	4920	276	256	2330	64	0.005	<0.001	12.2		<0.001	0.001	<0.001	<0.001	0.12	0.006	0.02	<0.01		<0.01	2.16	0.24	2.94		0.2	0.02

MB

Aqtesolv Output using BHP data (gas and water).



WELL TEST ANALYSIS

Data Set:
Date: 07/23/20 Time: 09:44:17

PROJECT INFORMATION

Test Well: RH60

AQUIFER DATA

Saturated Thickness: 775. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells			Observation Wells		
Well Name	X (m)	Y (m)	Well Name	X (m)	Y (m)
RH60	0	0	RH60	0	0

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)
T = 0.000366 m^2/day S/S' = 1.205

Time axis intercept (t/t') = 1.205
Pumping start day = 1 days 6/08/2016
Pumping stop day = 649 days 16/05/2018
extrapolating out t/t' in the Water Level Data tab until t/t' = 1.205

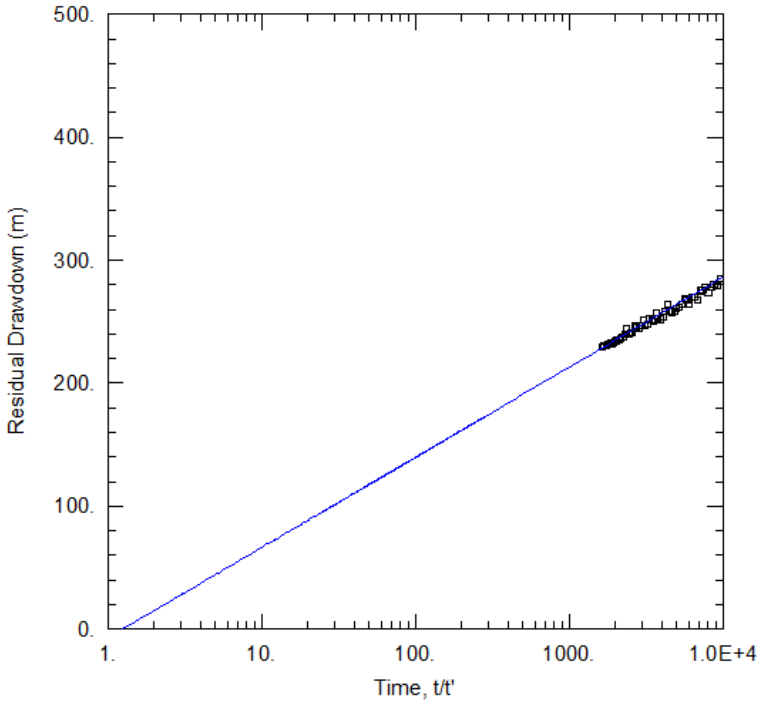
	t'	t	t/t'	
	789	1443	1.828897	2401
	3190	3844	1.2050	

t' (time since pumping stopped) = 3190 days 8/02/2027
t (total time since pumping started) = 3844 days 14/02/2027
100% recovery = 14/02/2027

	x	y	
recovery curve	649	704.6038	BHP monitoring point at start of recovery
	3844	0	100% recovery as determined above

MB

Using latest monitoring period (29/9/17 to 17/10/18) - Aqtesolv Output - using measured bottom hole pressure (gas and water)



WELL TEST ANALYSIS

Data Set:
Date: 07/23/20 Time: 07:43:33

PROJECT INFORMATION

Test Well: RH50

AQUIFER DATA

Saturated Thickness: 665. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
RH50	0	0

Observation Wells

Well Name	X (m)	Y (m)
RH50	0	0

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 0.001962 m^2/day S/S' = 1.247

Time axis intercept (t/t') =	1.247		
Pumping start day =	1	days	29/09/2017
Pumping stop day =	283	days	8/07/2018
extrapolating out t/t' in the RH30_all_data tab until t/t' = 1.247			
t' (time since pumping stopped) =	1141	days	22/08/2021
t (total time since pumping started - analysis period) =	1423	days	22/08/2021
t (total time since pumping started - all mon data) =	2092		
100% recovery =	22/06/2023		

	x	y	
recovery curve	1757.5	614.4019	BHP monitoring point at start of recovery
	2092	0	100% recovery as determined above

t'	t	t/t'
1141	1423	1.247152

□ □ □ □ □ **D** □□ □□ □□ □□ **B** □□ □□ □□ □□ □□ □□ **r** □□ □□ **R** □□ □□ □□ □□ □□ □□ □ **d** □□ □□ **r** □□ □□ □□ □□ □□ □

□

□

Australasian Groundwater
and Environmental Consultants Pty Ltd
Level 2 / 15 Mallon Street
Bowen Hills, QLD 4006 Australia

ABN 64 080 238 642
T. +61 7 3257 2055
F. +61 7 3257 2088
brisbane@ageconsultants.com.au
www.ageconsultants.com.au

Memorandum

Project number G1885G

To St.John Herbert

From Neil Manewell

Date 5 March 2021

RE **Bowen Sector & Regional model results**

1 Introduction

This document provides a summary of a local sector model and a revised regional model developed to simulate additional production from the Red Hill field to the north of the Moranbah Gas Project (MGP) CSG production area. The Red Hill Development is a relatively small (~5.5 km^2) addition to Arrow development in the area, consisting of 14 multi-lateral production wells extracting gas from the Goonyella coal measures.

The impact of the additional development has been assessed using both the local sector model and the revised regional model. Predictions made using the latter regional model therefore relate to the cumulative impacts of all proposed Arrow developments in the area.

2 Background

The original Northern Bowen Basin numerical groundwater model was developed by Ausenco Norwest for Arrow Energy in 2012 to predict and delineate areas where predicted groundwater level drawdowns exceed the Queensland Department of Environmental and Heritage Protection (DEHP) threshold criteria. The model was built in MODFLOW-SURFACT™ using the Groundwater Vistas 6 software package. A uniform mesh of 1500 m x 1500 m cells was simulated over 18 model layers (Norwest, 2012).

AGE updated the Ausenco Norwest model in 2017 by remeshing the model to increase the resolution of the mesh around the MGP area, to better delineate groundwater structures, and to increase the layer resolution within the Moranbah Coal Measures (MCM), increasing the total count to 22 layers. Pilot point multipliers were added to the aquifer/aquitard hydraulic and storage parameter fields and the model was calibrated to groundwater head data from January 2014 to November 2017. Updated measured and predicted production data from Arrow Energy was provided on a monthly basis, per production bore and used to revise the MODFLOW well input package (AGE, 2017).

3 Scope of Works

Production from the Red Hill field is scheduled to commence in February 2021. Gas will be extracted from the Goonyella Middle Seam and Lower Seams (Layers 15 and 17). This production was not simulated in the 2017 AGE model; hence the model mesh incorporates relatively large cell sizes in the Red Hill part of the model domain.

Arrow wishes to modify the current model to provide revised groundwater impact predictions for a new field development plan including development of the Red Hill area.

The objectives of the modelling work were to:

- develop a local sector model of the Red Hill development
- update the field development plan in the 2017 AGE regional model;
- change the regional model stress period setup;
- review and where necessary revise modelled specific storages values based on recent literature (Rau et al, 2018); and
- produce updated impact predictions.

4 Numerical model development

4.1 Regional and local model set up

Analysis of the groundwater impacts predicted using the 2017 AGE model suggest drawdowns of more than 5 m extending to approximately 2 km from the northern boundary of the MGP production field; approximately 2 km from the Red Hill field (AGE, 2017). GW001 is the closest monitoring bore to the MGP production field, situated approximately 5.6 km from the most northerly MGP extraction well (see Figure 4.1). Hence, it was considered unlikely that cumulative drawdown induced by the MGP would have a significant impact on GW001. Accordingly, a localised sector model (or sub-model) centred around the Red Hill development area was constructed initially to rapidly analyse future impacts due to Goonyella depressurisation. Subsequently the grid of the 2017 AGE regional model was also refined.

The original 22-layer setup from the 2017 model remained unchanged outside the Red Hill production area. The following cell dimensions were adopted for the Red Hill production areas for both the sector and regional models:

- 150 m cells within the Red Hill Production area, and
- 150 m cells centred at the location of each monitoring well.

Figure 4.1 and Figure 4.2 presents the adopted model cells over the entire sector and regional model domains and in the vicinity of the Red Hill production area, respectively.

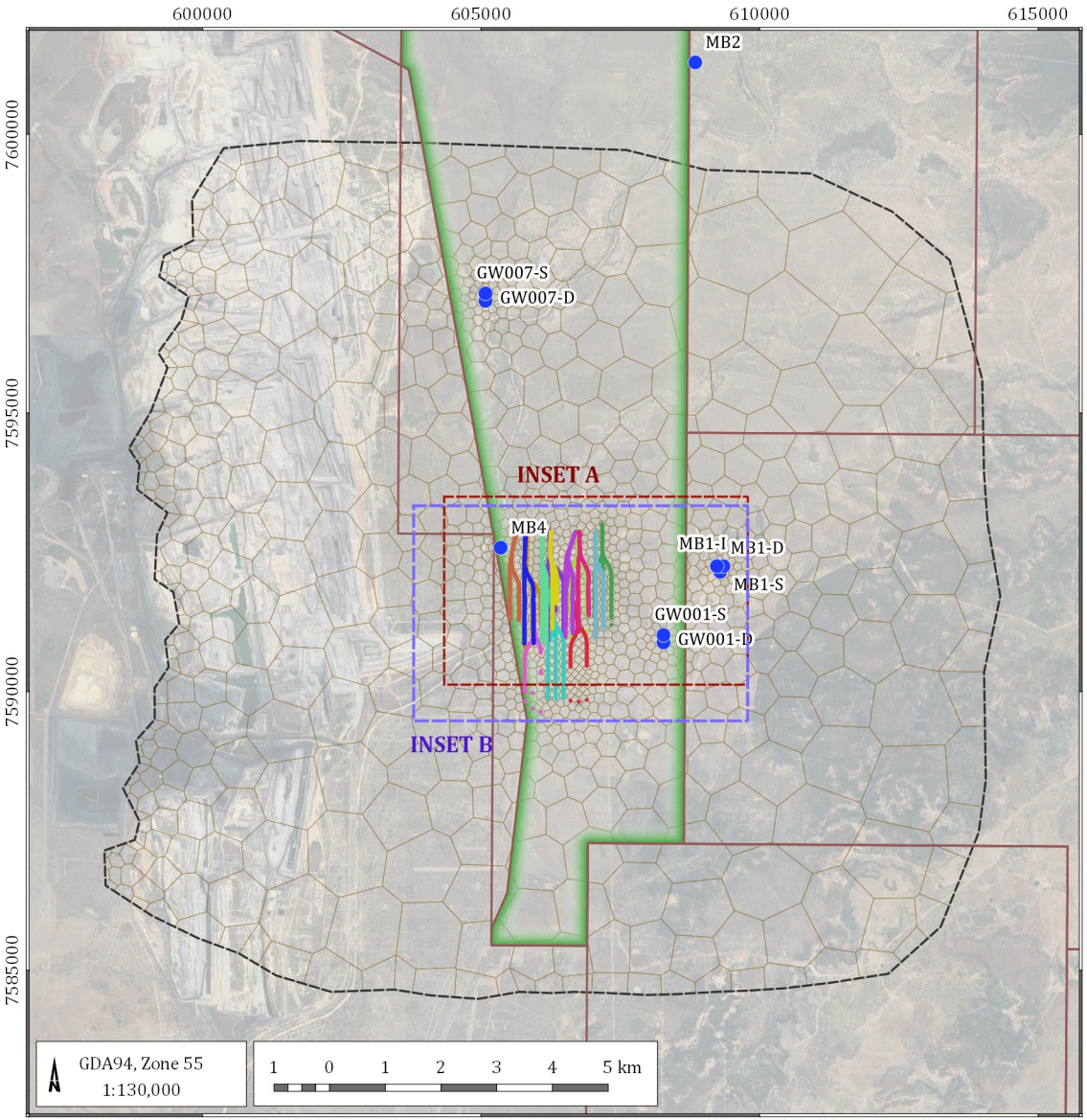
Overall, the sector model comprised of 18,450 cells across the 22 layers with significantly reduced model run times compared to the regional version. The refined regional model increased its cell count by 24,151 cells to a total of 212,667 cells across 22 layers.

The stress period setup for the sector model was as follows:

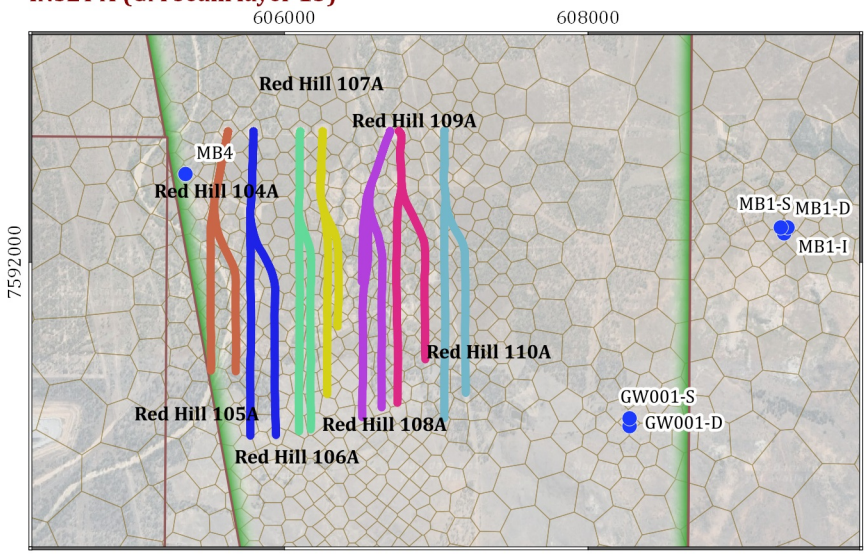
- 31 December 2003- steady state stress period, pre-mining initial conditions.
- January 2004 to May 2030 – 318 monthly stress periods.

A similar stress period setup was adopted for the regional model although longer model runs incorporating additional stress periods to year 2180 as follows:

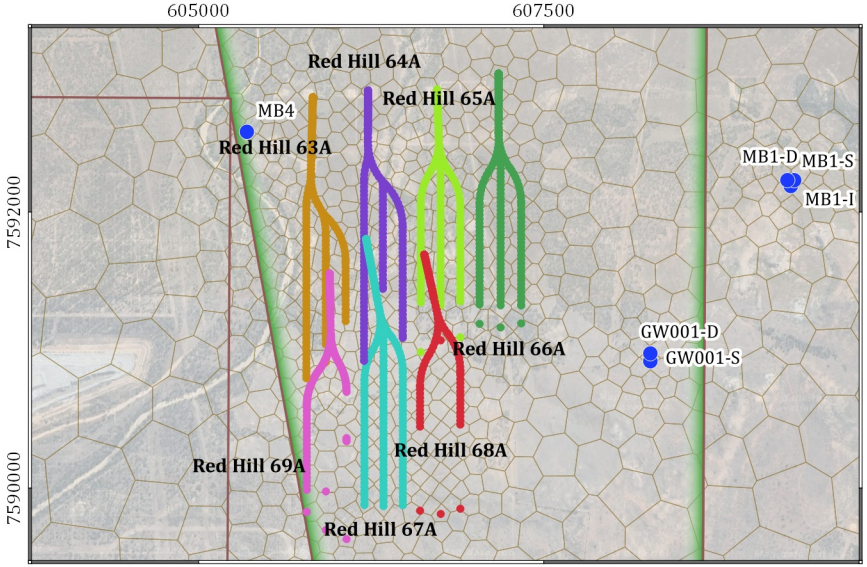
- June to December 2099 – 1 seven-month and 69 yearly stress periods.
- January 2100 to 2180 – 1 six-year and 15 five-year stress periods.



INSET A (GM seam layer 15)



INSET B (GL seam layer 17)



LEGEND

- Bowen GMMP monitoring
- Petroleum lease
- Arrow Petroleum lease
- Model boundary
- Sector model grid

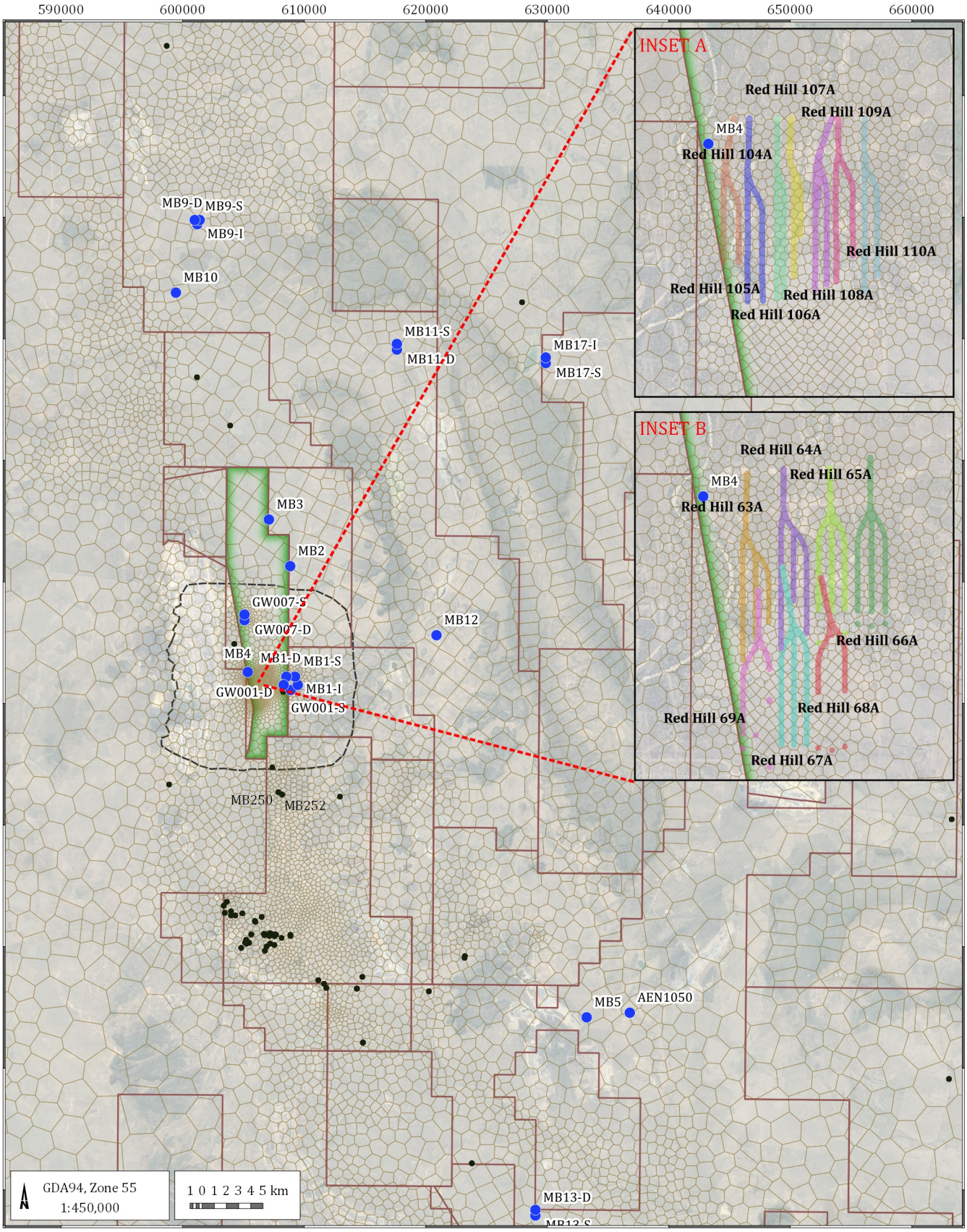
Arrow.BOWEN.Sector (G1885G)

Sector model grid

DATE
05/03/2021

FIGURE No:
4.1

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GBODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1885G.Bowen Groundwater Model Update\3_GIS\Workspaces\001_Deliverable1\04.01_G1885G_Sector model grid.qgs



LEGEND

- Bowen GMMP monitoring
- Petroleum lease
- Arrow Petroleum lease
- Sector model boundary
- Regional model grid
- Regional monitoring bores

Red Hill GL seam (Layer - 17)

- Red Hill 63A
- Red Hill 64A
- Red Hill 65A
- Red Hill 66A
- Red Hill 67A
- Red Hill 68A
- Red Hill 69A

Arrow.BOWEN.Sector model (G1885G)

Regional model grid

DATE 05/03/2021

FIGURE No: **4.2**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1885B.GHD.Arrow.BOWEN.UWIR\3_GIS\Workspaces\003_Deliverable3\04.02_G1885G_Regional model grid.qgs

4.2 Well package (WEL) construction

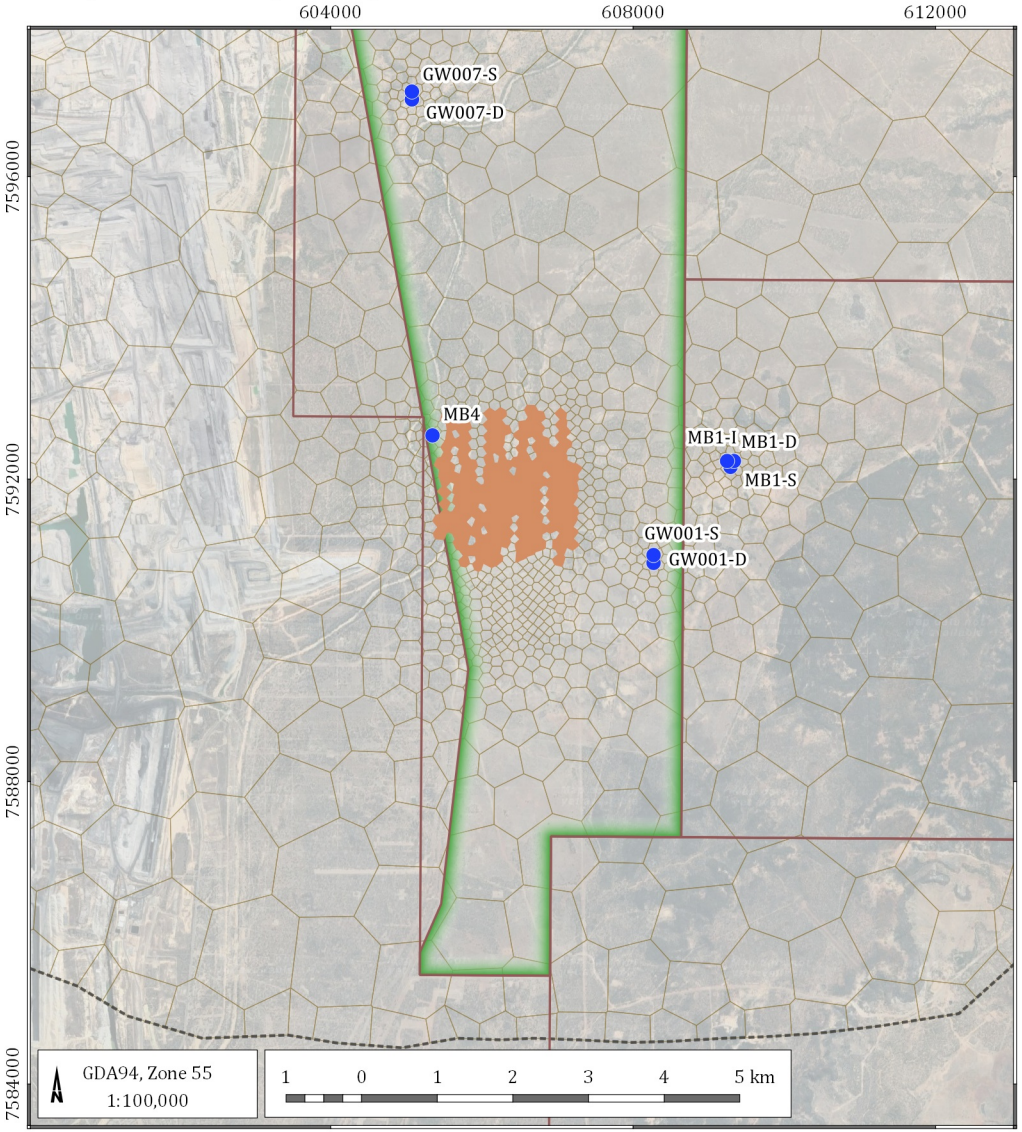
Monthly CSG well production data for all 14 Red Hill wells was provided by Arrow Energy. To best represent pumping in the model, a Fortran script was written to efficiently replicate future production in the sector model. Where a particular in-seam well intercepts a series of model cells, the WEL package was applied and the total flux rate was divided by the number of intercepted model cells.

Figure 4.3 show the model cells on the updated mesh, showing the start year for the Red Hill production simulated in the sector and regional models.

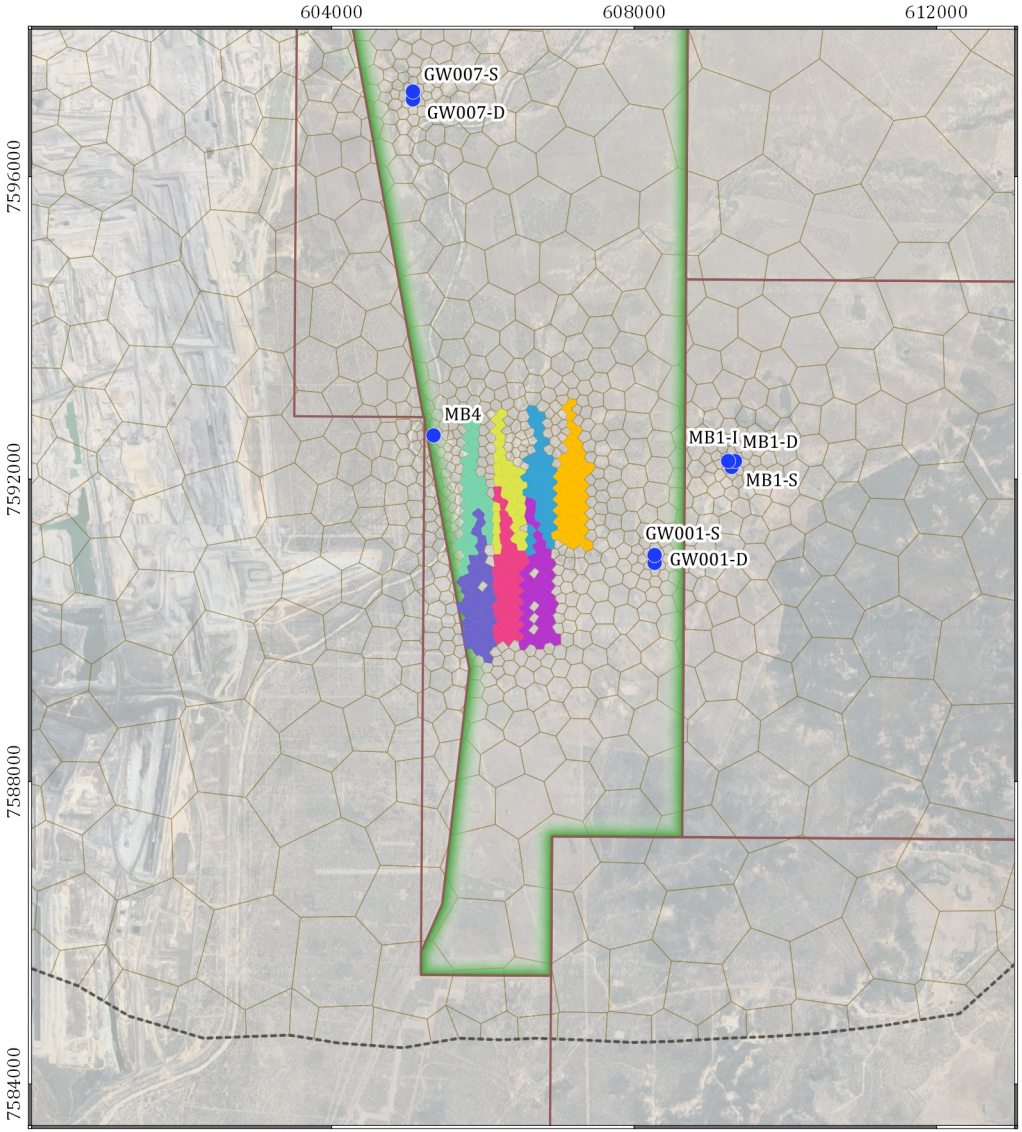
Figure 4.4 presents well production simulated in the sector and regional models.

Regional MGP and Mavis Downs production, as detailed in the AGE 2017 report, was unchanged. Bowen Gas Project (BGP) production was offset by three years to align with Arrows most recent field development plans.

Well production strat year - Layer 15 GM Seam



Well production strat year - Layer 17 GL Seam



LEGEND

- Bowen GMMP monitoring
- Petroleum lease
- Arrow Petroleum lease
- Model boundary
- Sector model grid

Start Year

- 1/02/2021
- 1/02/2024
- 1/03/2024
- 1/04/2024
- 1/05/2024
- 1/06/2024
- 1/07/2024
- 1/08/2024

Arrow.BOWEN.Sector (G1885G)

WEL production start year

DATE
05/03/2021

FIGURE No:
4.3

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1885G.Bowen Groundwater Model Update\3_GIS\Workspaces\001_Deliverable1\04.03_G1885G_WEL production start year.qgs

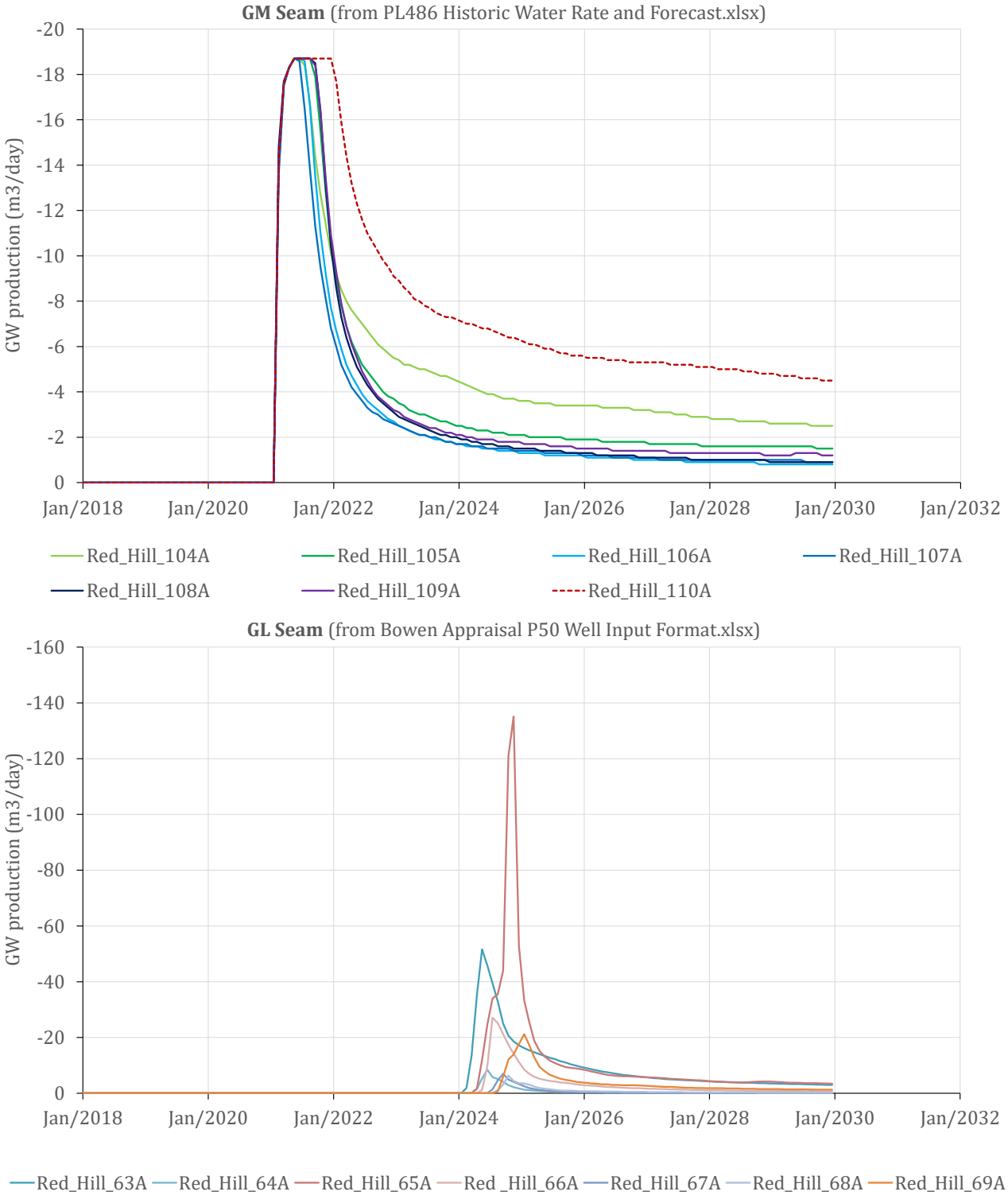


Figure 4.4 Red Hill production

4.3 Specific storage update

As discussed below since the development of the 2017 model, several papers have been released highlighting likely physical upper and lower bounds relating to specific storage. Specific storage represents the volume of water a portion of an aquifer (or aquitard) releases from storage, per unit change in hydraulic head, under fully saturated conditions. It is also known as 'elastic storage' as water can only be released from the decompression of the water, or compression of the aquifer.

To determine the magnitude and range for elastic storage, it is necessary to first understand the compressibility water, the compressibility of the aquifer matrix which contains the groundwater and the compressibility of the individual aquifer grains themselves.

Pells (2017) presented the following equation for specific storage based on poroelastic theory as part of a review of a proposed underground coal mine in NSW:

$$S_s = \rho_w g \left[\frac{(1+v)(1-2v)}{K(1-v)} + \theta \beta_w \right]$$

Where ρ_w is the density of water, g is the gravitational constant, β_w is water compressibility, v is Poisson's ratio, K is the bulk modulus, β_w is water compressibility, and θ is total porosity.

Rau et al (2018) described their work calculating uniaxial specific storage from undrained poroelastic properties, namely bulk modus, loading efficiency and the *Biot-Willis* coefficient. Specific storage was then derived using Loading efficiency (LE), derived from Barometric efficiency, the confined bulk modulus (K_v^u) and the Biot-Willis coefficient (α), as:

$$S_s = \rho_w g \frac{\alpha}{K_v^u LE(1-\alpha LE)}$$

Rau tested the methodology using field datasets collected at two sites with sand and clay dominated lithologies. Rau undertook a theoretical analysis using the equation outlined above to derive the physical limits of 2.3 x 10^{-7} m^{-1} and 1.3 x 10^{-5} m^{-1}.

Although the theoretically derived bounds presented in Rau (2018) use different combinations of elastic moduli to the Pells (2017) equation, and the relationships between the parameters possess inherent uncertainty at their upper and lower bounds, the results are consistent with the Pells (2017) relationship.

In light of these studies, it likely that the range of specific storage of the coal measures is between 1.0 x 10^{-6} m^{-1} and 4.0 x 10^{-6} m^{-1}. The calibrated 2017 model simulated specific storage of approximately 8.5 x 10^{-5} m^{-1} in the coal measures, and the uncertainty analysis explored values as low as 1.0 x 10^{-7} m^{-1}, although these parameter values were considered 'unlikely'. Hence, the specific storage values in the sector model were updated by 'recentering' the average value in three different sensitivity scenarios which span the likely range.

Table 4.1 presents the range of specific storage parameters tested in this assessment.

Table 4.1 Range of specific storage tested in sector model

Scenario	Coal Measures average Ss (m^{-1})	Interburden average Ss (m^{-1})	Tertiary average Ss (m^{-1})
Lower Pells bound	1.0 x 10^{-6}	1.0 x 10^{-6}	1.0 x 10^{-6} - 2.0 x 10^{-5}
Pells bound	4.0 x 10^{-6}	4.0 x 10^{-6}	1.0 x 10^{-6} - 2.0 x 10^{-5}
Upper Rau bound	2.0 x 10^{-5}	1.0 x 10^{-6}	1.0 x 10^{-6} - 2.0 x 10^{-5}

5 Drawdown predictions

5.1 Sector model

Table 5.1 presents the drawdown at the four Arrow groundwater monitoring bores within the sector model domain from 2020 to 2030. There is uncertainty regarding the construction details of the monitoring bores, therefore all major aquifer units present in the model at each location were extracted. The numbers at the end of the bore name indicate the layer the head was extracted from. The bold lines indicate the most likely screened section.

Table 5.1 Predicted maximum drawdown (sector model)

Bore	Unit	Upper Rau bound (2E-05)		Pells bound (4E-06)		Lower Pells bound (1E-06)	
		Date when >5 m drawdown occurs	Max drawdown (m)	Date when >5 m drawdown occurs	Maximum drawdown (m)	Date when >5 m drawdown	Max drawdown (m)
GW001-S_01	**Alluvium/ Regolith**	**NA**	**0.00**	**NA**	**0.00**	**NA**	**0.00**
GW001-D_08	FCCM	NA	0.00	NA	0.00	NA	0.00
GW001-D_09	FCCM	NA	0.00	NA	0.00	NA	0.00
GW001-D_10	**FCCM**	**NA**	**0.00**	**NA**	**0.00**	**NA**	**0.00**
GW001-D_11	MCM	NA	0.00	NA	0.00	NA	0.01
GW001-D_13	MCM	NA	0.01	NA	0.06	NA	0.95
GW001-D_15	MCM	NA	4.50	1/09/2022	50.75	1/07/2021	88.82
GW001-D_17	MCM	NA	0.18	1/04/2027	15.63	1/12/2024	49.66
GW007-S_01	**Alluvium/ Regolith**	**NA**	**0.01**	**NA**	**0.01**	**NA**	**0.01**
GW007-D_09	FCCM	NA	0.00	NA	0.00	NA	0.01
GW007-D_10	**FCCM**	**NA**	**0.00**	**NA**	**0.00**	**NA**	**0.00**
GW007-D_11	MCM	NA	0.01	NA	0.01	NA	0.01
GW007-D_13	MCM	NA	0.00	NA	0.02	NA	0.46
GW007-D_15	MCM	NA	0.09	NA	1.27	NA	2.35
GW007-D_17	MCM	NA	0.00	NA	0.23	NA	1.32
MB1-S_01	Alluvium/Regolith	NA	0.00	NA	0.00	NA	0.00
MB1-I_08	FCCM	NA	0.00	NA	0.00	NA	0.00
MB1-I_09	FCCM	NA	0.00	NA	0.00	NA	0.00
MB1-I_10	FCCM	NA	0.00	NA	0.00	NA	0.00
MB1-D_11	MCM	NA	0.00	NA	0.00	NA	0.01
MB1-D_13	MCM	NA	0.00	NA	0.01	NA	0.64
MB1-D_15	MCM	NA	0.00	NA	4.25	1/05/2023	19.14
MB1-D_17	MCM	NA	0.00	NA	0.06	1/04/2029	6.12
MB4_01	Alluvium/Regolith	NA	0.01	NA	0.01	NA	0.01
MB4_08	FCM	NA	0.01	NA	0.01	NA	0.01

Bore	Unit	Upper Rau bound (2E-05)		Pells bound (4E-06)		Lower Pells bound (1E-06)	
		Date when >5 m drawdown occurs	Max drawdown (m)	Date when >5 m drawdown occurs	Maximum drawdown (m)	Date when >5 m drawdown	Max drawdown (m)
MB4_09	FCM	NA	0.01	NA	0.01	NA	0.01
MB4_10	FCM	NA	0.00	NA	0.00	NA	0.00
MB4_11	MCM	NA	0.01	NA	0.01	NA	0.01
MB4_13	MCM	NA	0.03	NA	0.07	NA	0.77
MB4_15	MCM	1/06/2021	37.56	1/03/2021	104.47	1/03/2021	168.45
MB4_17	MCM	1/05/2025	16.48	1/06/2024	51.41	1/04/2024	97.06

The results indicate that GW001 and GW007 are unlikely to experience groundwater drawdown, given that the depth of these bores indicates they are constructed in the Fort Cooper Coal measures (FCCM) and above. MB4 is situated within the production field, so is predicted to experience groundwater drawdown exceeding 5 m in 2021. Results also suggest that MB1 will experience groundwater drawdown exceeding 5 m in May 2023.

Figure 5.1 presents a cross-section of modelled groundwater levels in the Goonyella Middle seam in April 2024 (upper panel). As shown groundwater levels remain well above the GM seam where the Upper Rau bound (SS of 2E-05 m^{-1}) is applied to the calibrated model. Conversely, scenarios simulating lower specific storage result in groundwater levels at or close to the top of the GM seam. Groundwater levels recovers faster in the scenarios with higher specific storage as less water is displaced, whereas the lower Pells bound scenario maintains some depressurisation down the GM seam until September 2027 (lower panel).

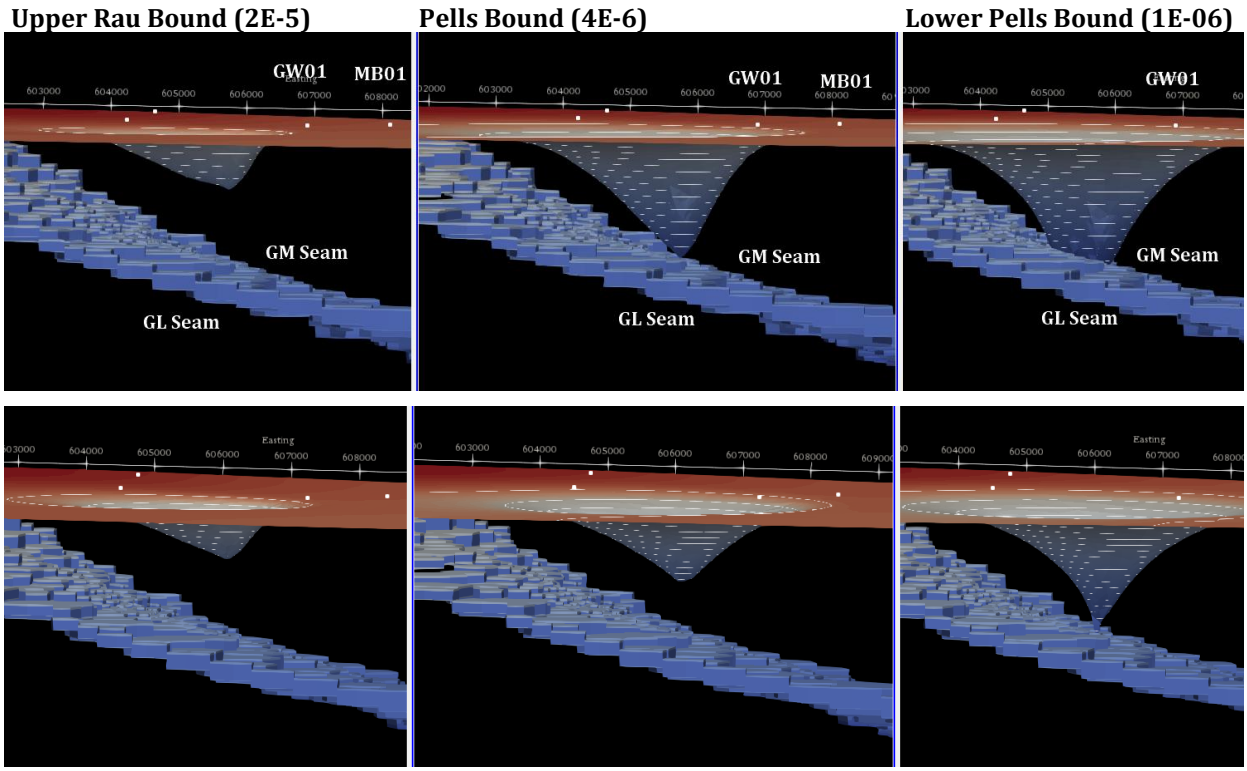
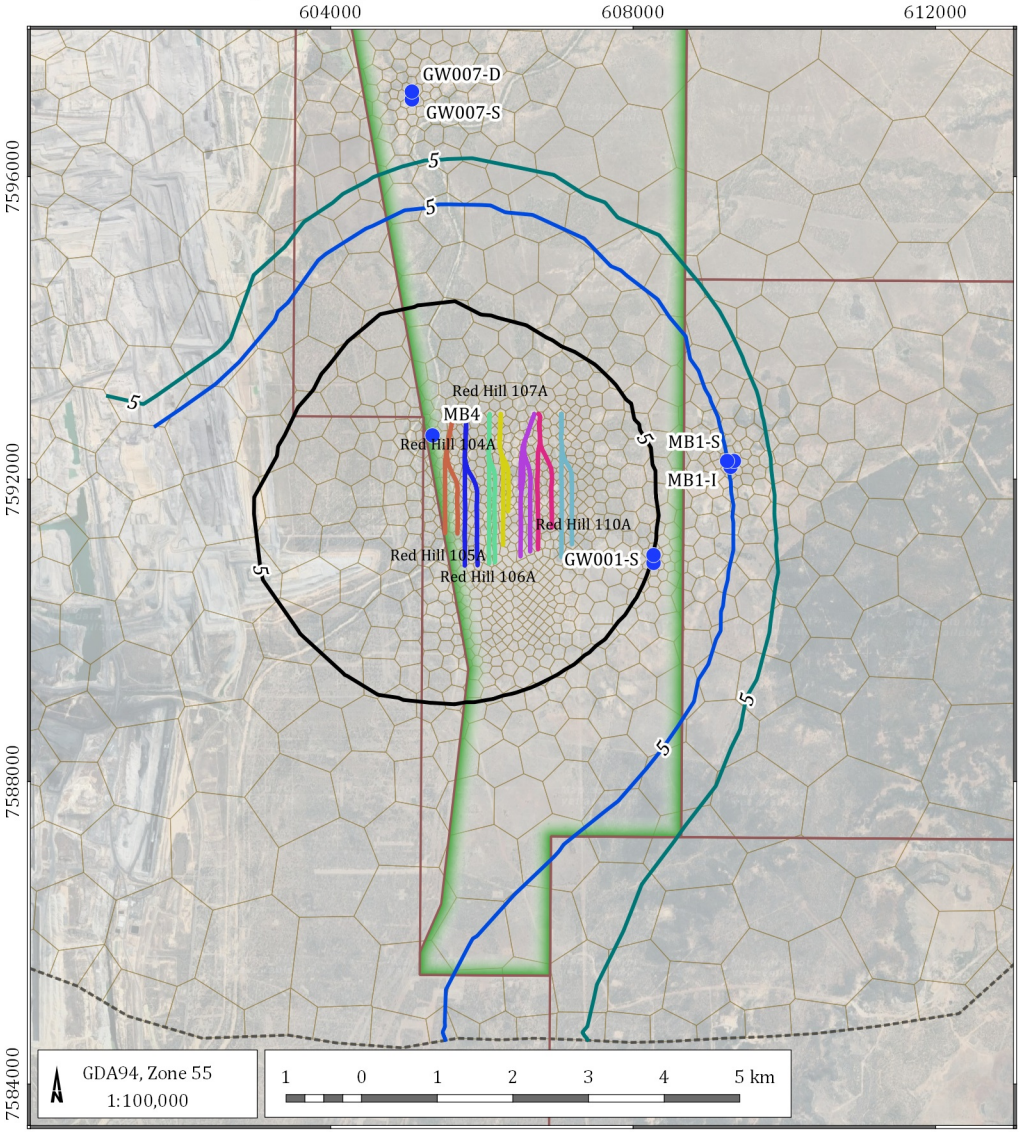
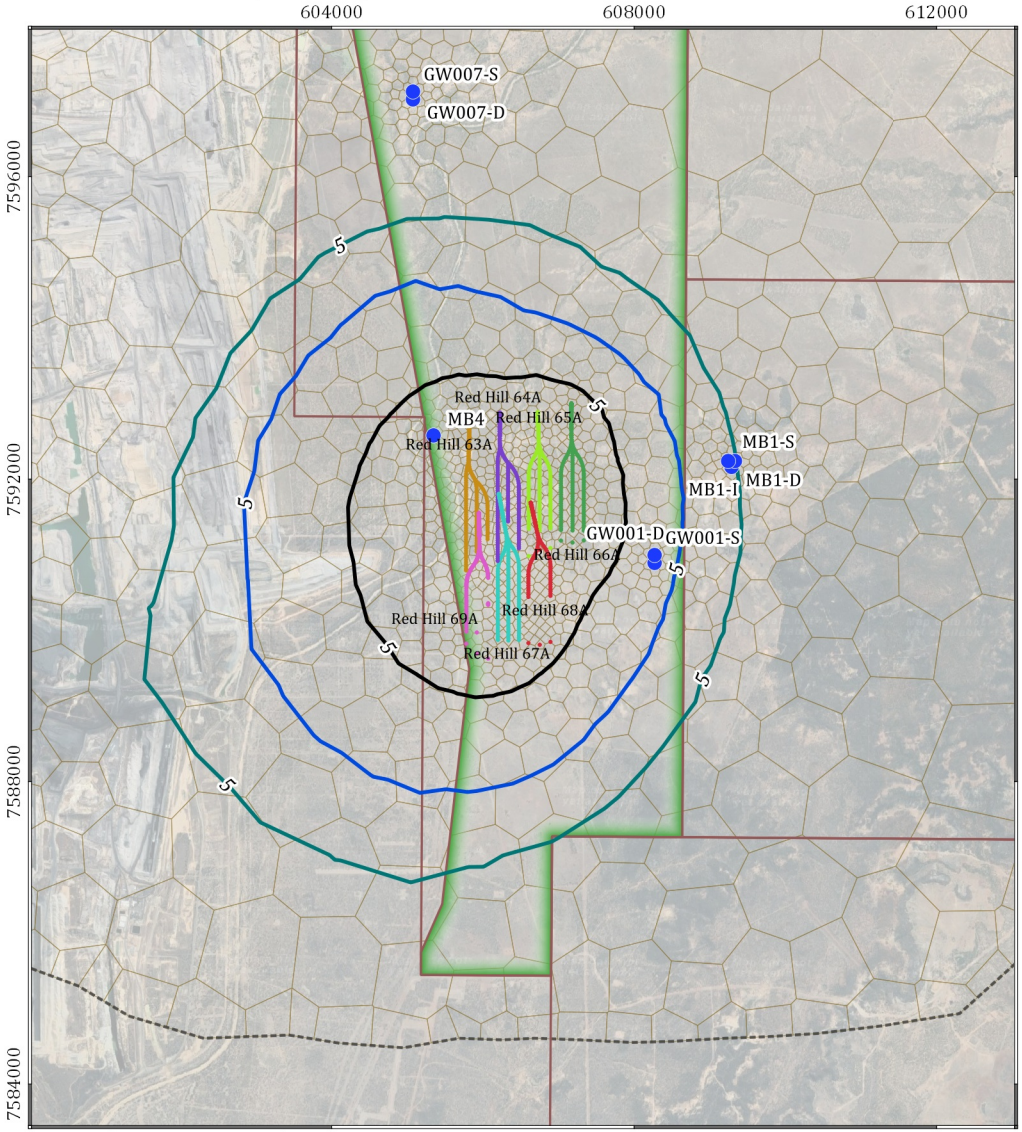


Figure 5.1 Cross section of GM head pressure (April 2024 and September 2027)

Drawdown contour (5 m) - Layer 15 GM Seam



Drawdown contour (5 m) - Layer 17 GL Seam



LEGEND

- Bowen GMMP monitoring
- Petroleum lease
- Arrow Petroleum lease
- Model boundary
- Sector model grid
- 5m drawdown contour - Upper Rau bound (2E-05)
- 5m drawdown contour - Pells bound (4E-06)
- 5m drawdown contour -Lower Pells bound (1E-06)

CSG production well

GM seam (Layer - 15)	GL seam (Layer - 17)
Red Hill 104A	Red Hill 63A
Red Hill 105A	Red Hill 64A
Red Hill 106A	Red Hill 65A
Red Hill 107A	Red Hill 66A
Red Hill 108A	Red Hill 67A
Red Hill 109A	Red Hill 68A
Red Hill 110A	Red Hill 69A

Arrow.BOWEN.Sector (G1885G)

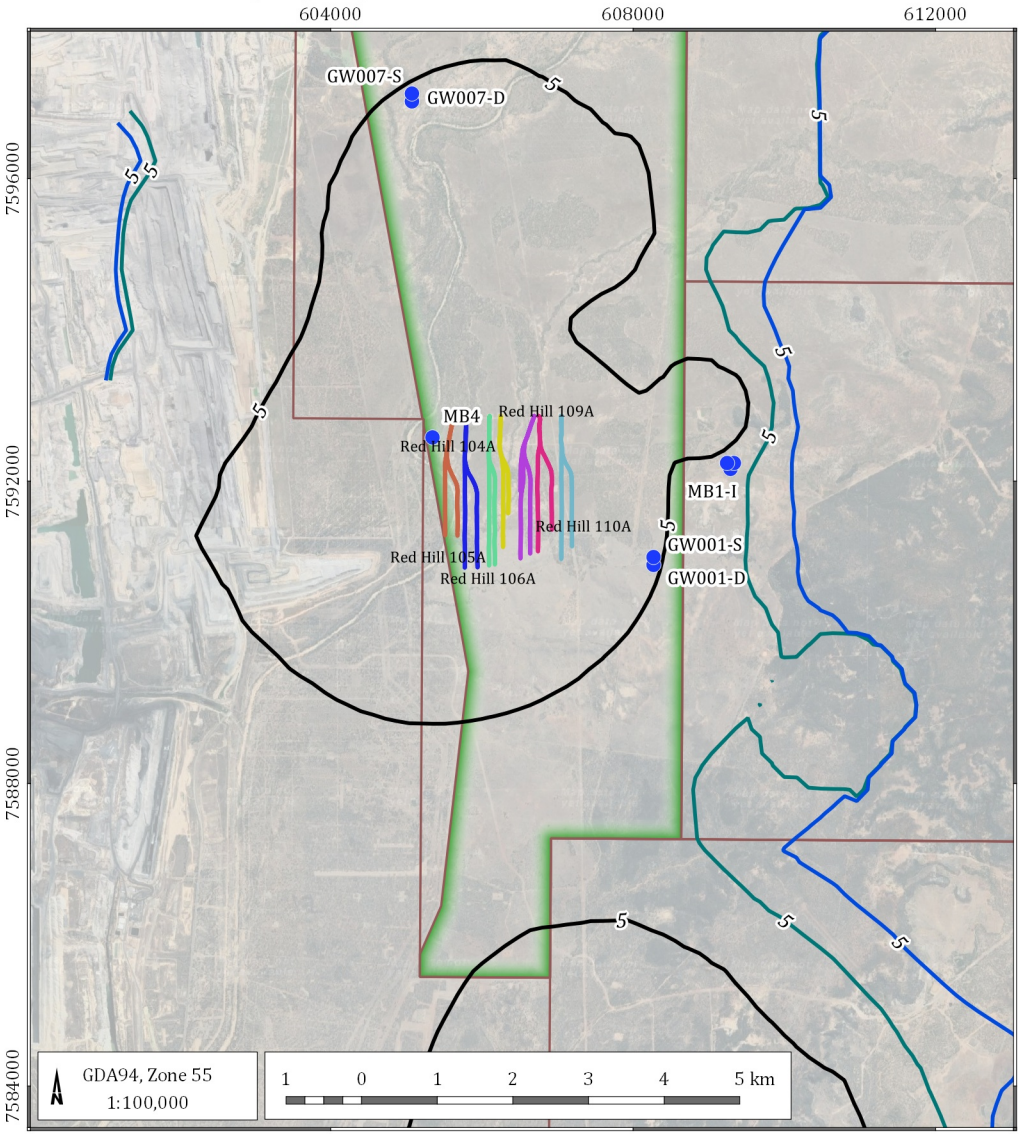
Sensitivity of maximum Red Hill drawdown (2020 to 2030)

DATE
05/03/2021

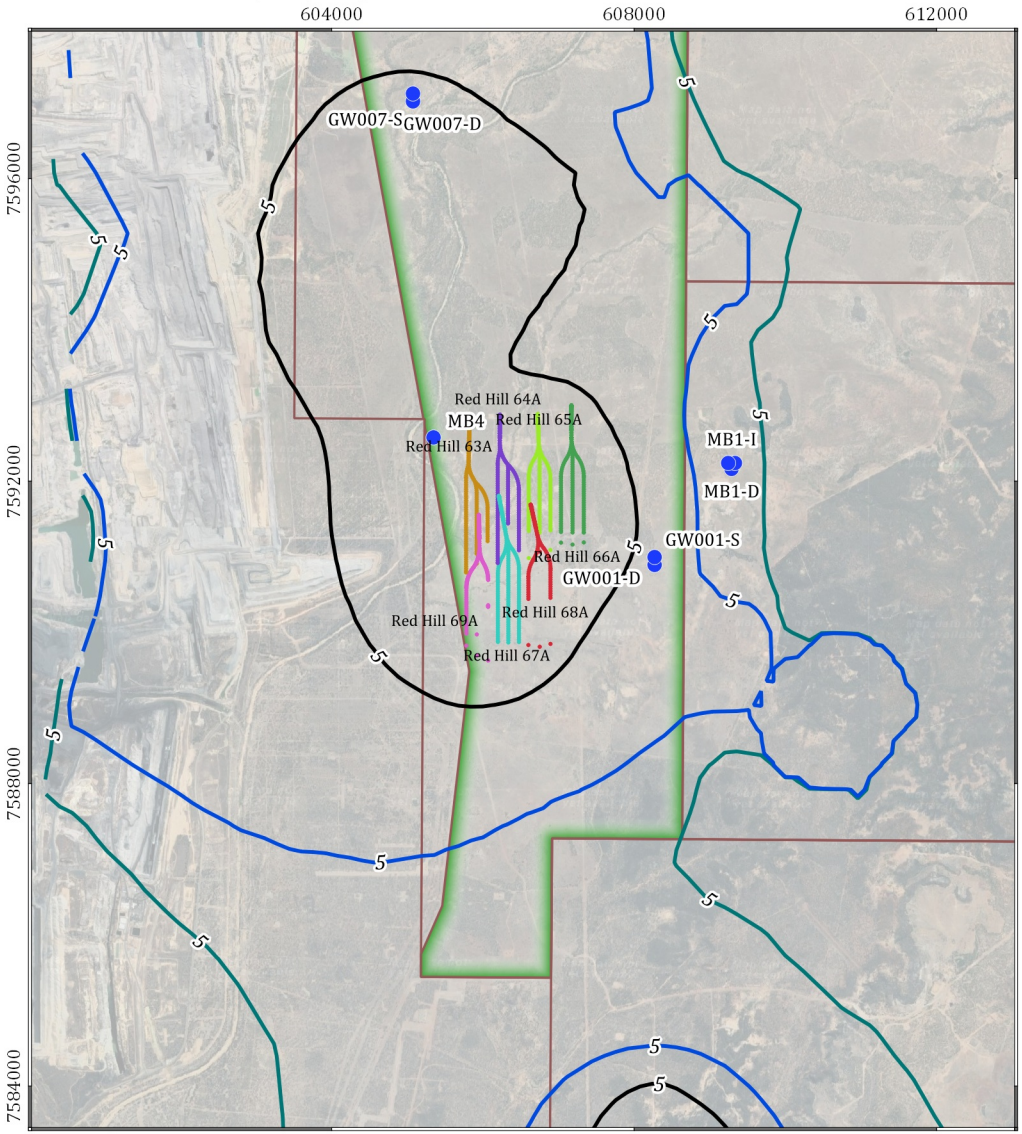
FIGURE No:
5.2

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GBODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1885G.Bowen Groundwater Model Update\3_GIS\Workspaces\001_Deliverable1\05.02_G1885G_Sensitivity of maximum Red Hill drawdown (2020 to 2030).qgs

Drawdown contour (5 m) - Layer 15 GM Seam



Drawdown contour (5 m) - Layer 17 GL Seam



LEGEND

- Bowen GMMP monitoring
- Petroleum lease
- Arrow Petroleum lease
- Model boundary
- Sector model grid
- 5m drawdown contour - Upper Rau bound (2E-05)
- 5m drawdown contour - Pells bound (4E-06)
- 5m drawdown contour -Lower Pells bound (1E-06)

CSG production well

GM seam (Layer - 15)

- Red Hill 104A
- Red Hill 105A
- Red Hill 106A
- Red Hill 107A
- Red Hill 108A
- Red Hill 109A
- Red Hill 110A

GL seam (Layer - 17)

- Red Hill 63A
- Red Hill 64A
- Red Hill 65A
- Red Hill 66A
- Red Hill 67A
- Red Hill 68A
- Red Hill 69A

Arrow.BOWEN.Sector (G1885G)

Sensitivity of maximum Red Hill drawdown (2020 to 2030) - Regional model

DATE
05/03/2021

FIGURE No:
5.3

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1885G.Bowen Groundwater Model Update\3_GIS\Workspaces\001_Deliverable1\05.03_G1885G_Sensitivity of maximum Red Hill drawdown (2020 to 2030).qgs

Figure 5.2 presents the sensitivity of maximum groundwater drawdown within the Goonyella Middle Seam (layer 15) and the Goonyella Lower Seam (layer 17) from 2020 to 2030 due to Red Hill Production to specific storage changes.

The results show that maximum drawdowns extends 2.5 km east and 3.3 km north of the Red Hill Production area are possible by 2030 if specific storage within the coal seams is 1 x 10^{-6} m^{-1}. Drawdown in the Goonyella Lower seam does not extend as far as the Goonyella Middle seam due to lower permeability and shorter CSG production.

Figure 5.3 presents maximum drawdown encountered in the regional model over the same period. The results show the effects of cumulative depressurisation of MGP and BGP production.

5.2 Regional model

Table 5.2 presents the drawdown at the four Arrow groundwater monitoring bores within the sector model domain from 2020 to 2180.

Table 5.2 Predicted maximum drawdown (regional model)

Bore	Unit	Upper Rau bound (2E-05)		Pells bound (4E-06)		Lower Pells bound (1E-06)	
		Date when >5 m drawdown occurs	Max drawdown (m)	Date when >5 m drawdown	Max drawdown (m)	Date when >5 m drawdown occurs	Max drawdown (m)
GW001-S_01	**Alluvium/ Regolith**	NA	0.01	NA	0.02	NA	0.04
GW001-D_08	FCCM	NA	0.41	NA	1.51	NA	3.40
GW001-D_09	FCCM	NA	0.95	NA	3.47	1/01/2035	7.82
GW001-D_10	**FCCM**	**NA**	**4.10**	**1/01/2035**	**14.22**	**1/01/2034**	**33.24**
GW001-D_11	MCM	1/01/2034	17.24	1/01/2034	50.66	1/01/2034	100.03
GW001-D_13	MCM	1/01/2034	20.48	1/01/2034	66.29	1/01/2034	141.74
GW001-D_15	MCM	1/04/2028	146.17	1/12/2011	173.59	1/09/2009	219.68
GW001-D_17	MCM	1/01/2036	107.46	1/09/2026	132.61	1/11/2010	195.77
GW007-S_01	**Alluvium/ Regolith**	**NA**	**0.03**	**NA**	**0.05**	**NA**	**0.07**
GW007-D_09	FCCM	NA	0.37	NA	1.26	NA	2.87
GW007-D_10	**FCCM**	**NA**	**1.38**	**NA**	**4.33**	**1/01/2034**	**8.23**
GW007-D_11	MCM	NA	3.63	1/01/2034	8.13	1/01/2034	16.40
GW007-D_13	MCM	1/01/2116	7.23	1/01/2043	8.22	1/01/2041	11.54
GW007-D_15	MCM	1/12/2028	64.79	1/02/2024	67.25	1/01/2035	21.75
GW007-D_17	MCM	1/04/2027	49.02	1/03/2024	61.82	1/04/2023	85.04
MB1-S_01	Alluvium/Regolith	NA	0.01	NA	0.03	NA	0.04
MB1-I_08	FCCM	NA	0.48	NA	1.83	NA	4.64
MB1-I_09	FCCM	NA	1.04	NA	4.02	1/01/2038	10.11
MB1-I_10	FCCM	NA	2.38	1/01/2043	9.57	1/01/2035	22.73
MB1-D_11	MCM	1/01/2054	5.61	1/01/2036	18.11	1/01/2034	32.46

Bore	Unit	Upper Rau bound (2E-05)		Pells bound (4E-06)		Lower Pells bound (1E-06)	
		Date when >5 m drawdown occurs	Max drawdown (m)	Date when >5 m drawdown	Max drawdown (m)	Date when >5 m drawdown occurs	Max drawdown (m)
MB1-D_13	MCM	1/01/2058	20.42	1/01/2038	52.50	1/01/2034	100.53
MB1-D_15	MCM	1/01/2052	81.50	1/02/2015	69.92	1/07/2012	147.76
MB1-D_17	MCM	1/01/2061	67.77	1/01/2049	72.93	1/01/2027	145.89
MB4_01	Alluvium/Regolith	NA	0.01	NA	0.02	NA	0.04
MB4_08	FCM	NA	0.03	NA	0.09	NA	0.19
MB4_09	FCM	NA	0.12	NA	0.39	NA	0.89
MB4_10	FCM	NA	0.61	NA	2.01	NA	4.19
MB4_11	MCM	NA	1.38	NA	4.07	1/01/2034	7.59
MB4_13	MCM	NA	4.55	1/01/2036	12.28	1/01/2034	26.26
MB4_15	MCM	1/05/2021	36.75	1/06/2011	100.08	1/08/2009	165.93
MB4_17	MCM	1/03/2025	21.17	1/07/2023	60.57	1/11/2010	111.41

The results indicate both abstraction from the pilot bores proximal to the Red Hill area and the effects of cumulative drawdown from the MGP + BGP exacerbates groundwater impacts at the monitoring bores. To validate the predictions above, observed groundwater drawdown at these locations was compared to the groundwater model predictions.

Figure 5.4 compares groundwater drawdown at bore GW001, located approximately 700 m east of BGP production. Observed drawdown (red points) is relative to the first reading in early 2017, whereas modelled drawdown (lines for each model layer) is relative to the no CSG production scenario. GW001 likely screens the alluvium (S - layer 1), and the Fort Cooper Coal Measures (D – layer 8 to 10). Observed groundwater level trends suggests drawdown of approximately 0.1 m are anticipated between 2017 and 2019. It is unknown if this rate of observed drawdown is associated with climate variation or CSG/coal mining depressurisation. Nevertheless, if the observation data is representative of the Fort Cooper coal measures, the model with the lowest specific storage values best replicates observed drawdown.

Figure 5.5 and Figure 5.6 present observed drawdown compared to total modelled drawdown at bores MB250 and MB252, located proximal to the MGP production area (see Figure 4.2). Detailed construction detail for these bores were not available and therefore significant uncertainty remains regarding which strata are monitored in of these bores. Regardless, simulated data suggests the model with lower specific storage best replicates observed drawdown.

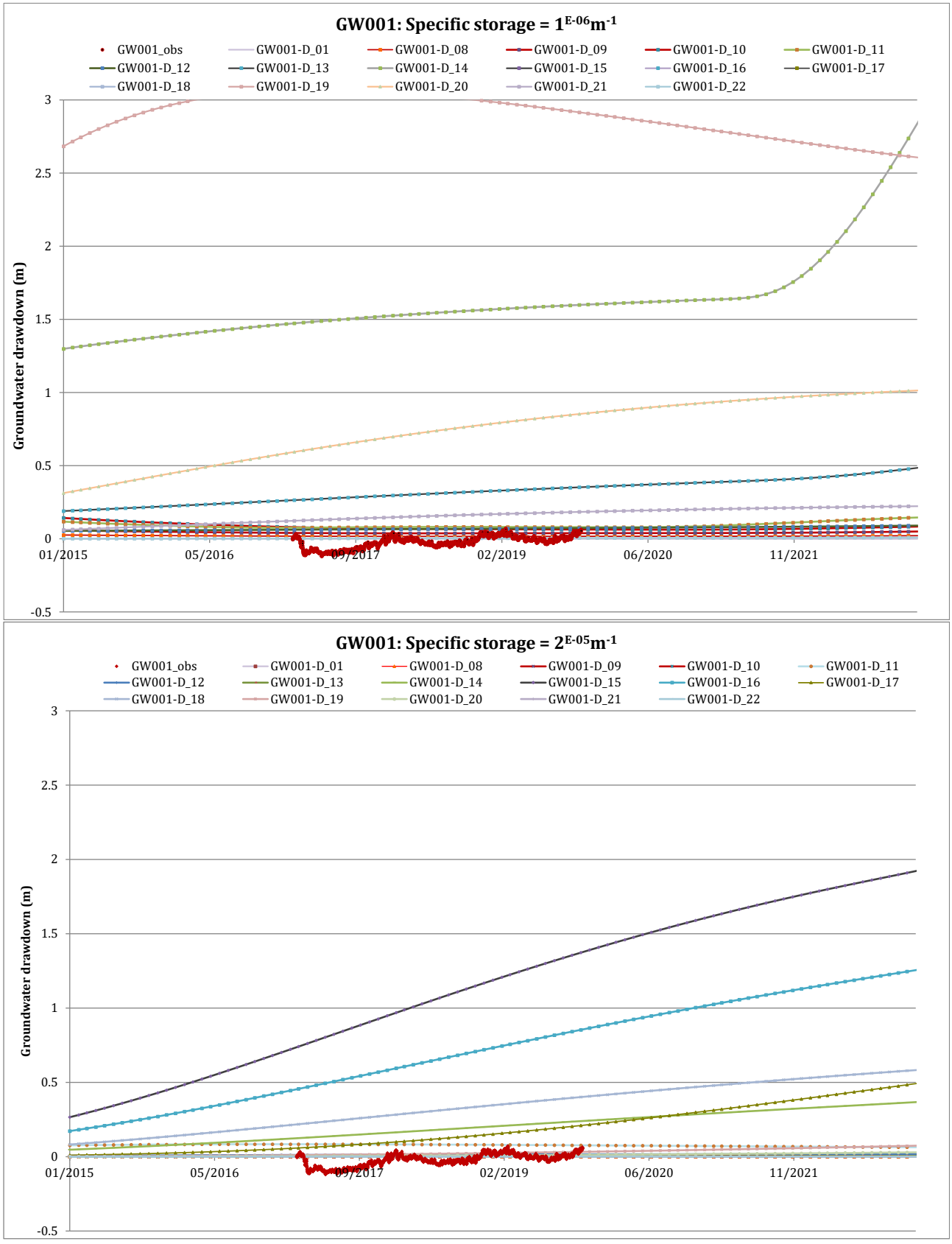


Figure 5.4 GW001 drawdown comparison

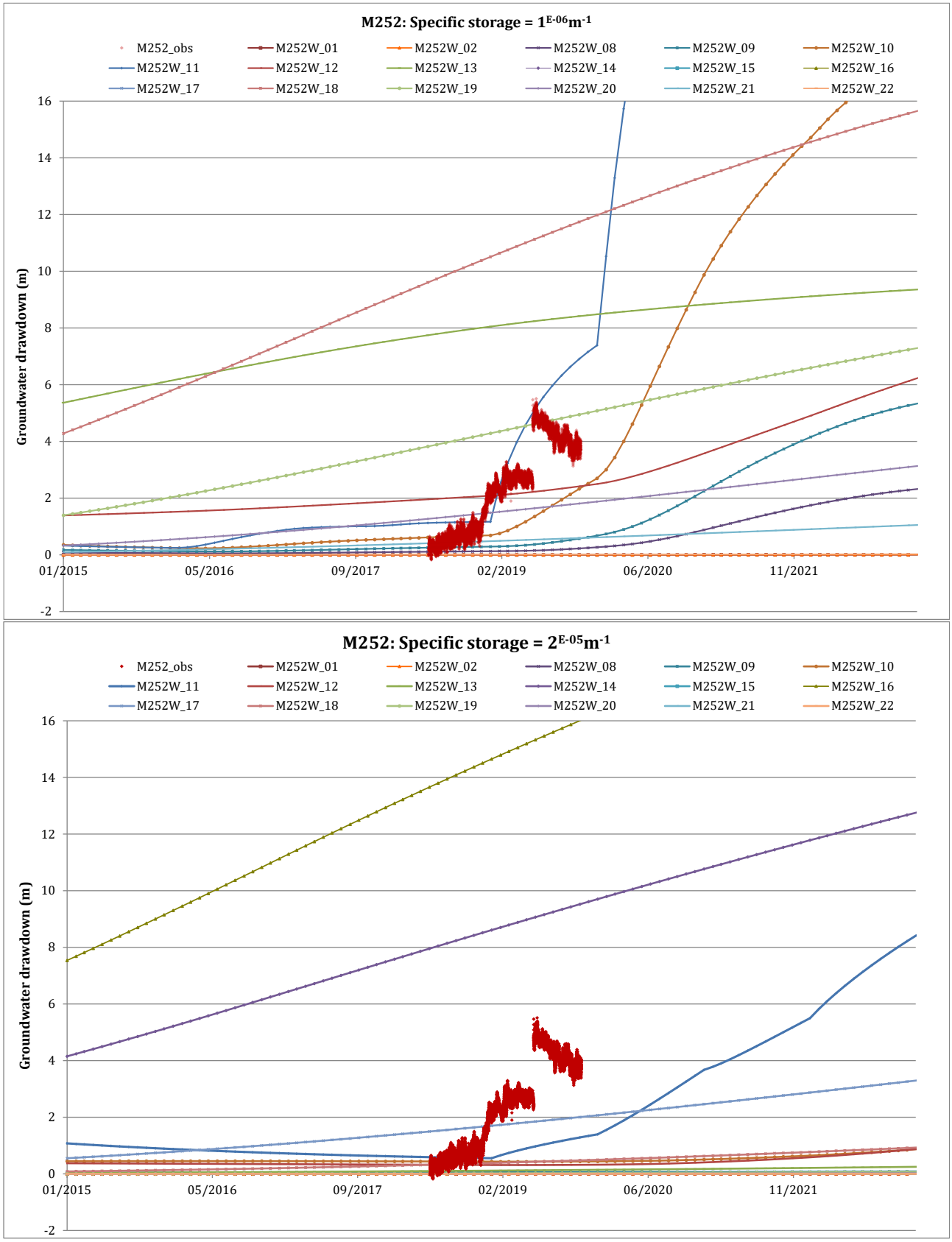


Figure 5.5 M252 drawdown comparison

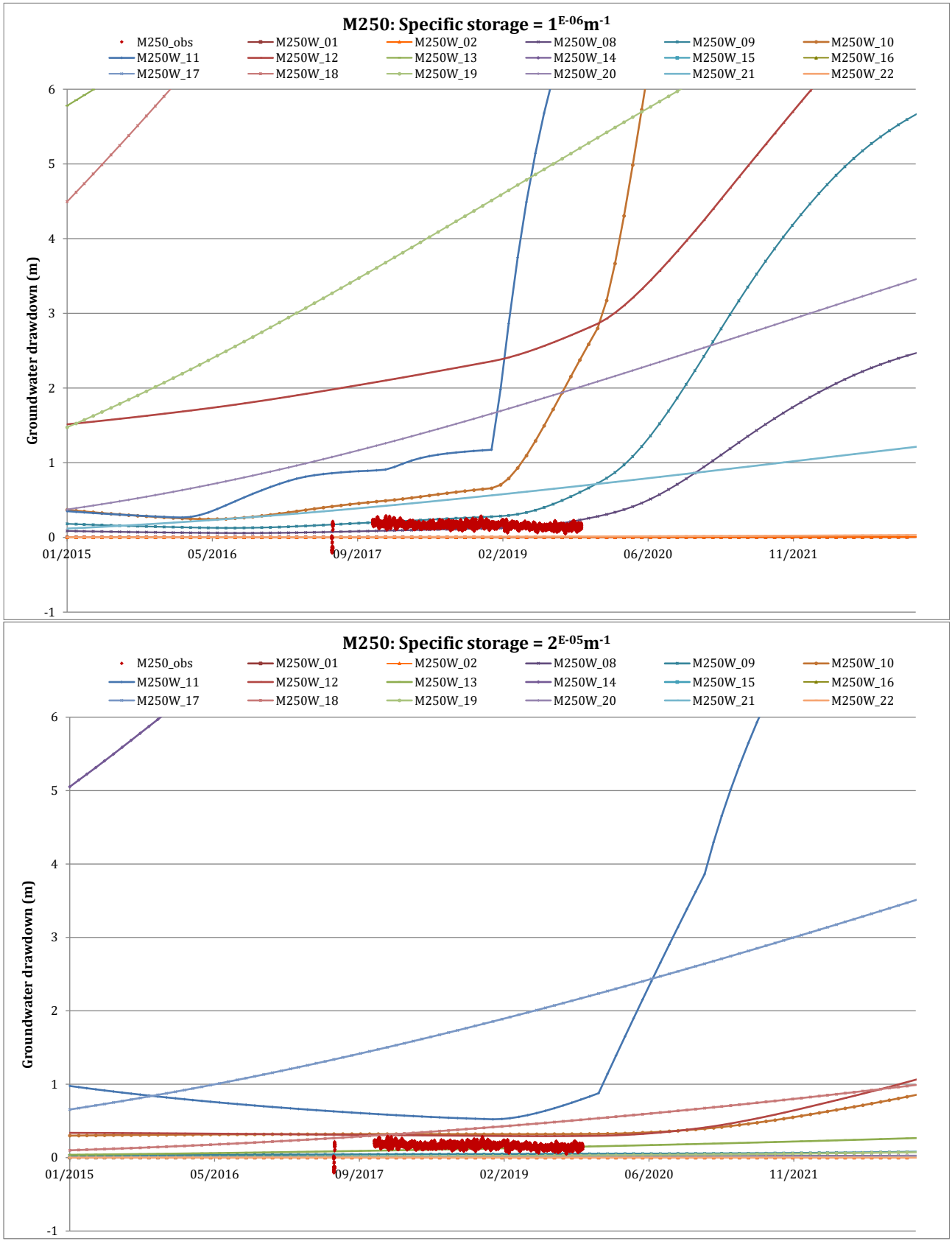


Figure 5.6 M250 drawdown comparison

6 Summary and conclusions

A sector model was developed initially to simulate additional extraction from the Red Hill area from 2021 to 2030. The model adopted the same structure and boundary conditions simulated in the regional 2017 AGE EIS model, however the sensitivity of predictions of a range of different specific storage values was also explored.

Predictions made using this sector model suggest that monitoring bore MB04 will experience groundwater drawdown exceeding 5m in early 2021 if it is screened in the Goonyella Middle seam. Similarly, more than 5 m of drawdown could occur in 2023 at monitoring bore MB01 if this bore is screened into the same coal seam. Conversely sector model predictions suggest it is unlikely that GW001 and GW007 will experience significant groundwater drawdown since none of the specific storage scenarios explored predicted significant drawdown in the Fort Cooper Coal Measures or alluvial sediments.

Since the regional model also includes the cumulative impacts of other Arrow Energy operations the predicted drawdowns are consistently higher than those predicted by the sector model. Accordingly, regional model predictions suggest that drawdowns of more than 5 m may already have occurred in the Goonyella Middle Seam at the location of monitoring bores MB01, MB04, and GW001. Conversely, all scenarios predict it is unlikely that Fort Cooper coal measures and shallow aquifer system will experience significant drawdown at any time in the next 160 years.

Exploring specific storage was undertaken around the 2017 calibrated parameter set. It is possible that the combination of lower specific storage and calibrated horizontal hydraulic conductivity/recharge assessed in this study may produce a poorly calibrated model. Validation of such parameter combinations should be tested using the regional model to ensure adequate history matching proximate to the Red Hill field.

It recommended that groundwater bore construction details regarding screened intervals are collated for the existing Arrow groundwater monitoring network. The potential effects from climate and pumping activities should be explored and separated for the purpose of future calibration exercises and trigger exceedance tests. The regional model could be improved by calibrating the model to the drawdowns apparent in the dataset.

7 References

Australasian Groundwater and Environmental Consultants Pty Ltd (2017), *Arrow Project - Report on Bowen GMMP Uncertainty Analysis.*

Norwest (2012), *Groundwater Model, North West Bowen Basin Regional Model Impact Predictions, Queensland, Australia*, October 10, 2012.

Pells, S. (2017), Groundwater Modelling of the Hume Coal Project, https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-7172%2120190319T233221.791%20GMT .

Rau, G. C., Acworth, R. I., Halloran, L. J. S., Timms, W. A., & Cuthbert, M. O. (2018). *"Quantifying compressible groundwater storage by combining cross-hole seismic surveys and head response to atmospheric tides".* Journal of Geophysical Research: Earth Surface, 123, 1910–1930. https://doi.org/10.1029/2018JF004660 .