Lower Gwydir Groundwater Source

Water level review

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Acknowledgment of Country

The Department of Planning and Environment acknowledges the Traditional Owners and Custodians of the land on which we live and work and pays respect to Elders past, present and future.

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1 Analysis summary

This report provides results of groundwater level analysis of the Lower Gwydir Groundwater Source up to mid-2021. This report identifies areas of long-term declining water level trends and large seasonal drawdown in response to extraction and drought, and where further water level management may be required in the future.

A summary of the findings of this groundwater level analysis for the Lower Gwydir Groundwater Source groundwater source is listed in **Table 1.**

Table 1 Summary of groundwater level analysis

Groundwater Source	Comments
Lower Gwydir - Trade Area 1	The water levels are within the acceptable levels. Water level recovery has been observed between 2006 and 2021 in an area between Pallamallawa and Yarraman. However, the overall long-term water level is declining over time in most of Trade Area 1.
Lower Gwydir - Trade Area 2	There is ongoing decline in water levels across Trade Area 2, with the following trends occurring: • Over the last 5 years (2016-2021), multiple monitoring bores show that pumping drawdown has exceeded 40% baseline total available drawdown, with some sites exceeding 50% baseline total available drawdown. • Ongoing decline in recovered water levels, with multiple monitoring bores in the are having a recovered water level greater than 25% of the baseline total available drawdown, with some sites exceeding 30% of the baseline total available drawdown. • Change in recovered water levels over time is greater than 10m at multiple monitoring bores. Water level management may be required to mitigate the declining trend.

2 Introduction

This report provides results of groundwater level analysis of the Lower Gwydir Alluvial groundwater sources up to mid-2021. This report identifies areas of long-term declining water level trends and large seasonal drawdown in response to extraction and drought, where further water level management may be required in the future.

The Lower Gwydir Alluvial Groundwater Source is an alluvial aquifer system located in the Gwydir River Catchment (**Figure 2 – page 3**)

For detailed information of the hydrogeology and past long-term water level behaviour refer to the report 'Groundwater resource description report for the Gwydir Alluvial groundwater sources' (https://www.industry.nsw.gov.au/__data/assets/pdf_file/0020/192323/Gwydir-alluvium-resource-description-report.pdf).

2.1 Climate

The Gwydir catchment has a temperate to sub-tropical climate with generally summer dominant rainfall with the heaviest rainfall occurring from October to March.

Cumulative deviation from mean rainfall (also known as rainfall residual mass) plots have been constructed using daily data sourced from the Scientific Information for Landowners (SILO) database. This graph plots the cumulative difference from the monthly average rainfall and provides a visual representation of the rainfall history in an area.

A falling trend indicates a period of lower than average rainfall, a rising trend showing periods of above average rainfall. The residual mass graph of average monthly rainfall from 1970 for Pallamallawa, Moree, and Collarenebri is displayed in **Figure 1**. This period corresponds to the period of groundwater monitoring in the Gwydir Alluvium which commenced in the early 1970s.

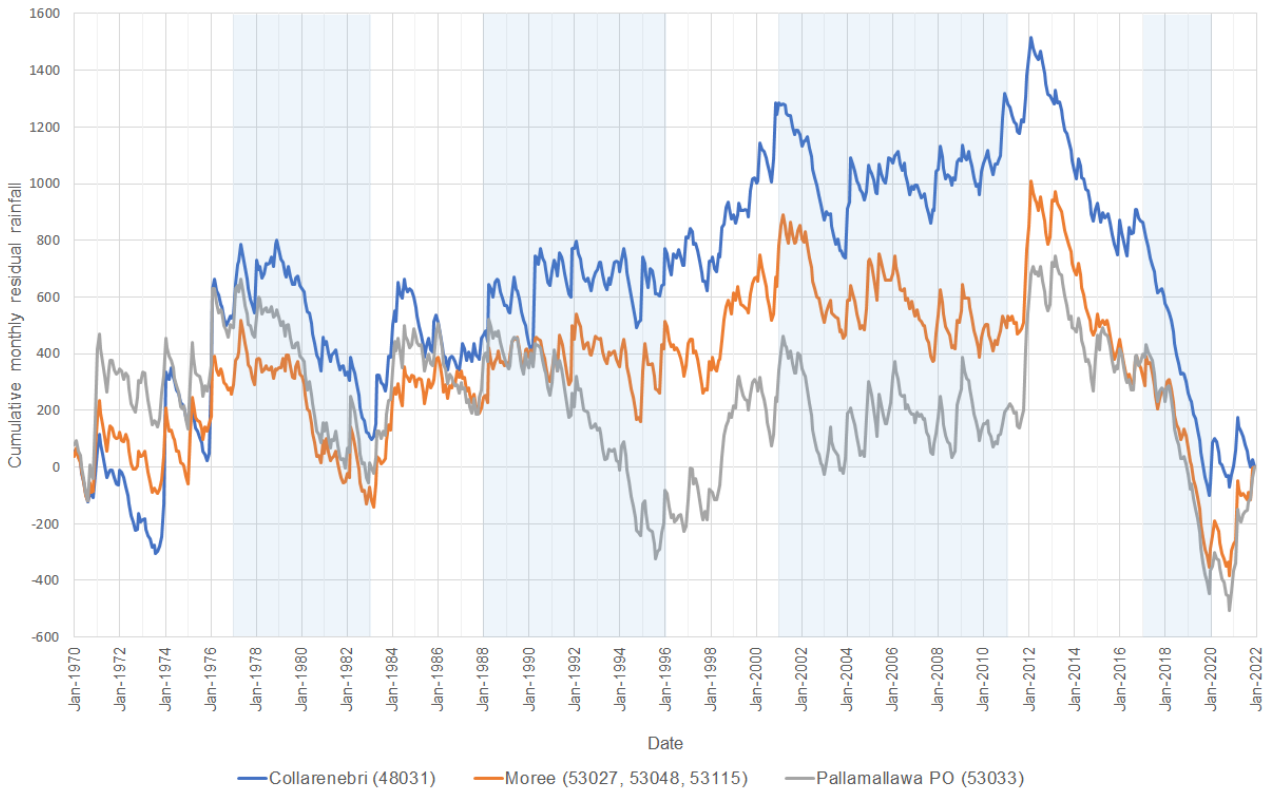


Figure 1 Cumulative deviation from mean monthly rainfall

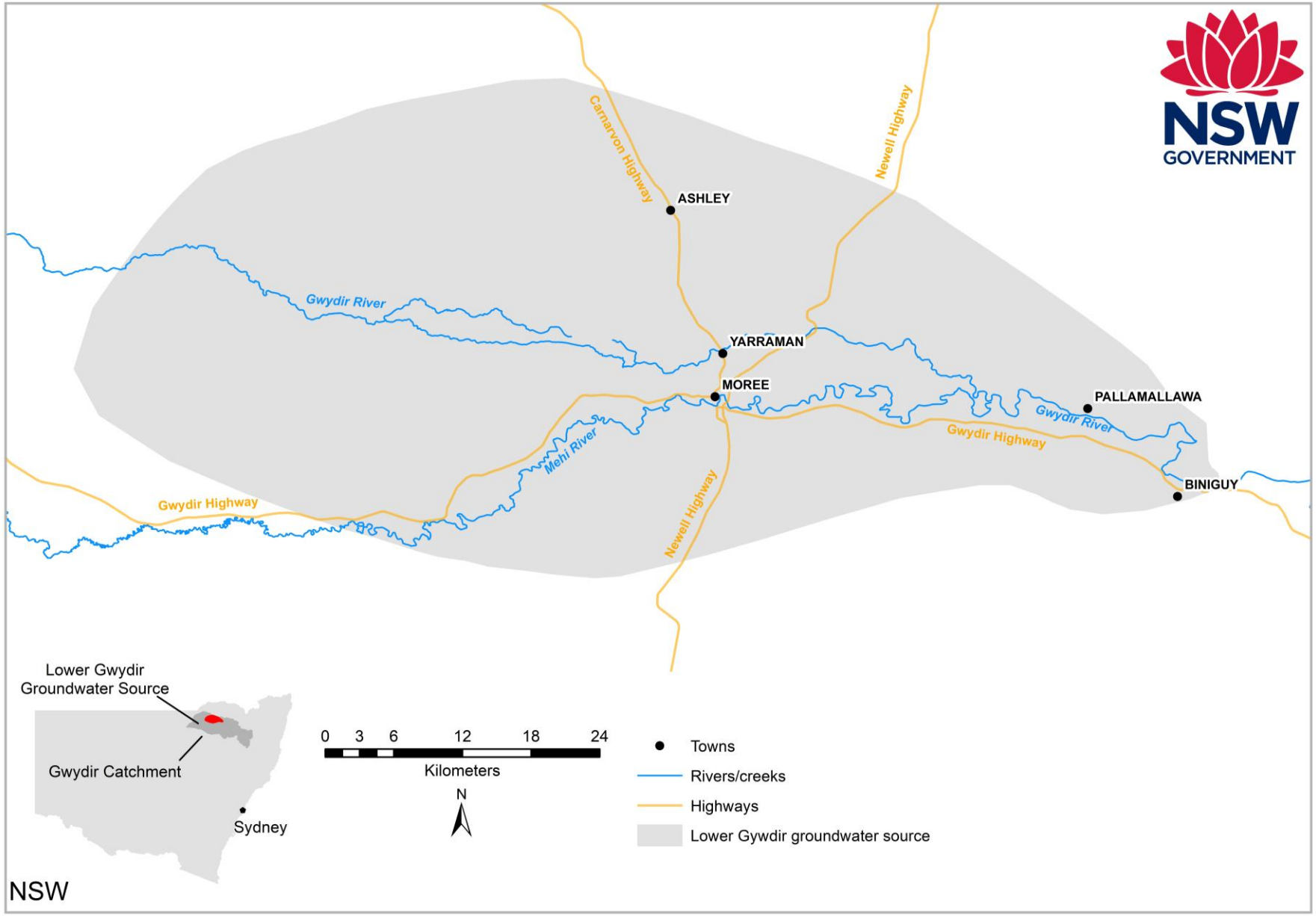


Figure 2 Location of the Lower Gwydir groundwater source

2.2 Bores

There are approximately 1,587 registered bores across the Lower Gwydir Groundwater Source. The majority of these bores are used for stock and domestic purposes (basic landholder rights). There is also significant use of groundwater for irrigation (**Table 1**). The location of the bores is shown in **Figure 3**.

Table 2 Approximate number of licensed bores in Lower Gwydir Groundwater Source (at June 2021)

Registered Bore Purpose		
Basic Landholder Rights	Production	Local Water Utility
1,159	389	39

2.3 Accounts and extraction

Groundwater is managed to a long-term average annual extraction limit under the existing water sharing plan. The total allocated shares and extraction limit for the Lower Gwydir Groundwater Source is listed in **Table 2**.

Table 3 Long term average annual extraction limit and share component for the Lower Gwydir groundwater source (as of 30 June 2021)

Long term average annual extraction limit (ML/year)	Volume allocated to Basic Rights (ML/year)	Aquifer Access Licence total shares	Local Water Utility Access Licence total shares
32,300	700	28,858	3,572

Total extraction per year since the commencment of the water sharing plan is shown in **Figure 4**. The distribution of extraction based on the 5 year average is shown in **Figure 5**.

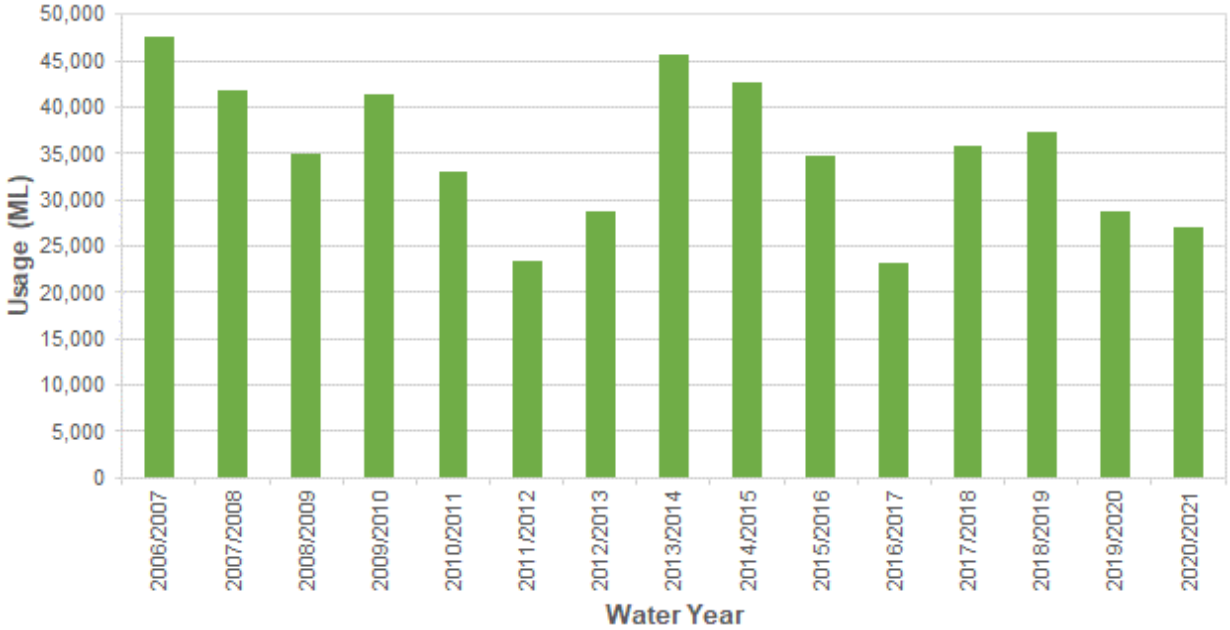


Figure 3 Annual usage

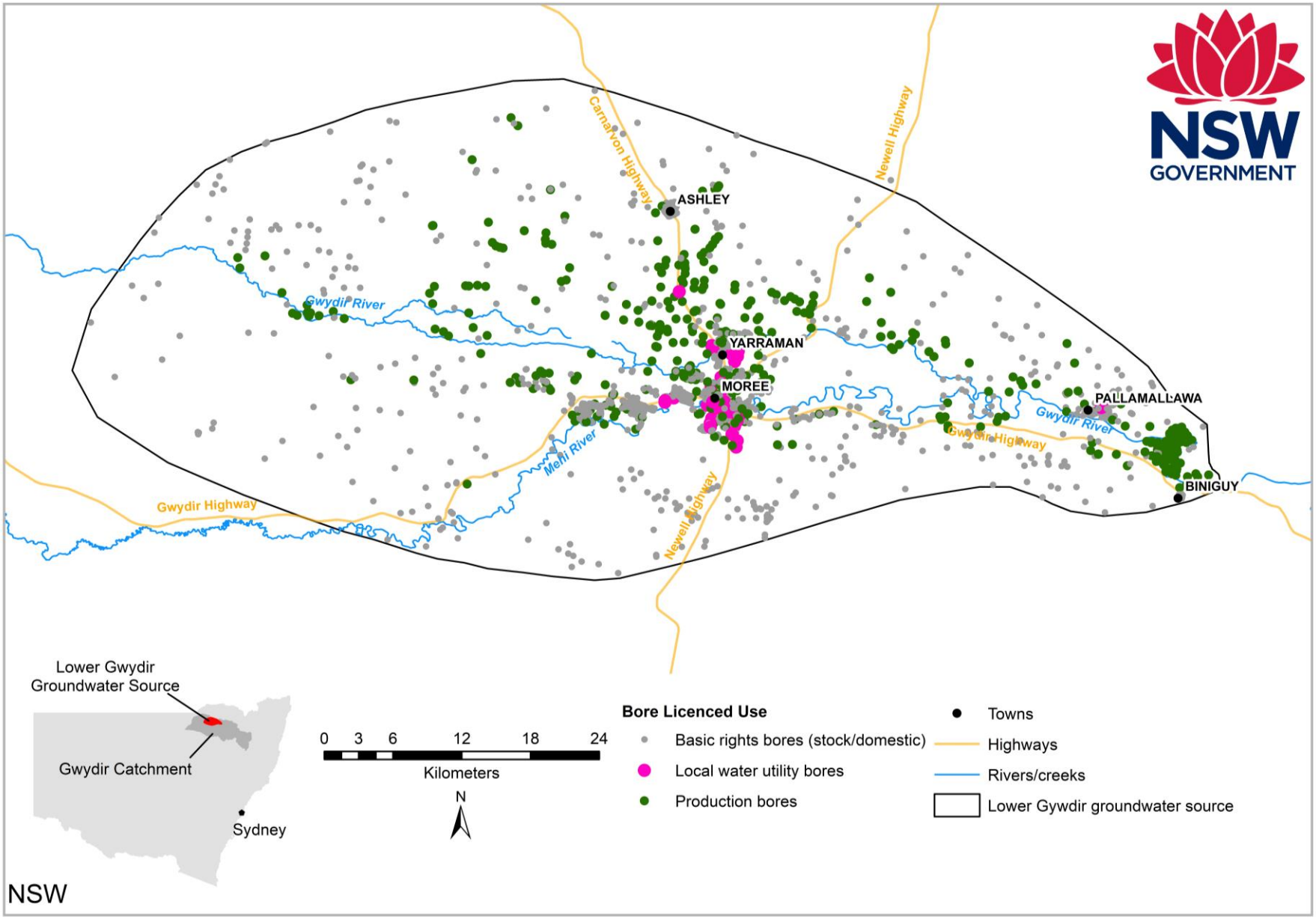


Figure 4 Bores in the Lower Gwydir Groundwater Source

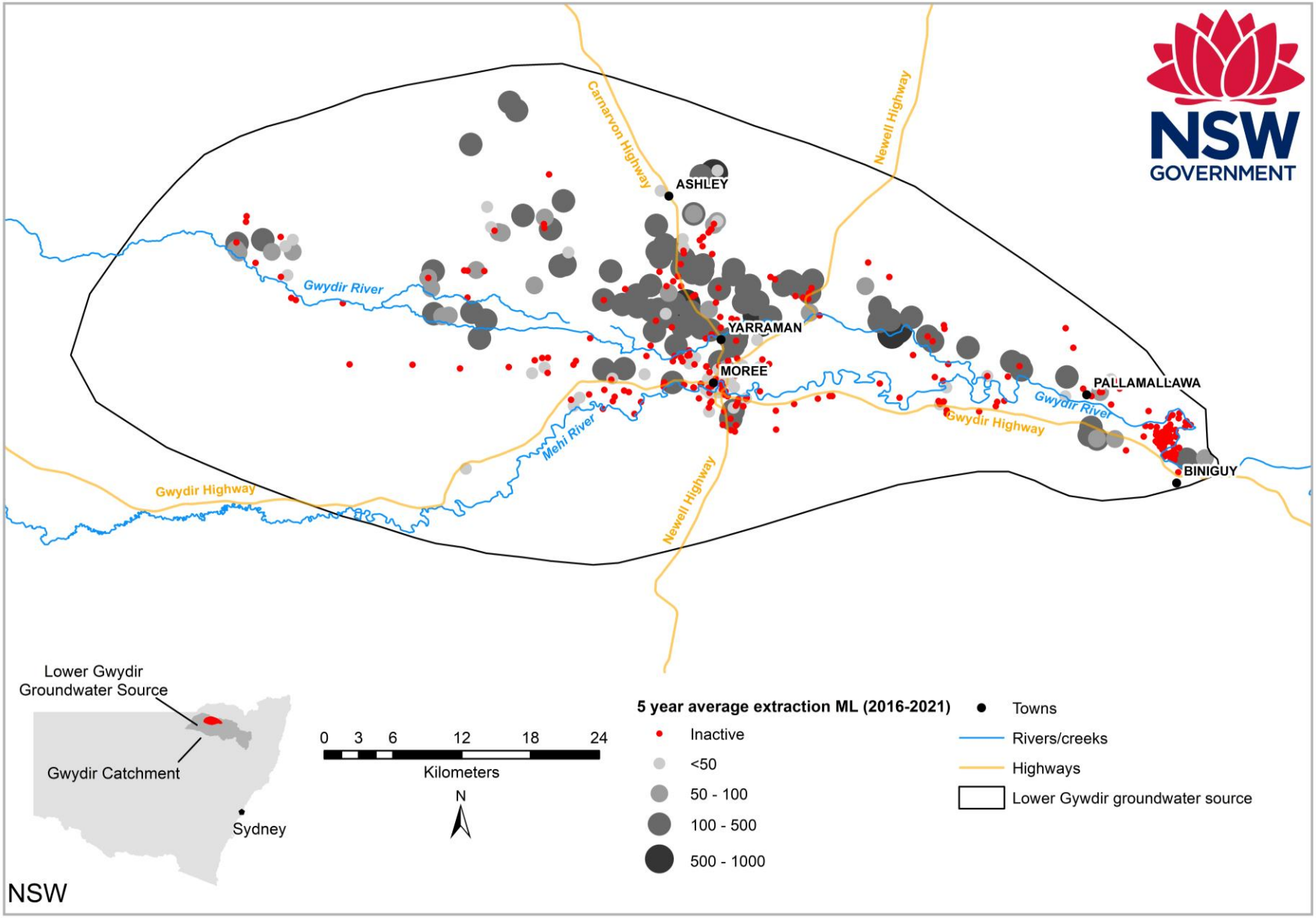


Figure 5 Distribution of extraction showing the average annual extraction over the five-year period from 2016-2017 to 2020-2021

2.4 Groundwater monitoring network

The water bearing sands and gravels within the alluvial sediments of the Lower Gwydir Groundwater Source are broadly divided into two main aquifer systems; a shallow aquifer system up to approximately 30 metres (m) deep and a deep aquifer system up to a maximum of approximately 90 m deep.

There are 58 government groundwater monitoring sites across the Lower Gwydir Groundwater Source. The sites are shown in **Figure 6** and listed in **Table 3**.

At most monitoring sites there are two or more pipes monitoring different depths. Most of the bores are monitored manually and measurement taken generally every four to eight weeks. Data is also available for approximately 19 of the groundwater monitoring sites in real-time via telemetry, this data is available from the WaterNSW Realtime Data data portal (https://realtimedata.waternsw.com.au/).

Table 4 Number of government monitoring bores in the Lower Gwydir groundwater source

Number of sites	Number of bores	Telemetered sites
58	123	19

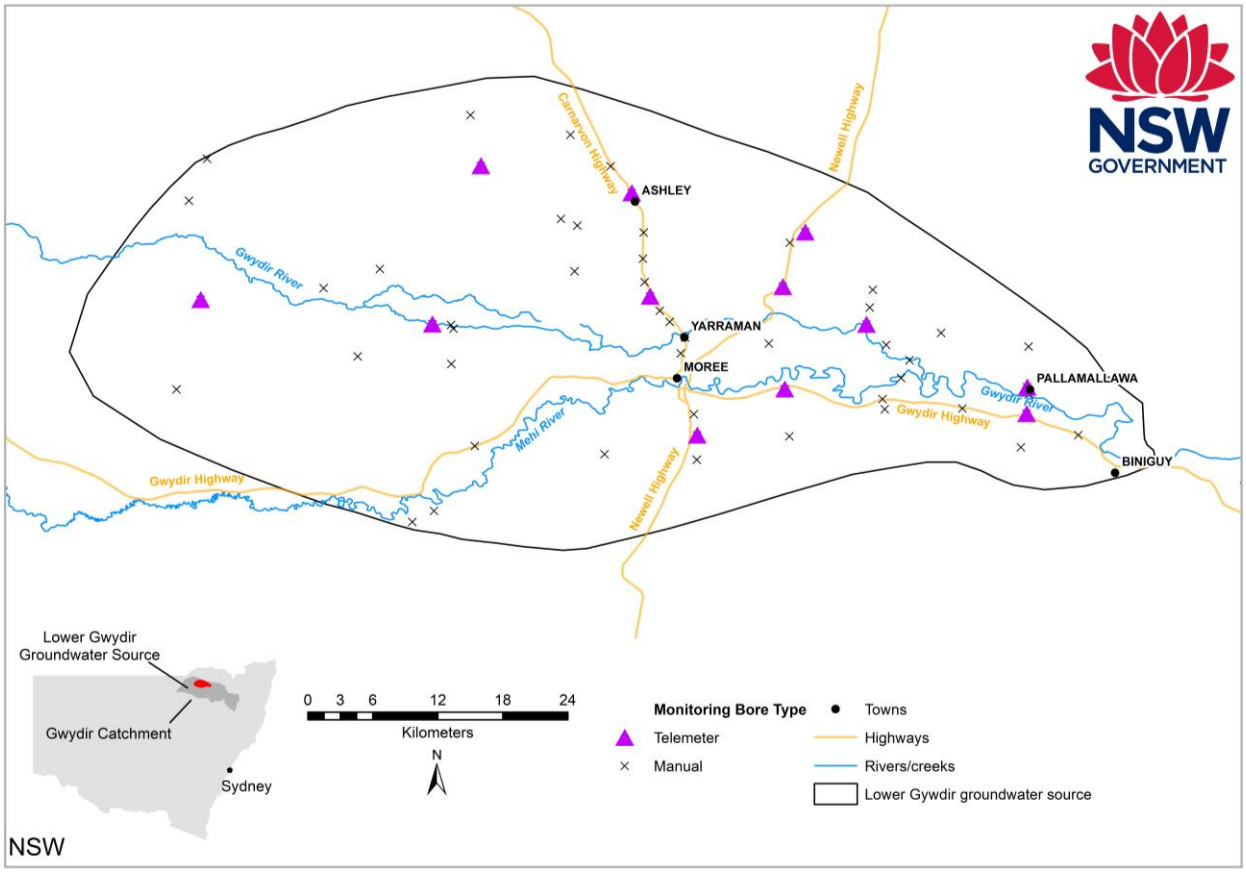


Figure 6 Location of monitoring sites

3 Groundwater level analysis

Pumping groundwater causes the water level in the aquifer to drawdown close to the pumping bore. When the pumping stops, the water level recovers (rises), these concepts are show in **Figure 8**. If there are multiple bores pumping, the area of drawdown around the individual bores can combine to form large broad areas of lower groundwater levels during the pumping season. The size and shape of the area affected by the drawdown depends on the volume being pumped, how transmissive the aquifer is and also the level of confinement of the aquifer (that is, how connected the aquifer is to the water table).

If groundwater levels do not fully recover before the start of the next pumping season and this continues for multiple seasons, there is an ongoing decline in the recovered groundwater levels from one season to the next. The depth of the pumping drawdowns will then drop deeper each successive irrigation season.

In large groundwater systems reliant on episodic recharge events to replenish the groundwater store, a decline in the seasonally recovered groundwater levels is an expected management outcome. However, if the seasonally recovered groundwater levels continue to decline after successive recharge events it is an indicator that the levels of pumping in that area of the water source may not be viable in the long term.

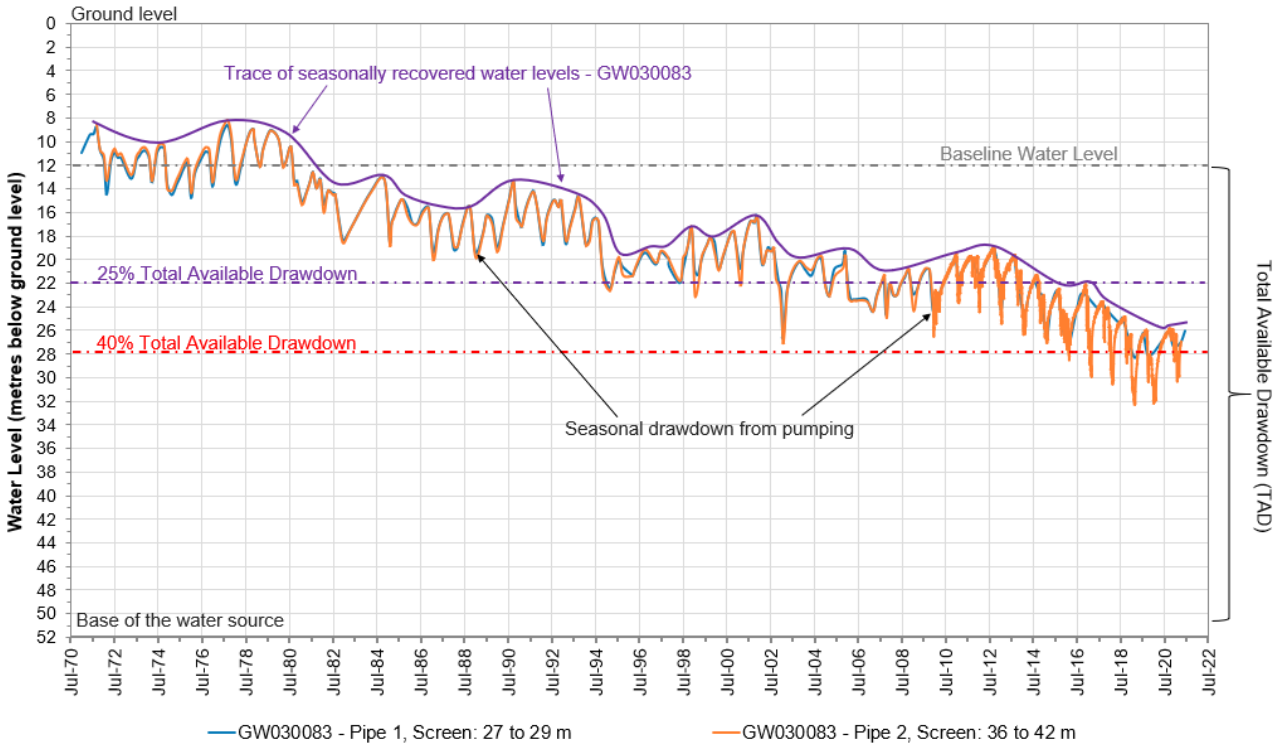


Figure 7 Hydrograph illustrating concepts and water level triggers

To assess whether the monitored groundwater levels are fluctuating within these acceptable levels, a baseline is set for each area to reference the magnitude of the observed changes. Depending on the period of available data this baseline is generally set prior to widespread groundwater pumping in an area and is typically the median recovered water level prior to 1990.

The change in groundwater levels is expressed as a percentage of the total available drawdown (TAD) relative to the baseline water level. For most groundwater sources this is the height of the groundwater head above the base of the groundwater source as illustrated in Figure 8. The level of acceptable change in the groundwater level compared to the baseline period is

a percentage rather than an absolute value in recognition of the relative capacity of a groundwater system to buffer changes in groundwater levels.

For the Lower Gwydir Alluvial Groundwater Source the acceptable level of drawdown is set at 40% of the pre-development total available drawdown (Figure 8).

The trigger for decline in the seasonally recovered water level is 25% of the baseline total available drawdown (Figure 8).

The relative change in recovered water level has also been reviewed to look at the rate and magnitude of change over time. The following two periods were reviewed.

- The change from the baseline water level to the 2021 recovered water level (long term change)
- The change from the 2006 recovered water level (drought year) to the 2021 recovered water level (change since the start of the water sharing plan)

3.1 Assessment of drawdown

The maximum drawdown over the last 5 years (2016 to 2021) has been calculated as a percentage of the baseline total available drawdown from water level data in the deeper aquifer from relevant monitoring bores. This information has been contoured and is displayed **Figure 8**.

There is an area in the Lower Gwydir Groundwater Source (**Figure 8**) between Ashley and Yarraman, generally corresponding to Trade Area 2, where seasonal drawdown has exceeded 40% and up to more than 50% of the baseline total available drawdown. Drawdown approaching 40% of the baseline total available drawdown was also observed along the Gwydir River between Pallamallawa and Yarraman (**Figure 8**).

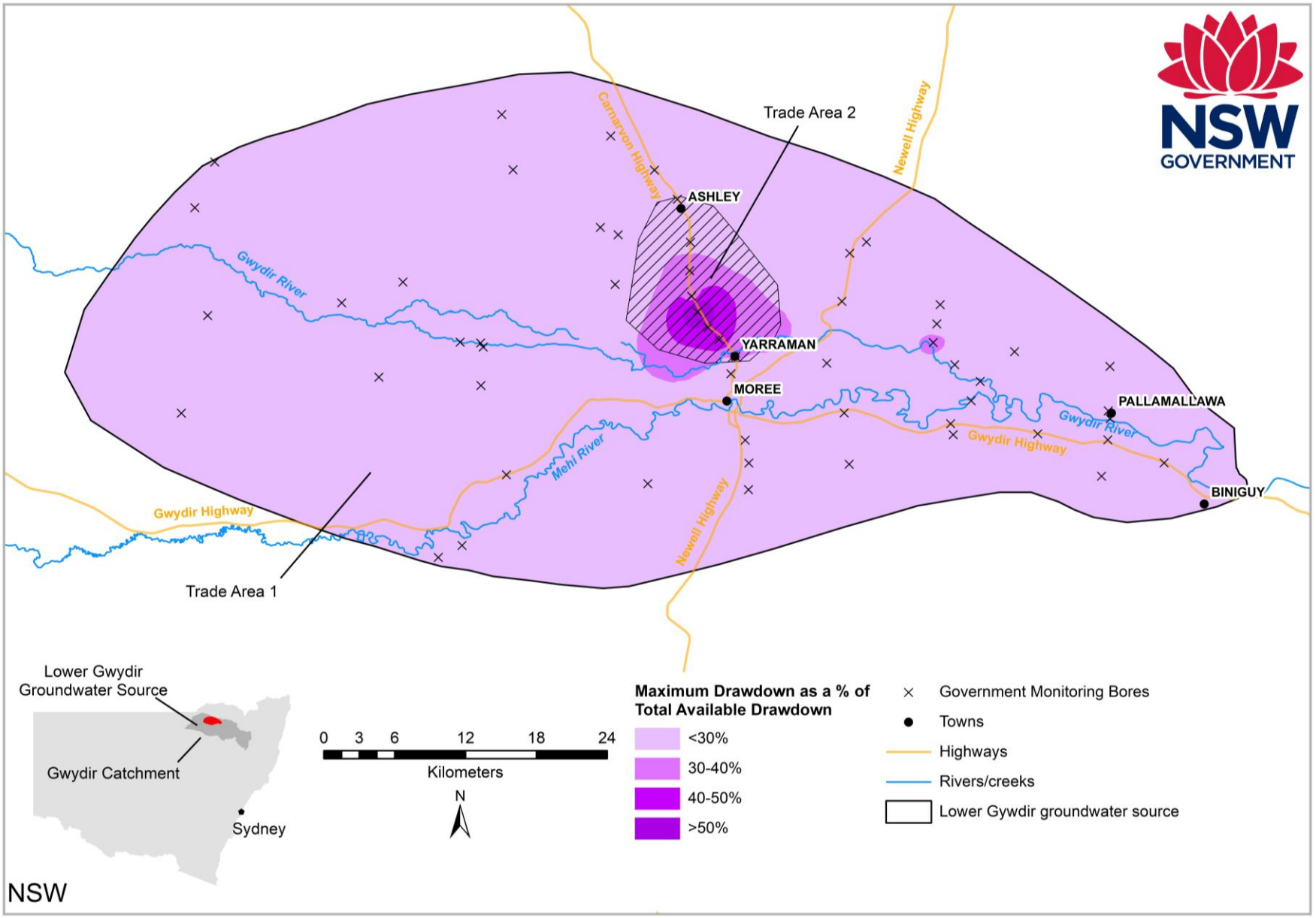


Figure 8 Lower Gwydir Groundwater Source maximum pumping drawdown (2016 to 2021) as a percent of baseline total available drawdown (deep aquifer)

3.2 Assessment of recovery

3.2.1 Recovered water level as a percent of baseline total available drawdown

The maximum recovered water level has been calculated as a percentage of the baseline total available drawdown for the deeper aquifer system from relevant monitoring bore data. Two years are reported:

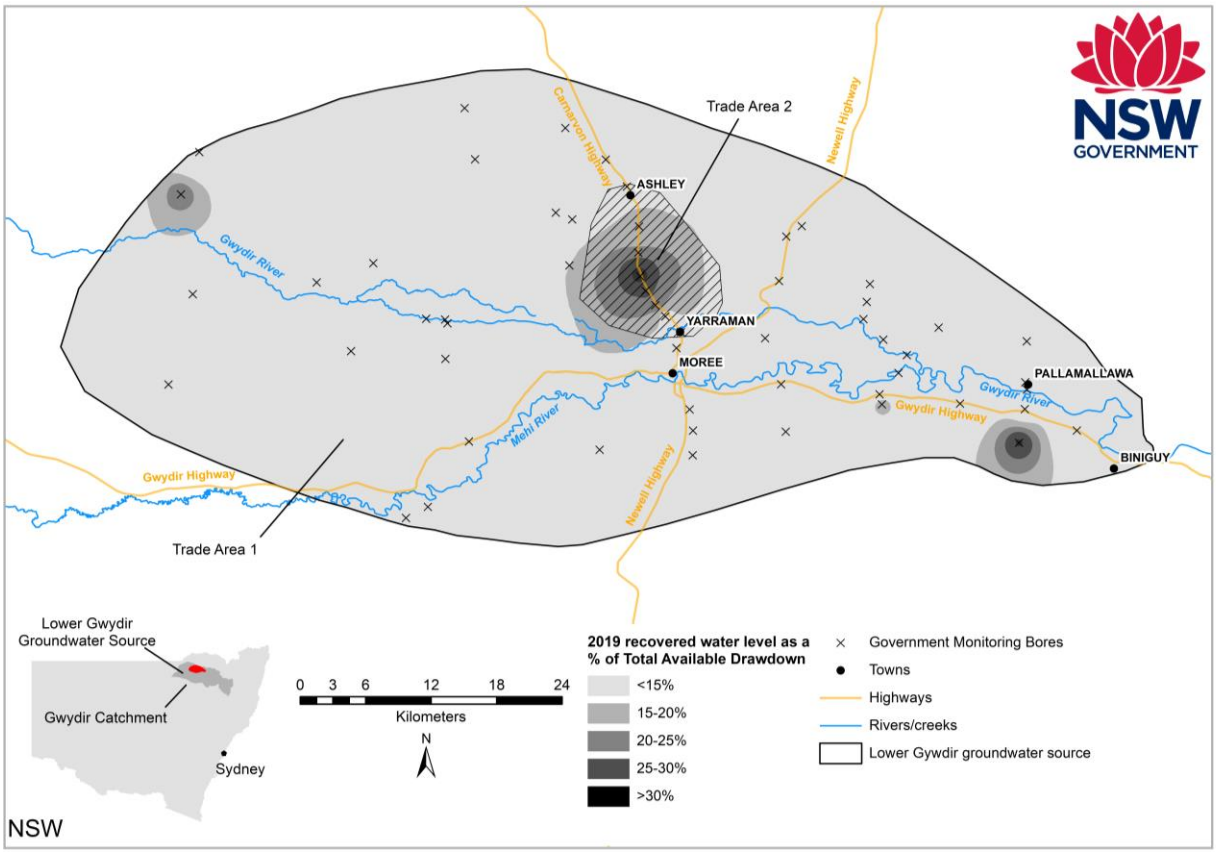
- 2019 recovered water level – corresponding to the recent drought
- 2021 recovered water level – as the most recent recovered water level (wetter conditions)

This information has been contoured and is displayed in **Figure 9A** and **Figure 9B** for the shallow aquifer and **Figure 10A** and **Figure 10B** for the deep aquifer.

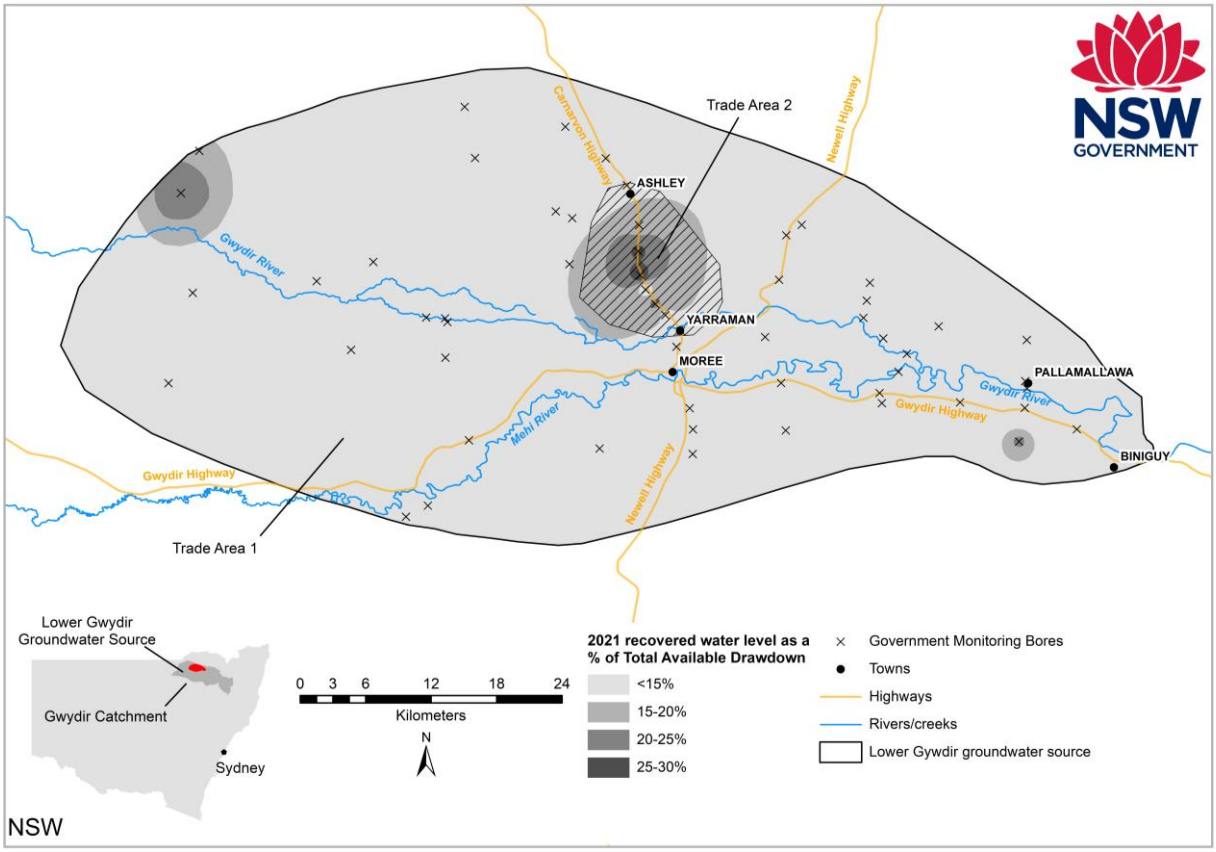
Similar to the assessment of the maximum drawdown as a percent of baseline total available drawdown, the area between Ashley and Yarraman, shows the recovered water level has declined by more than 25% of the baseline total available drawdown, and in some areas by more than30%, in both the shallow and deep aquifers (**Figure 9A**, **Figure 9B**, **Figure 10A**, **Figure 10B**). Whilst some groundwater level recovery has occurred between 2019 (height of drought) and 2021 (La Nina), recovered water level is close to or has exceeded 30% of the baseline total available drawdown during 2021 in both the shallow and deep aquifers (**Figure 9A**, **Figure 9B**, **Figure 10A**, **Figure 10B**).

Recovered water level in the shallow aquifer declined by more than 20% of the baseline total available drawdown south of Pallamallawa in 2019 (**Figure 9A**), and has begun recovering once the drought finished (**Figure 9B**).

Recovered water level in the north-west of the Lower Gwydir Groundwater Source had declined by more than 20% of the baseline total available drawdown in the shallow aquifer in 2019, and declined further between 2019 and 2021 (**Figure 9A**, **Figure 9B**). The recovered water level of the deep aquifer in this area is approaching 20% of the baseline total available drawdown (**Figure 10A**, **Figure 10B**).

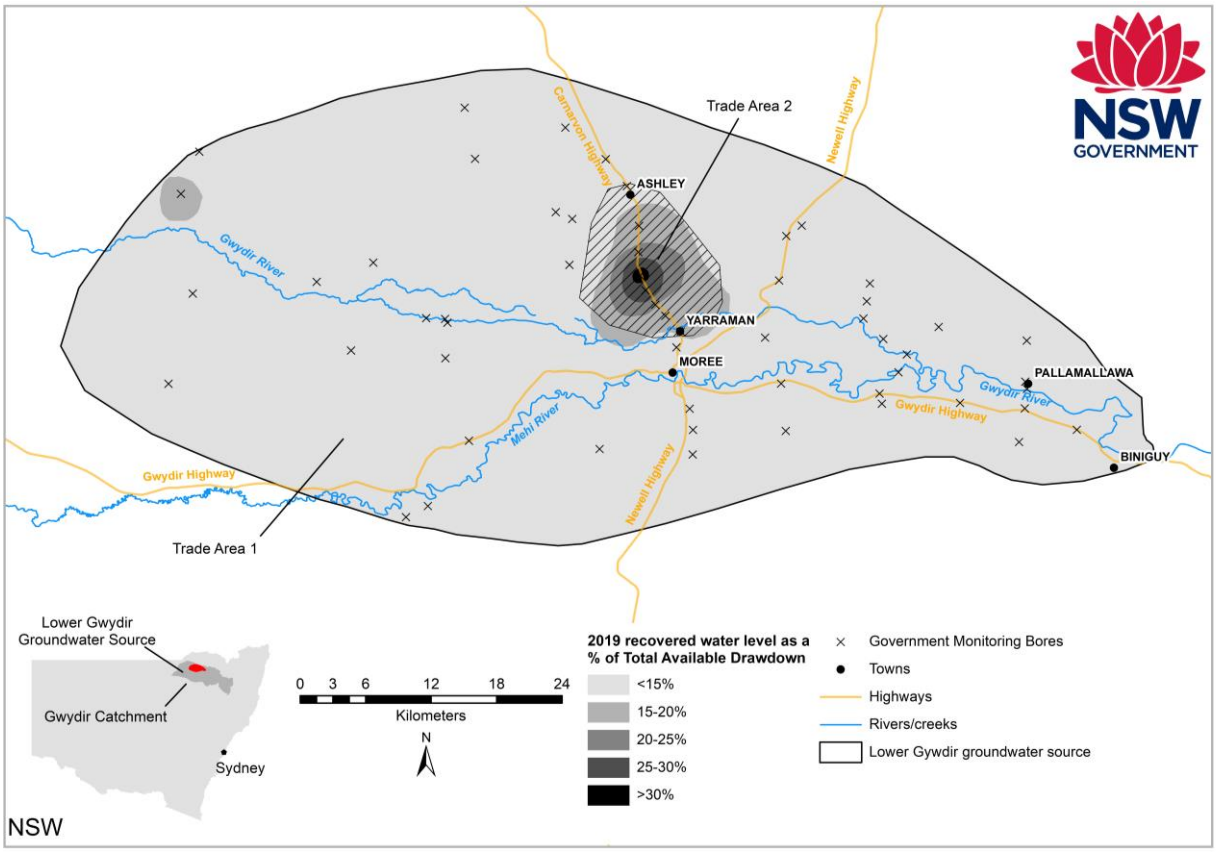


A



B

Figure 9 Recovered water level in the shallow aquifer of the Lower Gwydir Groundwater Source as a percent of Total Available Drawdown - 2019 and 2021



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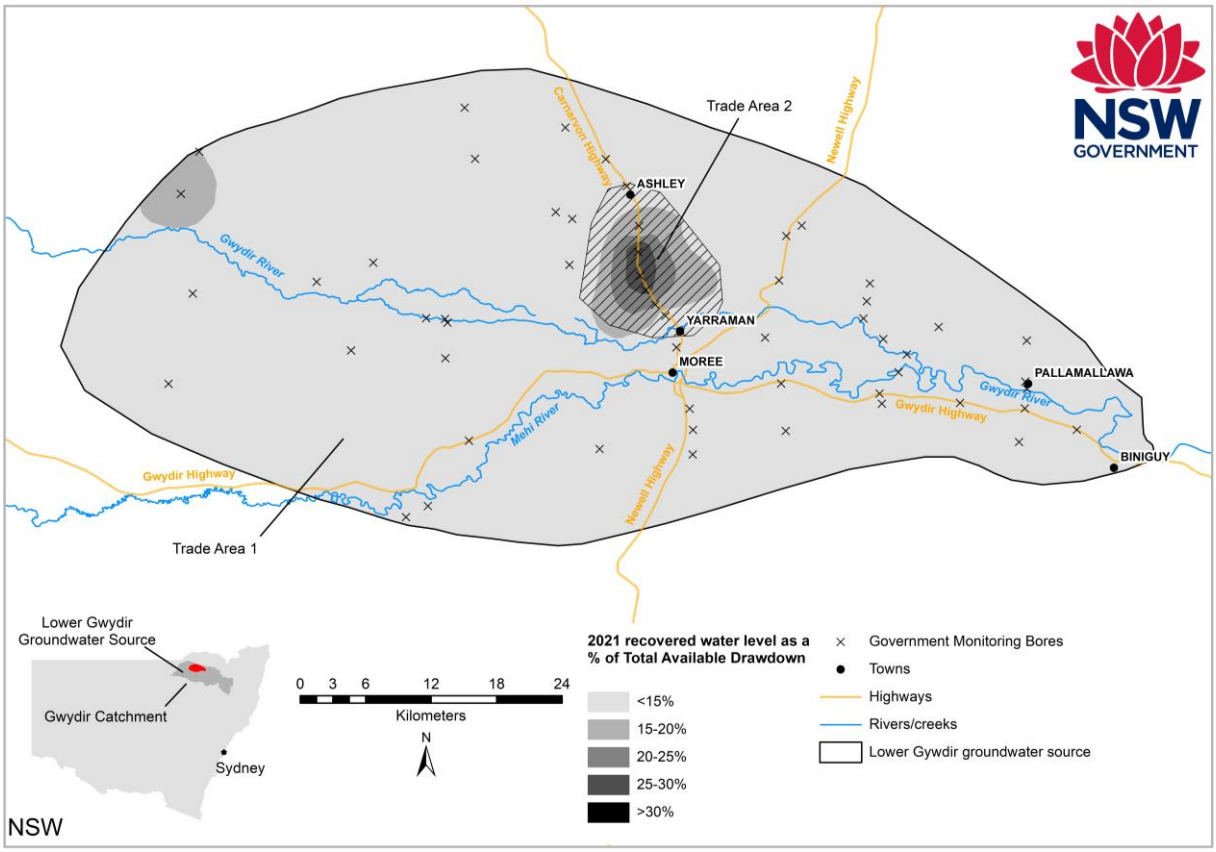


B

Figure 10 Recovered water level in the deep aquifer of the Lower Gwydir Groundwater Source as a percent of Total Available Drawdown - 2019 and 2021

3.2.2 Change in recovered water level over time

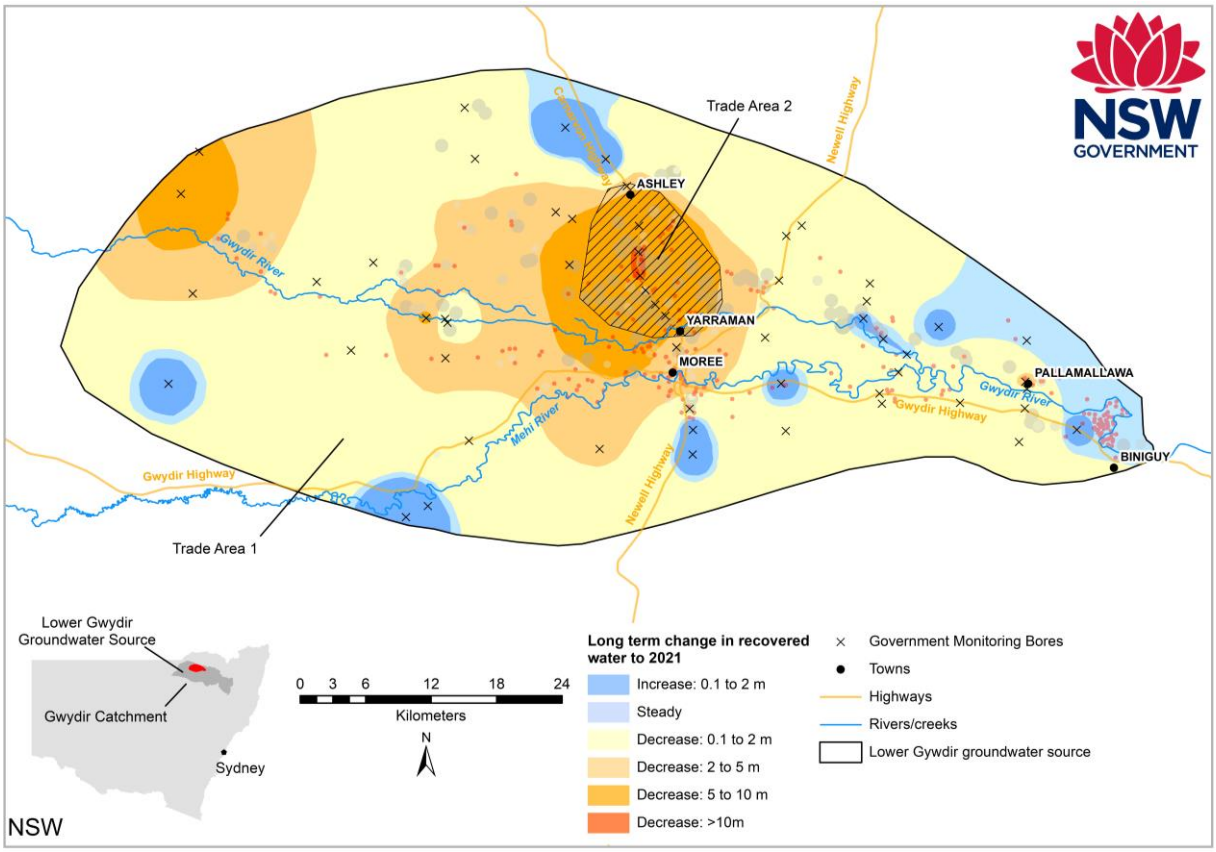
Recovered groundwater levels in the shallow and deep part of the Lower Gwydir Groundwater Source have been compared and contoured over the following two periods:

- Baseline water level to 2021 - long term change
- 2006 (drought year) to 2021 (wetter year) - change since commencement of the water sharing plan.

In the shallow aquifer (**Figure 11A**), the long-term change in recovered water level trend shows a significant decline in water levels, with at least a 2 to 5 m decline across the middle and north-west of the groundwater source. Localised long-term increasing groundwater level trends also occur along the basin highs and margins where alluvial deposits are thinner.

Similarly, in the deep aquifer, the long-term change (**Figure 12A**) shows a large area where the water levels have declined by more than 10 m across the middle of the groundwater source between Ashley and Yarraman. A water level decline of 5 to 10 m has occurred in the north-west of the groundwater source.

The shorter-term comparison of recovered water level from 2006 to 2021 in the shallow and deep aquifers (**Figure 11B**, **Figure 12B**) comparing a drought year (2006) to a wet year (2021) shows areas where the water levels has improved; between Pallamallawa and Yarraman, south-east of Moree, and in the south-west of the groundwater source. In the rest of the Lower Gwydir there is up to a 2 m decline in recovered water levels. Between Ashley and Yarraman there is up to a 5 m decline in recovered water levels in the shallow aquifer and up to a 10 m decline in the deep aquifer (**Figure 11B**, **Figure 12B**).



A

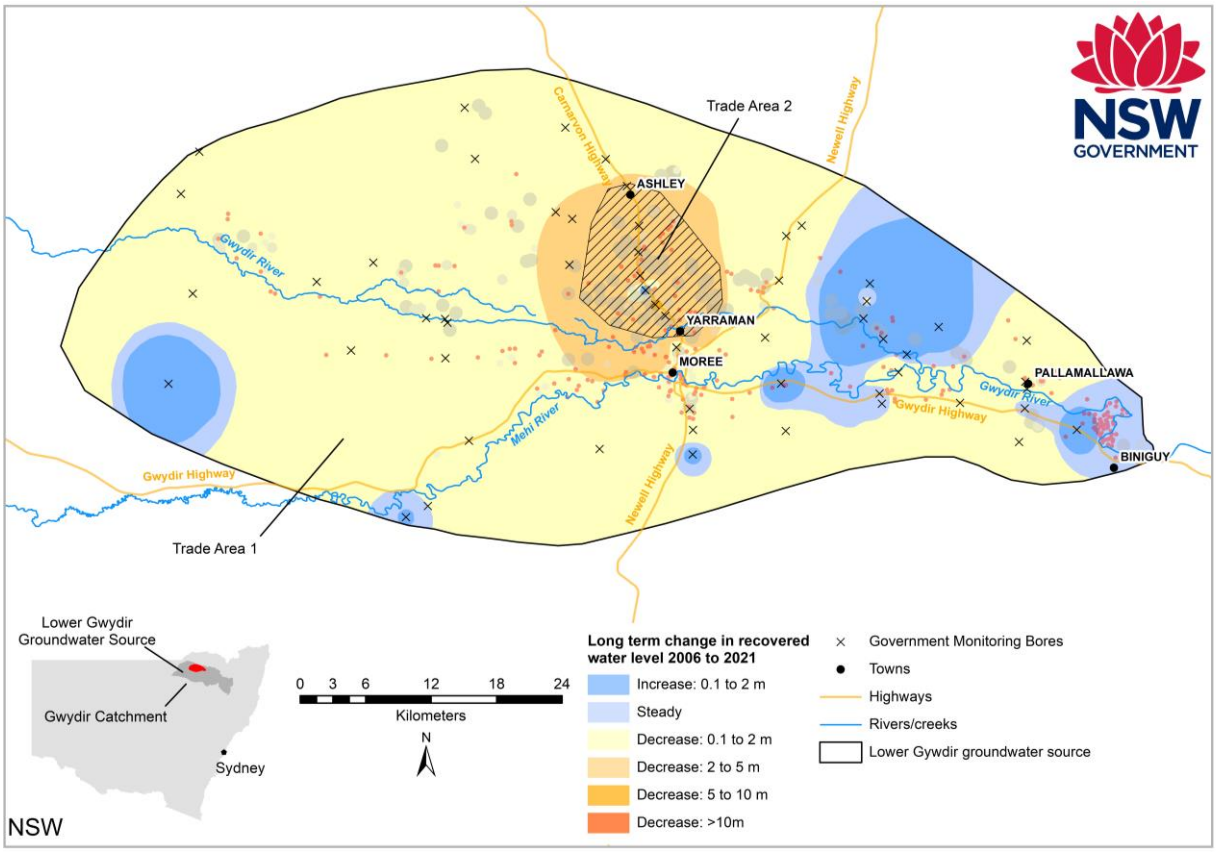


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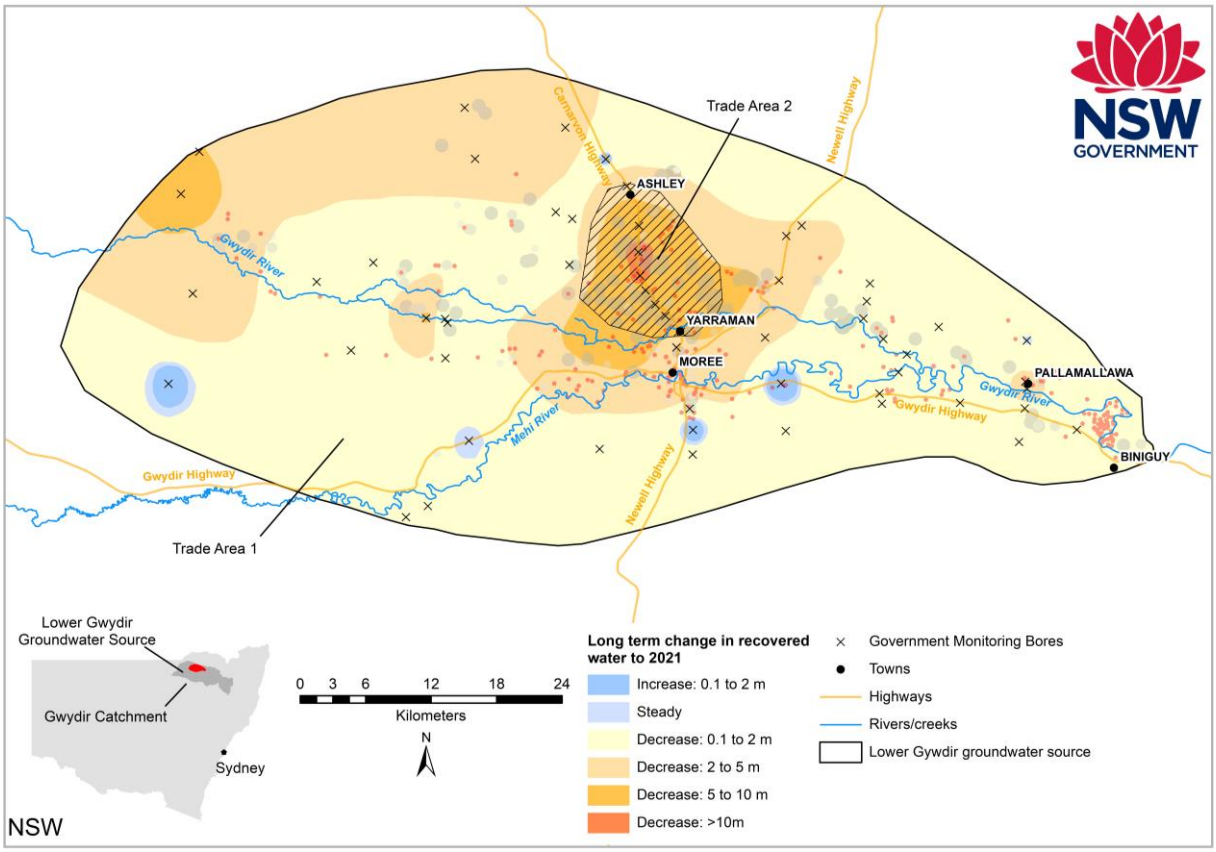
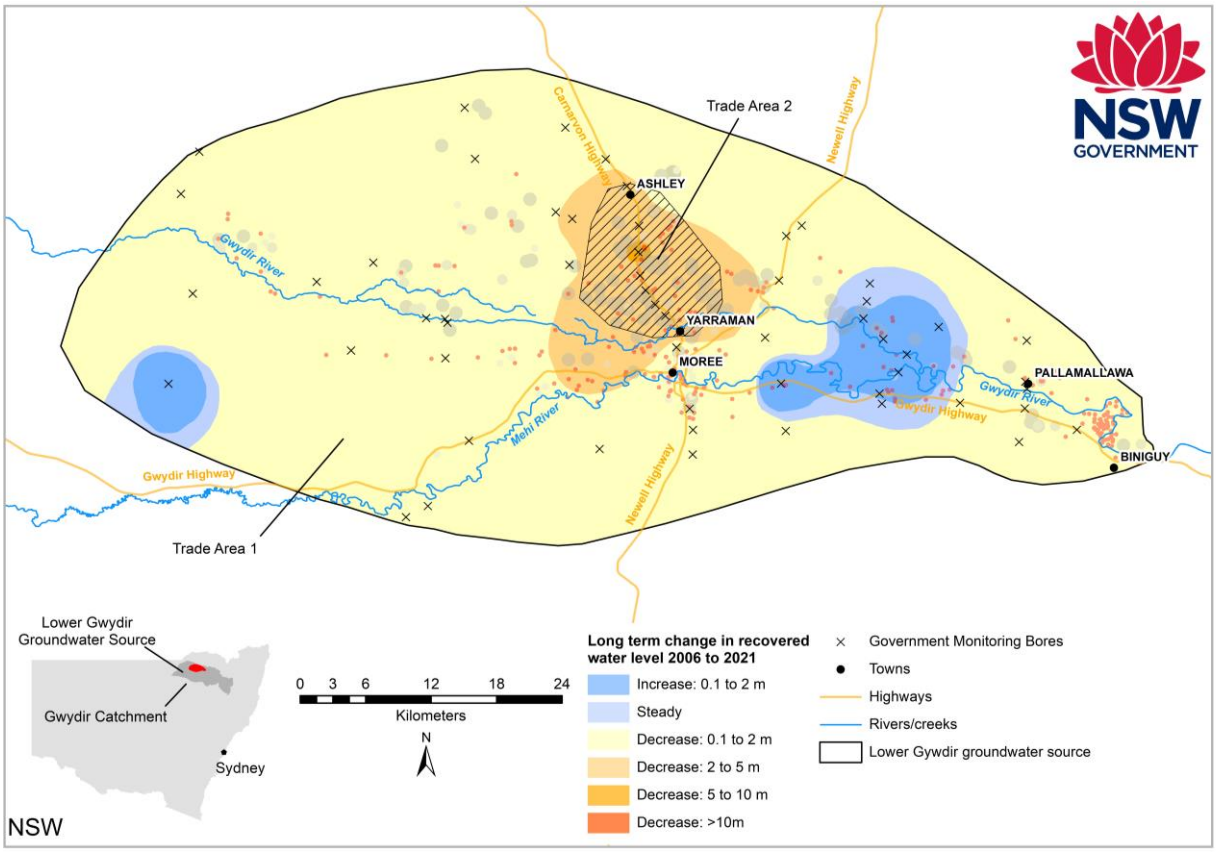
Figure 11 Change in recovered water levels in the shallow aquifer of the Lower Gwydir Groundwater Source



A



B

Figure 12 Change in recovered water levels in the deep aquifer of the Lower Gwydir Groundwater Source

4 Detailed analysis, Lower Gwydir groundwater source: Trade Area 2

An area of concern has been identified from the groundwater level analysis. This includes an area between Moree and Ashley which was previously identified as an area of concern in 2008 due to cumulative impacts from groundwater extractions. This is known as Trade Area 2.

This chapter includes a more detailed review of groundwater level hydrographs and usage patterns in this area.

The draft Lower Gwydir Groundwater Source numerical model (Modflow 2005), has been used to run various usage scenarios based on the calibration data with and without the pumping included in the simulation.

4.1 Local area restrictions

In 2008 an area between Moree and Ashley in the Lower Gwydir Groundwater Source was identified as an area of concern due to cumulative impacts from groundwater extractions. This lead to two trade management areas being established to assist in the management of temporary groundwater trades (Dealings). The location of the trade areas are shown in **Figure 13**.

The rules that apply to these trade areas restrict the volume that can be traded in the different trade areas. Trade is allowed:

- Into Trade Area 1 (including trades out of Trade Area 2)
- Into and within Trade Area 2, but will be capped so that the take limit for a year does not exceed the past maximum history of use of the buyer (i.e. temporary dealings + take limit is no greater than the maximum history of use of the buyer).

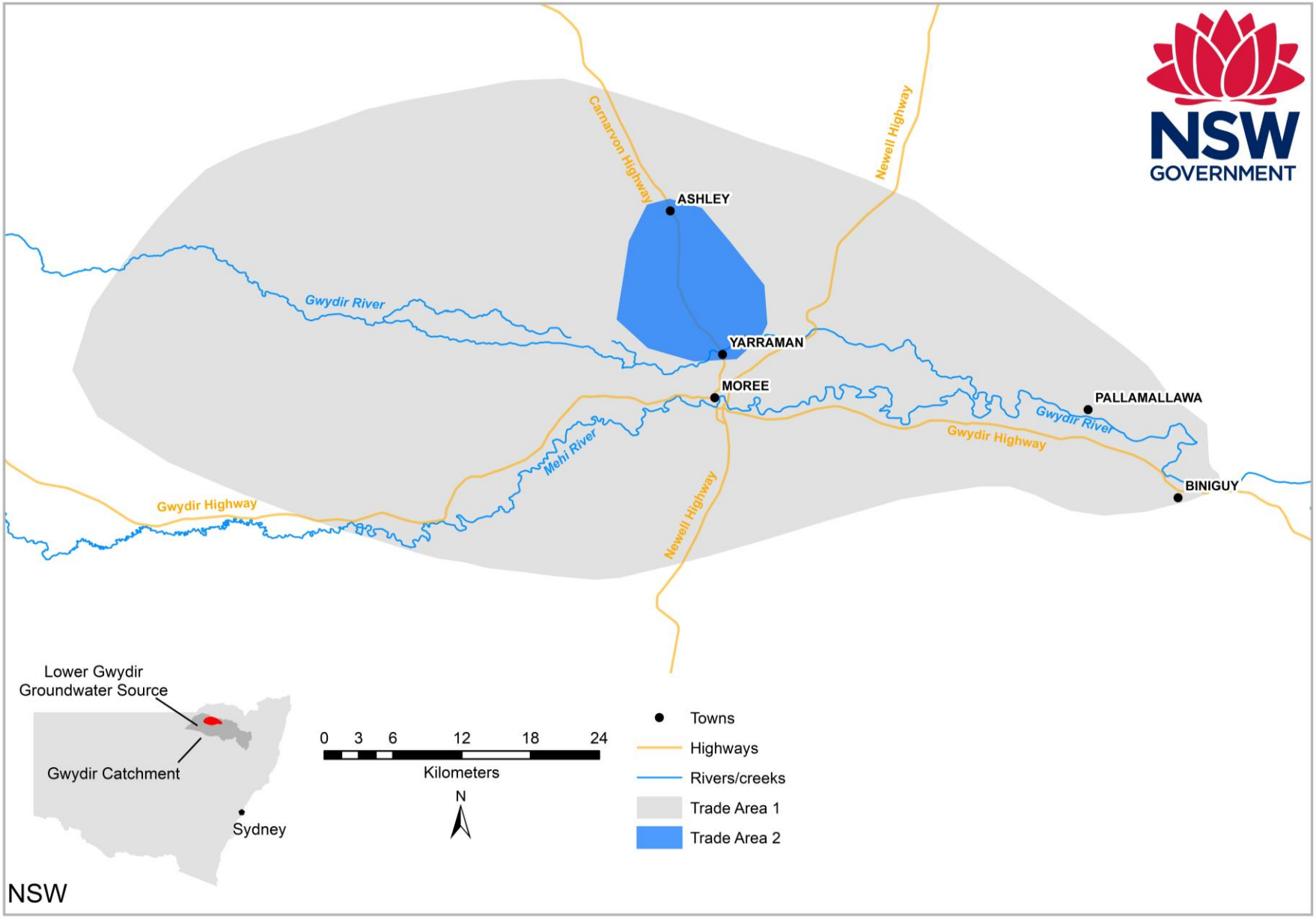


Figure 13 Trade management areas in the Lower Gwydir Groundwater Source

4.2 Hydrograph review

The long term seasonally recovered water levels have been declining since the 1980/90's across much of Lower Gwydir. The numerical model was used to compare the impact of pumping on groundwater levels in addition to the extrapolation of the long-term trends of the monitoring bore data to illustrate the potential future water level outlook.

The Lower Gwydir model has been developed and calibrated for the period from 1986 to 2016. This model was used to run two scenarios. The first is the extension of the model to 2020 using actual pumping data. The second scenario is the same model run but with the groundwater pumping turned off. The modelled groundwater levels from these scenarios were compared to actual water level data from the government monitoring bores, the locations shown in **Figure 14**. The monitoring bores reviewed include GW030462 (**Figure 15**), GW030461 (**Figure 16**), GW030460 (**Figure 17**), GW036018 (**Figure 18**), GW030459 (**Figure 19**), and GW030458 (**Figure 20**) located in Trade Area 2.

The measured water level data, showing the baseline total available drawdown trigger for that site and a projection of the potential water level trend 10 years into the future, is also shown in the bottom hydrograph of each figure.

Most sites show that modelled groundwater levels without pumping are steady to increasing over time (**Figure 15**, **Figure 16**, **Figure 17**, **Figure 18**, **Figure 19**, Figure 20). This suggests that groundwater extraction is a primary influence on declining groundwater levels within Trade Area 2.

Recovered water levels at monitoring sites GW030461, GW030460, and GW036018 has already exceeded 25% of the baseline total available drawdown (**Figure 16**, **Figure 17**, **Figure 18**). Recovered water levels at monitoring site GW030459 is approaching 25% of the baseline total available drawdown (**Figure 19**).

Projections of the seasonally recovered water level trend 10 years into the future shows that, if seasonally recovered water levels continue to decline at the current 2006 – 2021 trend, that recovered water levels may approach or exceed 25% of baseline total available drawdown in the next 10 years at monitoring sites GW030462 and GW030459 (**Figure 15**, **Figure 19)**. Seasonally recovered water levels may approach or exceed 40 % of baseline total available drawdown at monitoring sites GW030461 and GW030460 (**Figure 16**, **Figure 17**).

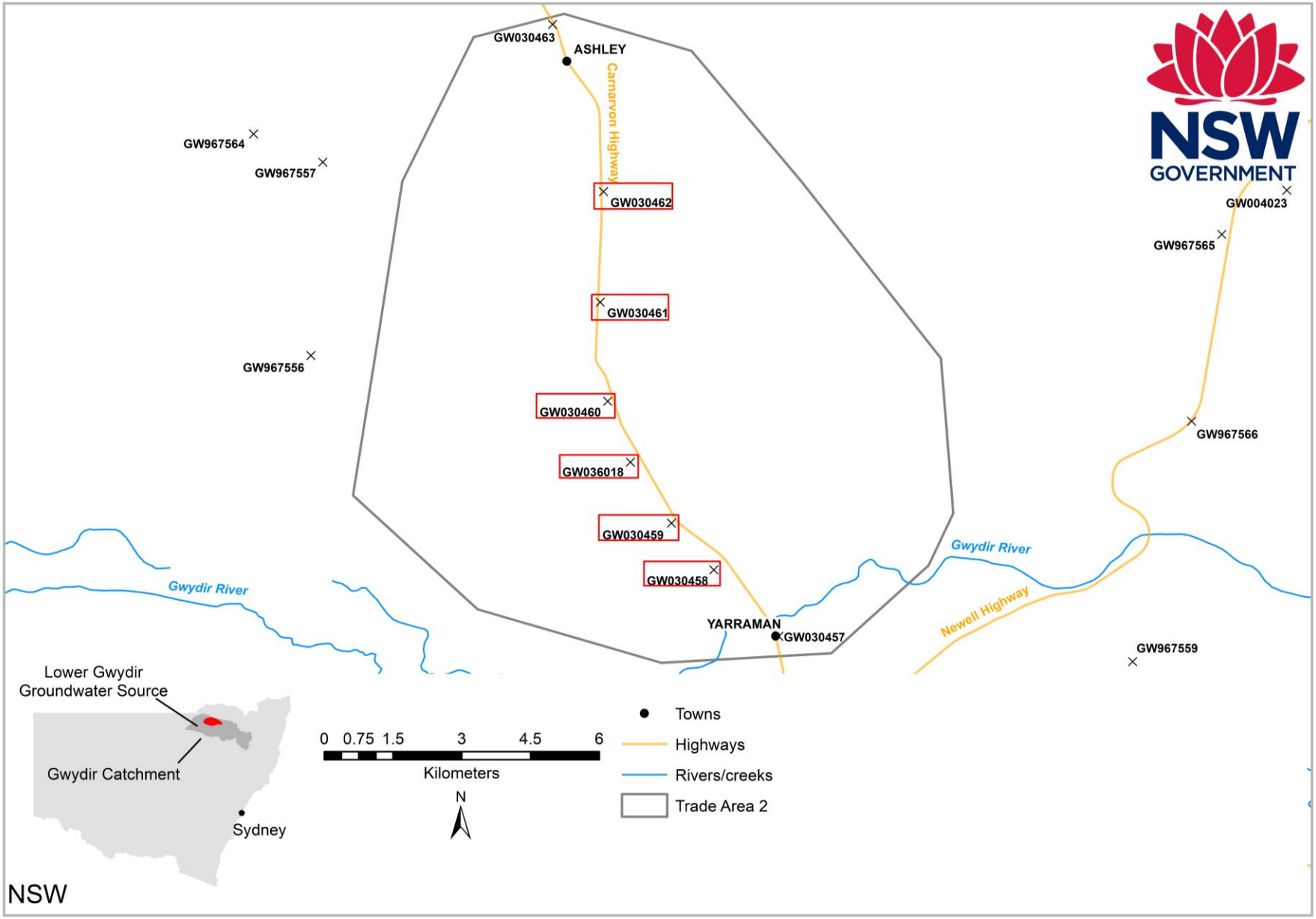


Figure 14 Lower Gwydir Trade Zone 2 location of reviewed monitoring bores

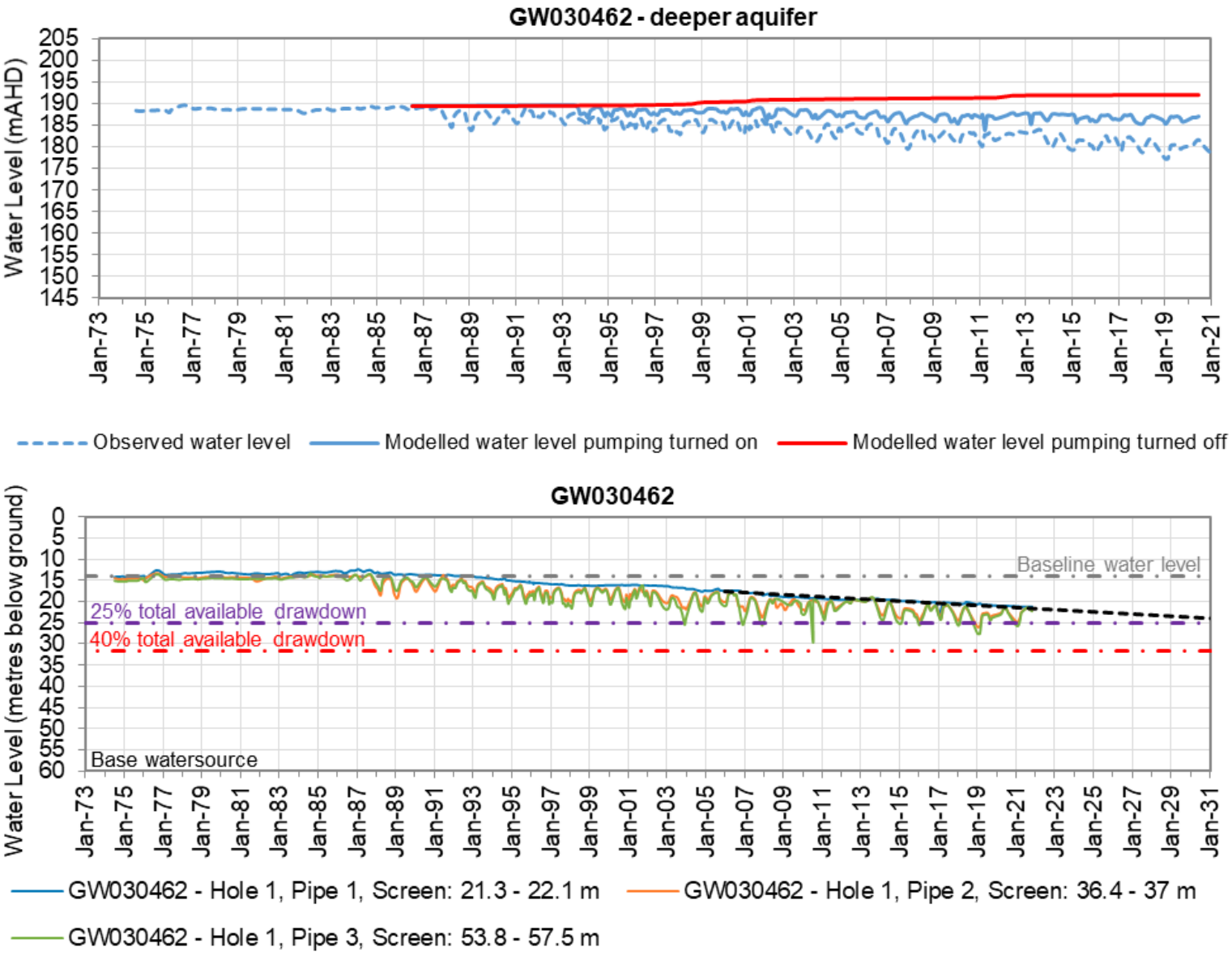


Figure 15 Monitoring bore GW030462: Top – modelled and observed water levels. Bottom: observed water levels with trend projected ten years into the future

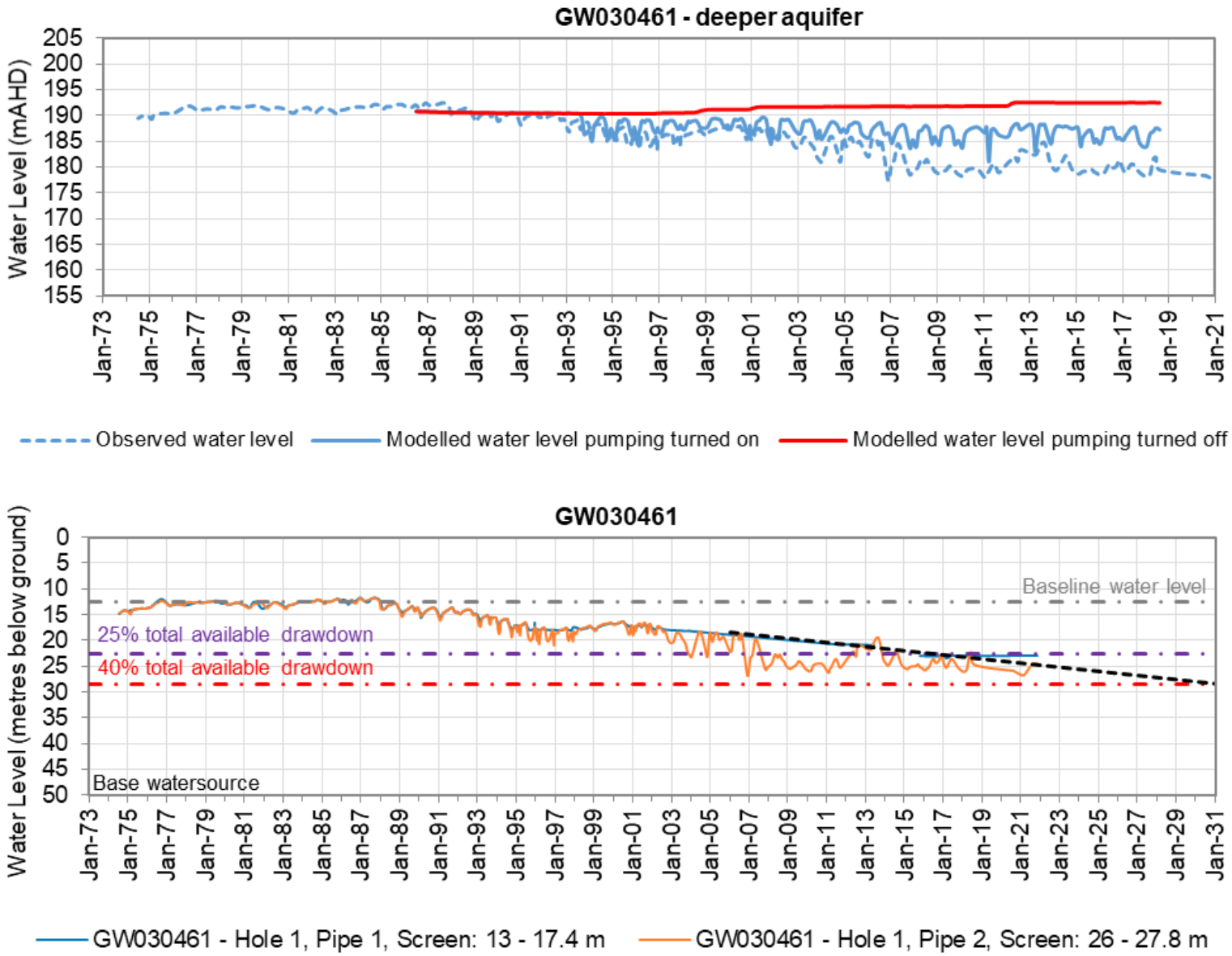


Figure 16 Monitoring bore GW030461: Top – modelled and observed water levels. Bottom: observed water levels with trend projected ten years into the future

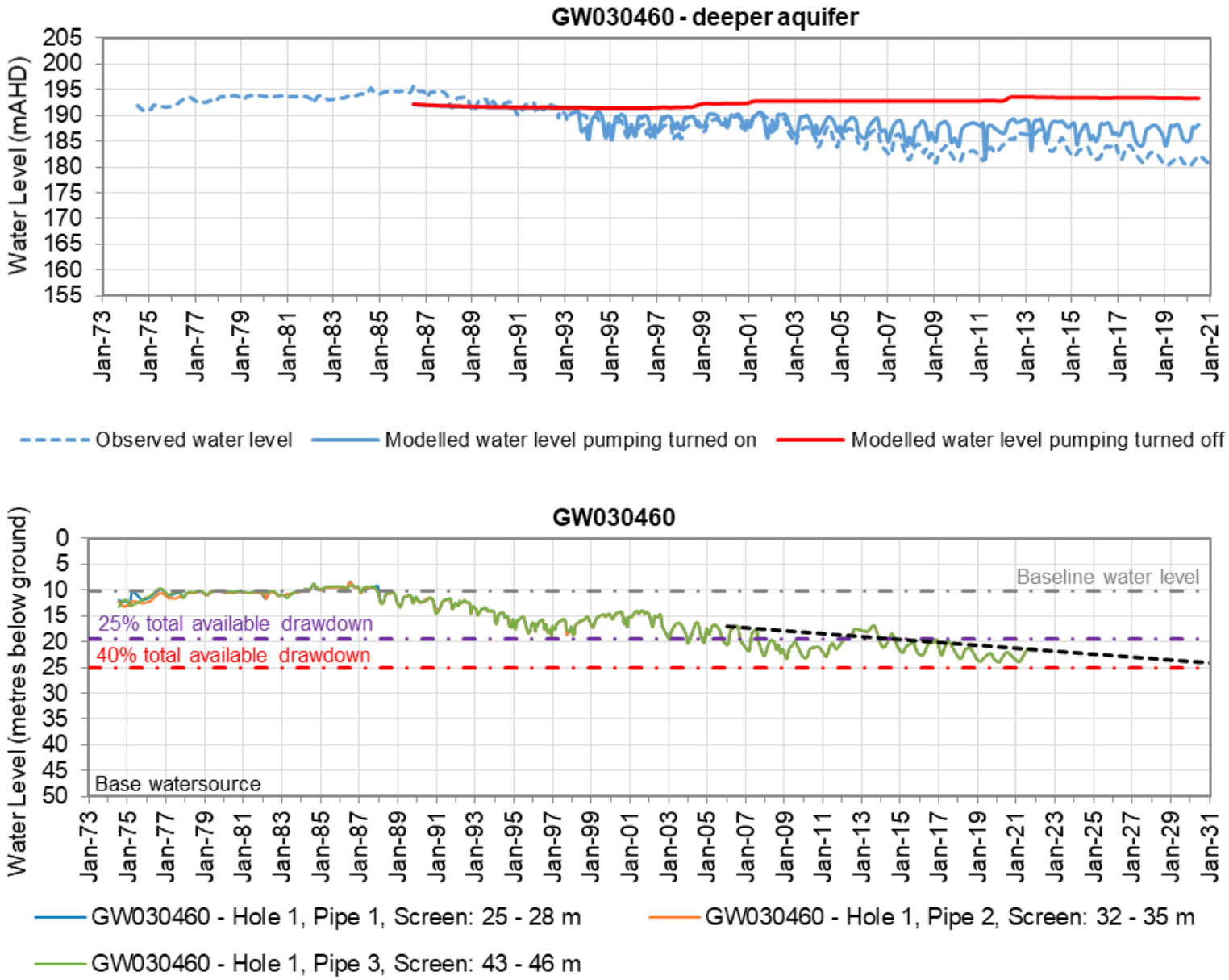


Figure 17 Monitoring bore GW030460: Top – modelled and observed water levels. Bottom: observed water levels with trend projected ten years into the future

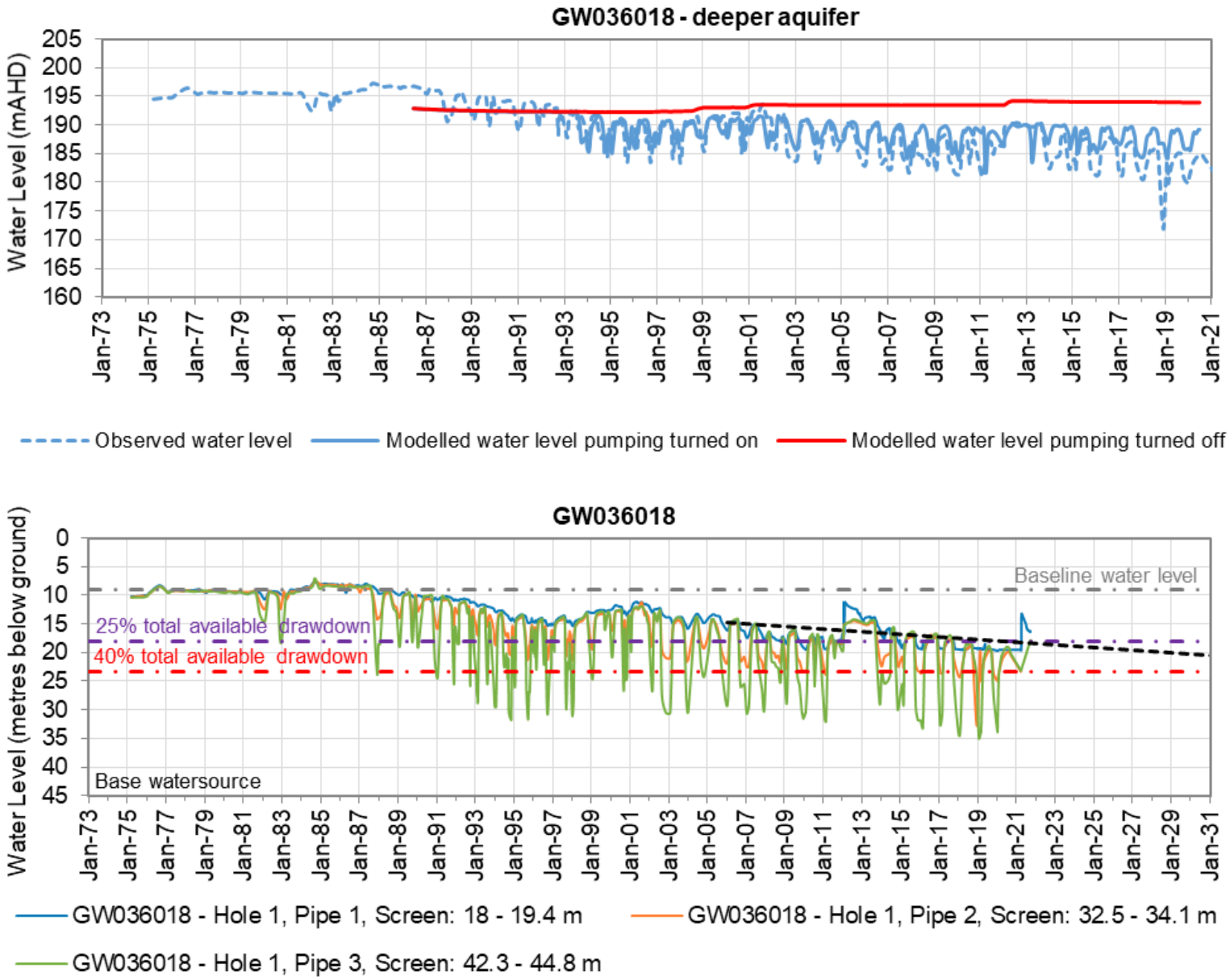


Figure 18 Monitoring bore GW030618: Top – modelled and observed water levels. Bottom: observed water levels with trend projected ten years into the future

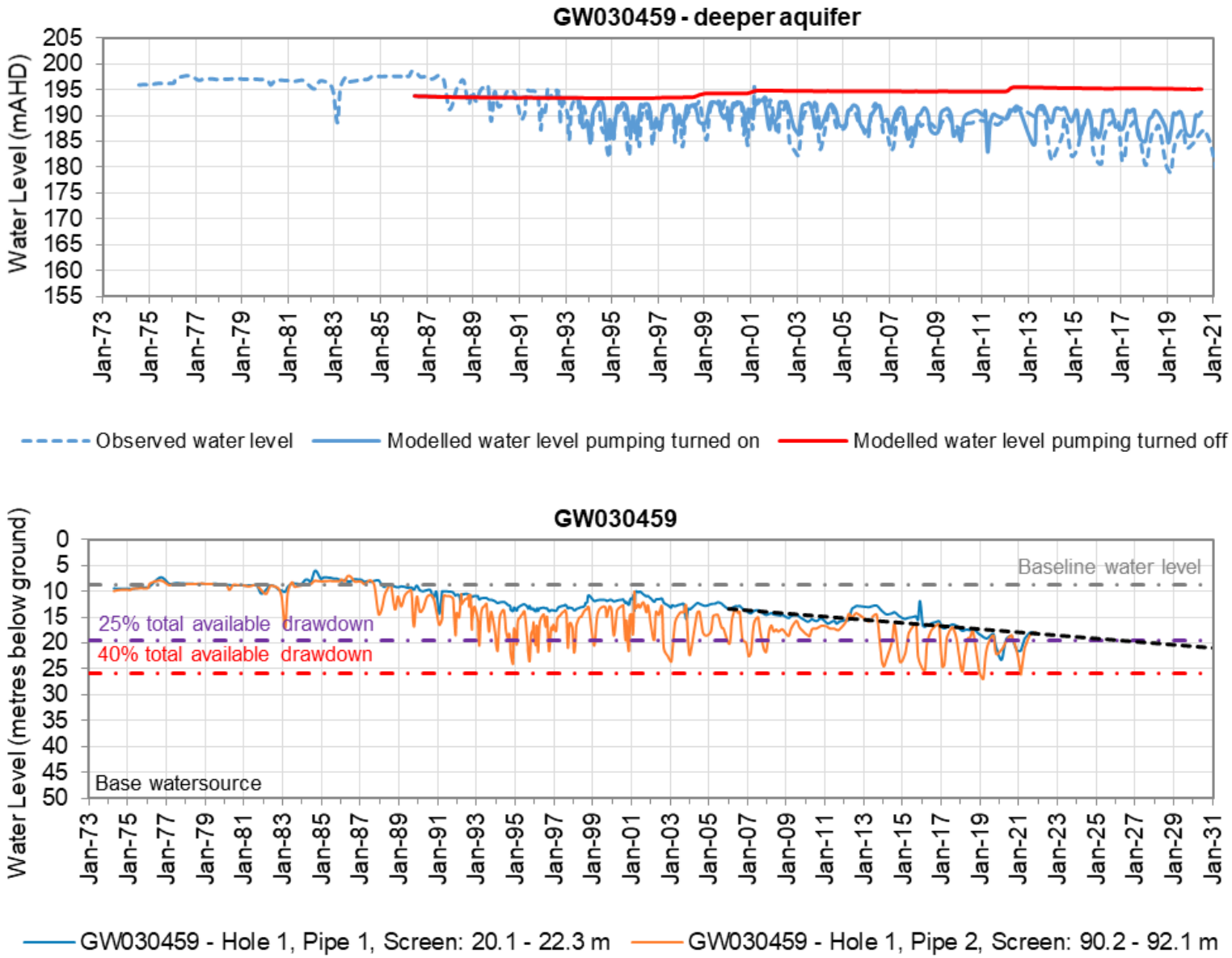


Figure 19 Monitoring bore GW030459: Top – modelled and observed water levels. Bottom: observed water levels with trend projected ten years into the future

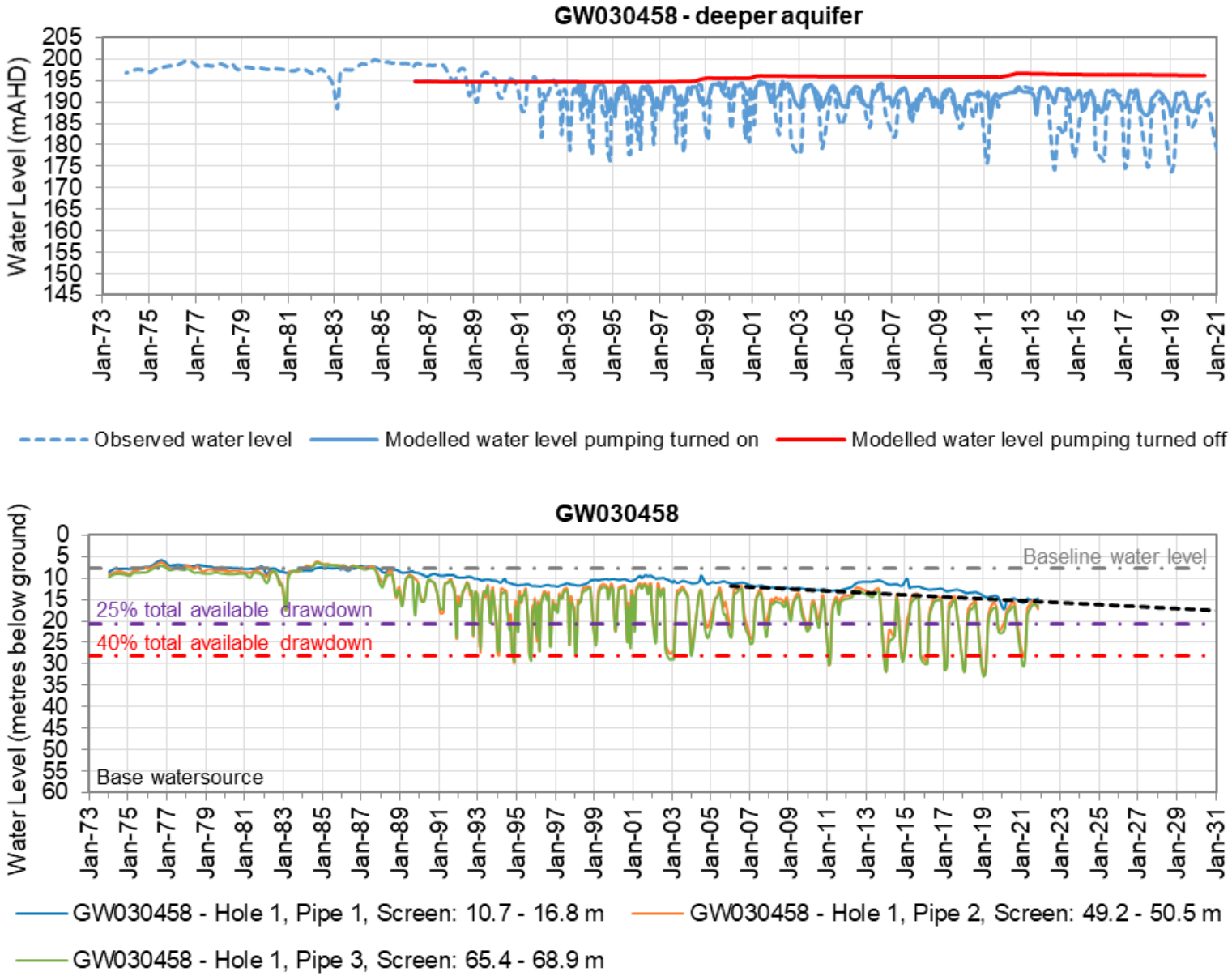


Figure 20 Monitoring bore GW030459: Top – modelled and observed water levels. Bottom: observed water levels with trend projected ten years into the future

4.3 Accounts and extraction

The account, trade and usage statistics are listed in **Table 5** for the whole of the Lower Gwydir Groundwater Source, as well as for Trade Area 1 and Trade Area 2 licences. Trade direction statistics are listed in **Table 6**. The account water compared to extraction over the last 5 years is graphed for the whole of the Lower Gwydir (**Figure 21**), Trade Area 1 (**Figure 22**) and Trade Area 2 (**Figure 23**).

There are approximately 122 production bores in Trade Area 2, 50 of which are consistently actively pumped. Average extraction in Trade Area 2 over the last 5 years has been approximately 16,190 ML/year compared to the volume available for extraction of 17,414 ML/year. The maximum extraction in the last 5 years occurred in 2018/2019 at 19,228 ML/year, during the height of the recent drought (**Figure 23**).

Temporary trading (71T Dealings) into Trade Area 2 is predominantly from Trade Area 1, and on average accounts for approximately 29% of all temporary trading in the Lower Gwydir Groundwater Source. These temporary trades into Trade Area 2 from Trade Area 1 account for approximately 3,567 ML/year and is approximately 40% of all volume transferred in temporary trading (**Table 6**).

This is in contrast to temporary trading into Trade Area 1 from Trade Area 2, which on average accounts for 9% of all temporary trading in the Lower Gwydir Groundwater Source (**Table 6**). The volume of temporary trading (71T Dealings) into Trade Area 1 from Trade Area 2 is approximately 470 ML/year, and is approximately 5% of all volume transferred in temporary trading in the Lower Gwydir Groundwater Source (**Table 6**).

Average extraction in Trade Area 2 is less than the extraction limit (**Table 5)**. Extraction has generally been similar to the extraction limit for the previous 5 years. However, extraction exceeded the extraction limit during the high use period of 2018/2019 (**Figure 23**). This was not observed for the Lower Gwydir Groundwater Source as a whole or for Trade Area 2 (**Figure 21**, **Figure 22**).

Table 5 Account, trade, and usage statistics (annual average from 2016-17 to 2020-21)

	All Lower Gwydir	Trade Area 1	Trade Area 2
Total Licences	164	139	25
Total shares	32,712	18,333	13,839
Volume in account 2020/2021	48,737	30,605	18,132
Volume available for extraction 2020/2021	44,689	27,275	17,414
Average Extraction (ML/year)	30,382	14,192	16,190
No. licences that use >100% of their share volume on average	27	20	7
No. licences who temporary trade IN	23	17	6
No. licences who temporary trade OUT	56	47	9
Average Volume traded IN (71T) ML	8,875	4,636	4,239
Average volume pumped from accounts that traded IN (ML)	20,626	7,993	12,633

Table 6 Trade direction statistics (annual average from 2016-17 to 2020-21)

	Number Trades	% Trades	Volume (ML)	% Volume
Trade Area 1 to Trade Area 1	36	56.5	4,166	46.9
Trade Area 2 to Trade Area 1	6	8.8	470	5.3
Trade Area 1 to Trade Area 2	18	29.0	3,567	40.2
Trade Area 2 to Trade Area 2	4	5.7	672	7.6

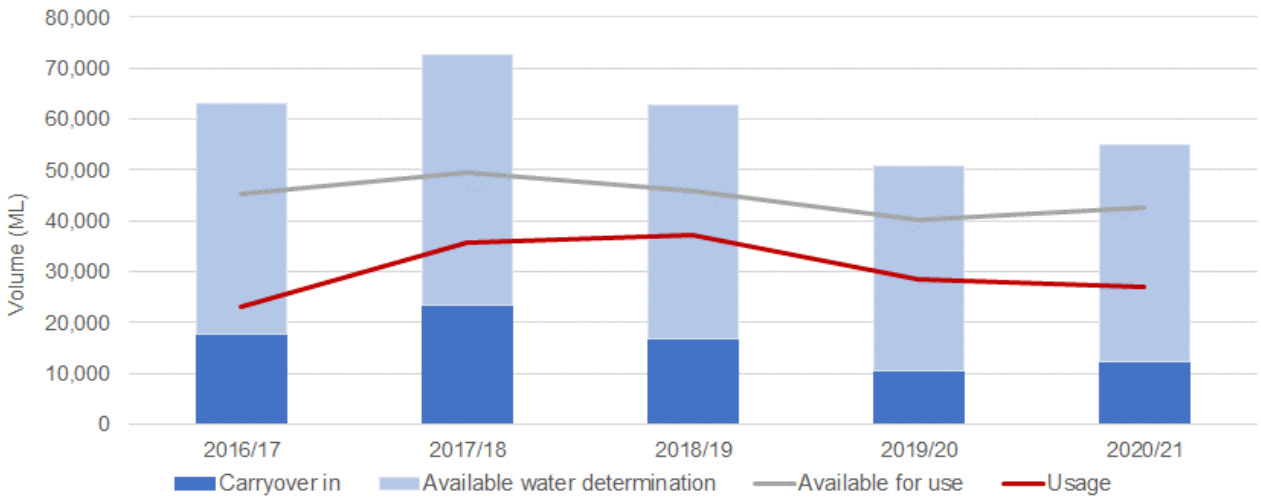


Figure 21 Whole of Lower Gwydir Groundwater Source account and usage data 2016/17 to 2020/21

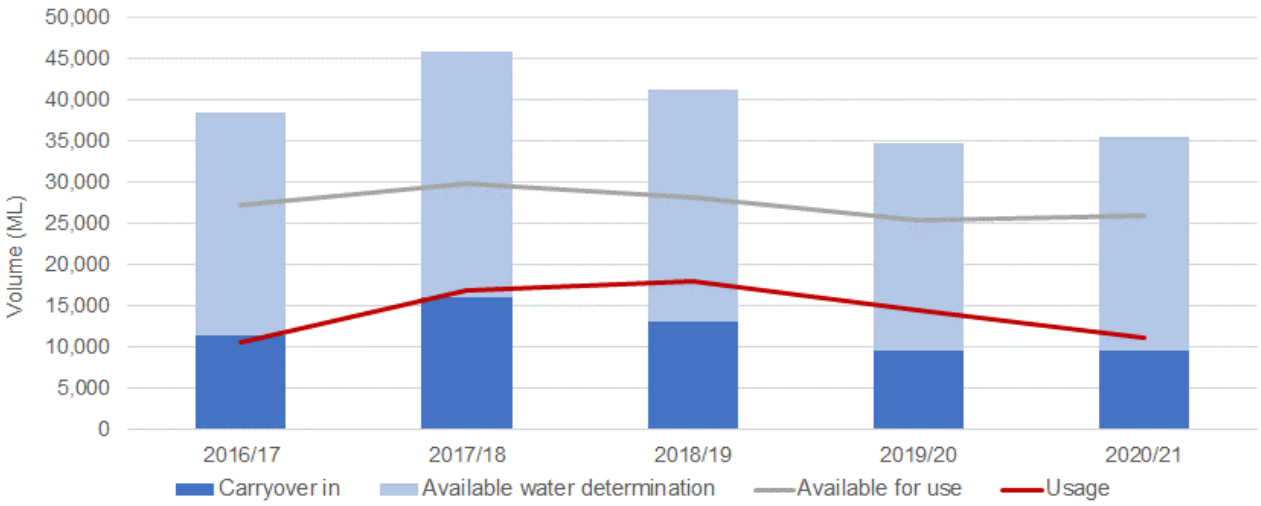


Figure 22 Lower Gwydir Groundwater Source – Trade Area 1 account and usage data 2016/17 to 2020/21

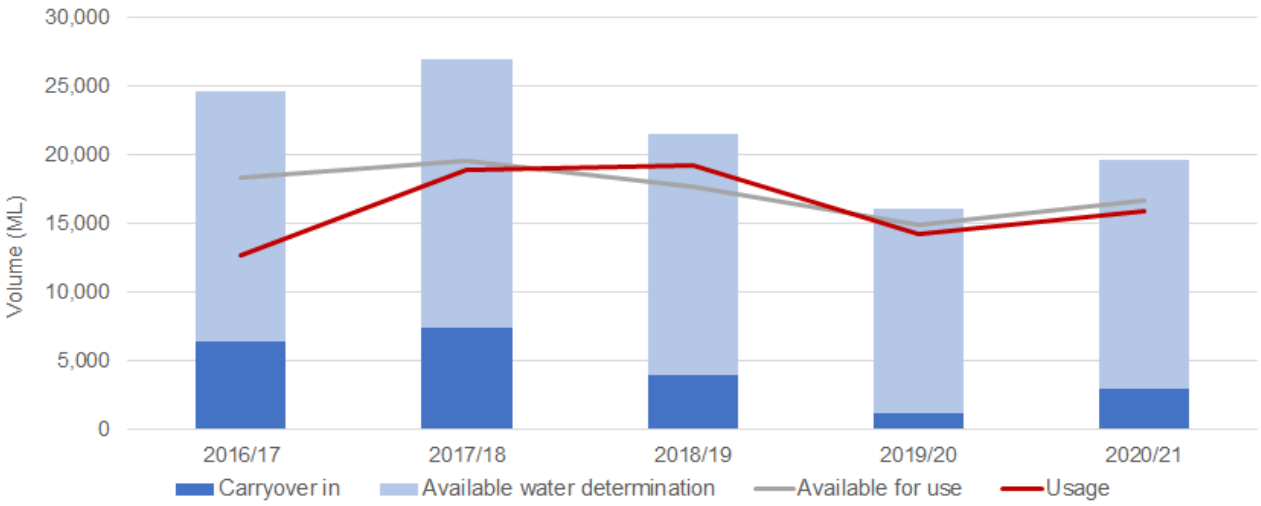


Figure 23 Lower Gwydir Namoi Groundwater Source – Trade Area 2 account and usage data 2016/17 to 2020/21

4.4 Lower Gwydir: Trade Area 2 summary

The analysis highlighted the following:

- Extraction fluctuates depending on climate, with overall average extraction across the groundwater source less than the extraction limit. However, the water level continues to decline over time, even including wetter low usage years.
- The projection of the seasonally recovered water level trend 10 years into the future shows that the water level could continue to decline to 40% of the baseline total available drawdown in the area between Mooree and Ashley. This area is known as Trade Area 2.
- Modelling runs comparing pumping and no groundwater scenarios indicates the declining trend is mainly driven by groundwater extraction as the water levels remain relatively stable over time without extraction.
- Average extraction exceeds the total allocated shares in Trade Area 2. This is compared to the whole Lower Gwydir where average extraction over the last 5 years is less than the total shares allocated.
- There is temporary trading (71T Dealings) occurring in the area, with approximately 29% of trade occurring from Trade Area 1 to Trade Area 2 (i.e the buyer's licence is in Trade Area 2 and the seller's licence is in Trade Area 1. Approximately 2.7% of temporary trading in occurring within Trade Area 2 (i.e. the buyer and seller licences are in Trade Area 2).
- Approximately 47.8% of the total volume traded (71T Dealings) within the Lower Gwydir is to licences in Trade Area 2.
- Approximately 53% of total usage in the Lower Gwydir is from Trade Area 2.