Western Mount Lofty Ranges Prescribed Water Resources Area 2020–21 water resources assessment

Department for Environment and Water
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DEW Technical Note 2022/14

Government of South Australia
Department for Environment and Water

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1 Summary

WMLR PWRA	Fractured rock aquifers
	Permian sand
	Tertiary limestone
	Surface water (Torrens and Onkaparinga)
	Surface water (Fleurieu)

LEGEND

- Highest on record
- Very much above average
- Above average
- Average
- Below average
- Very much below average
- Lowest on record

Rainfall

- Average annual rainfall across the Western Mount Lofty Ranges (WMLR) typically varies from 500 mm at lower elevations near the coast to greater than 950 mm at higher elevations. Total rainfall in 2020–21 is significantly lower than the 1973 to 2021 averages throughout the WMLR.
- Annual rainfall at Hindmarsh Valley in 2020–21 is 776 mm, 11% below the 1973 to 2021 annual average, while at Mount Bold it is 755 mm, 6% below average.

Surface water

- In 2020–21, 4 of the 8 representative stations for the Prescribed Water Resources Area (PWRA) recorded 'Below average' streamflow, 2 stations recorded 'Average' streamflow and 2 recorded 'Above average' streamflow.
- Data for the 1973 to 2021 period of record indicate a slightly decreasing trend for Mount Pleasant and a slightly increasing trend for the Inman River. The high rainfall and streamflow of 2016 has a high influence on the current trend, whereas at least 13 of the past 20 years have recorded 'Below average' streamflow for both stations.
- The flow regime observed in 2020–21 is likely to have worsened current aquatic species' distribution and diversity due to the reduced number of days with flows above the threshold flow rate (TFR) observed in most stations.
- The highest salinity in 2020–21 is 732 mg/L in the Onkaparinga River, which is within the historical ranges recorded at this site, with most median monthly values being below the median salinity values for the period of record.

Groundwater

- In 2021, water levels for the majority of wells in all aquifers are generally commensurate with historical levels.
- Water levels in 61% of monitoring wells in fractured rock aquifers recorded 'Average' or higher levels compared to respective historical levels.
- In the 10 years to 2021, the majority of wells in the fractured rock aquifers (64%) show decreasing salinity trends.
- In 2021, salinity data was not available for Permian Sand and Tertiary limestone aquifers; however, historical data shows that salinity within the Myponga and Hindmarsh Tiers basins is typically less than 1,000 mg/L.

Water use

- Water for irrigation, commercial, stock and domestic purposes comes from a variety of sources. These include pumping and diversions from watercourses and aquifers, interception and storage by farm dams and water from SA Water's reticulated distribution network
- Water consumption in 2020–21 totalled 116,677 ML, comprising licensed surface water take (20,202 ML), licensed watercourse take (10,437 ML), estimated non-licensed surface water demand (4,956 ML), forestry (17,413 ML), SA Water extraction from reservoirs (50,323 ML) and groundwater extraction (13,346 ML).

1.1 Purpose

The Department for Environment and Water (DEW) has a key responsibility to monitor and report annually on the status of prescribed and other groundwater and surface water resources. To fulfil this, data on water resources are collected regularly, analysed and reported in a series of annual reports. Three reports are provided to suit a range of audiences and their needs for differing levels of information:

- **Technical Notes**: (this document) provides detailed information and assessment for each resource area, helping to identify resource condition in further detail.
- **Fact sheets**: provide summary information for each resource area with an Annual Resource Status Overview.
- **State-wide summary**: provides summary information for the main water resources across most regions in a quick-reference format.

This document is the Technical Note for the Western Mount Lofty Ranges (WMLR) Prescribed Water Resources Area (PWRA) and collates rainfall, surface water, groundwater and water-use data for 2020-21.

1.2 Regional context

The Western Mount Lofty Ranges Prescribed Water Resources Area (WMLR PWRA) is located 10 km east of Adelaide (Figure 1.1). It lies predominantly within the Hills and Fleurieu Landscape Region but has small areas also located within the Green Adelaide and Northern and Yorke Landscape Regions. The PWRA includes both groundwater and surface water resources and these are prescribed resources under the *Landscape South Australia Act 2019*. The Water Allocation Plan for the Western Mount Lofty Ranges Prescribed Water Resources Area, adopted in 2013, provides rules for their management.

Approximately 75% of the state's population has dependence on the water resources of the WMLR PWRA, which on average supplies around 60% of metropolitan Adelaide's water requirements. Effective management of these water resources are therefore vitally important socially, economically and ecologically.

The eastern regions of the PWRA include the highest elevations in the area and form the upland eastern extent of the Mount Lofty Ranges watershed. Several important watercourses drain the northern and central parts of the PWRA, including the South Para River, Little Para River and the River Torrens. The Onkaparinga River and Myponga River drain the southern parts of the PWRA and flow west before discharging to Gulf St Vincent.

The south-western part of the PWRA includes the Fleurieu Peninsula, which is characterised by smaller coastal catchments, draining a central plateau. The Fleurieu Peninsula contains numerous wetlands including the Fleurieu Swamps, listed under the *Environment Protection and Biodiversity Conservation Act 1999*. The most south-easterly parts of the PWRA comprise the Hindmarsh River and Inman River catchments which drain the Fleurieu Peninsula towards the south-east (Figure 1.1).

There are two types of aquifers in the WMRL PWRA: fractured rock aquifers and sedimentary aquifers. Fractured rock aquifers occur where groundwater is stored and moves through joints and fractures in the basement rocks. There are three main sedimentary groundwater systems within the WMLR PWRA: the Permian Sand, Tertiary limestone and Quaternary aquifers. The McLaren Vale Prescribed Wells Area (PWA) located within the boundaries of the WMLR PWRA (Figure 1.1) is managed under a separate water allocation plan (AMLR NRM Board 2013) and consequently, a dedicated Water Resource Assessment Program report (DEW 2021) has been prepared for the aquifers in this PWA.

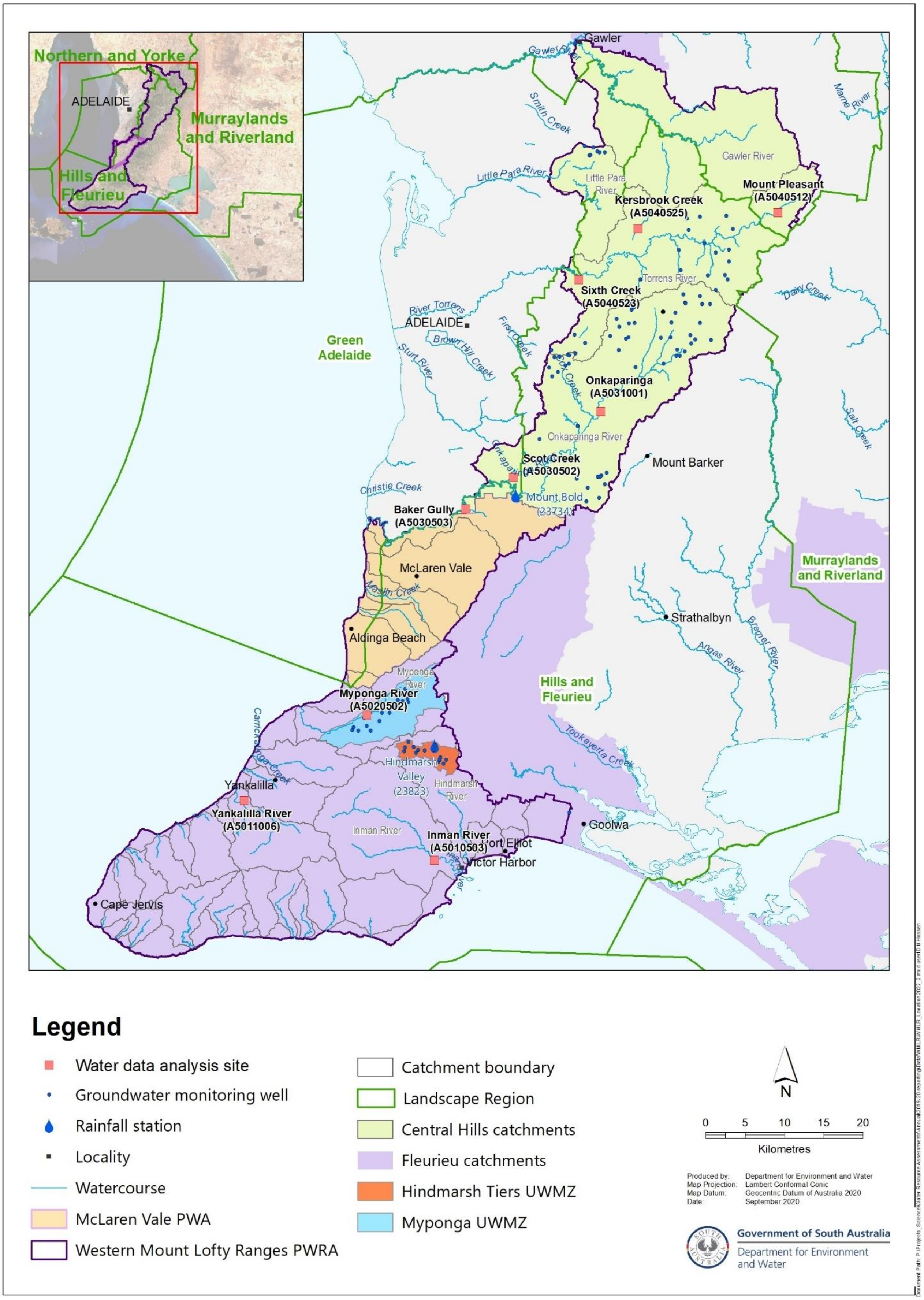

Figure 1.1 Location of prescribed areas of the Western Mount Lofty Ranges

2 Methods and data

This section describes the source of rainfall, surface water, groundwater and water-use data presented in this assessment and the methods used to analyse and present these data. The period of data adopted for each parameter is shown in Table 2.1.

Table 2.1 Reporting period description

Parameter	Reporting period	Comment
Rainfall	1 July 2020 to 30 June 2021	Monthly data for July to September 2021 are also presented to provide additional context.
Surface water	1 July 2020 to 30 June 2021	Monthly data for July to September 2021 are also presented to provide additional context.
Groundwater	1 January to 31 December 2021	Groundwater levels typically show a delayed response to incident rainfall and aggregate groundwater extraction; hence the lag in reporting period (See section 2.3.1).
Water use	1 July 2020 to 30 June 2021	In South Australia, water accounting is reported between 1 July through to 30 June of the following year

For rainfall, surface water and water-use data, the financial year or 'water year' was adopted, as defined in the BoM Australian Water Information Dictionary.

2.1 Rainfall

Daily rainfall observations were used from selected Bureau of Meteorology (BoM) stations in order to calculate monthly and annual totals. The data were obtained from the SILO Patched Point Dataset[1] service provided by the Queensland Government, which provides interpolated values to fill gaps in observations (Figure 3.2 and Figure 3.3).

Rainfall maps were compiled using gridded datasets obtained from the BoM (Figure 3.1 and Figure 3.4). The latest available long-term annual rainfall map (1986 to 2015 average) was obtained from Climate Data Online[2]. The map of total rainfall in 2020–21 was compiled from monthly rainfall grids obtained for the months between July 2020 and June 2021 from the Australian Landscape Water Balance[3] website.

[1] https://www.data.qld.gov.au/dataset/silo-patched-point-data

[2] http://www.bom.gov.au/jsp/ncc/climate_averages/rainfall/index.jsp

[3] http://www.bom.gov.au/water/landscape/#/rr/Actual/year/-28.4/130.4/3/Point////2020/12/31/

2.2 Surface water

2.2.1 Annual streamflow

The status of each of the streamflow gauging stations is determined by expressing the annual streamflow for the reporting year as a percentile[4] of the total period of data availability. The common streamflow data availability period for the WMLR streamflow gauging stations is 1973 to 2021. Streamflow data were then given a description based on their percentile and decile[4] (Table 2.2 and Figure 4.1).

Table 2.2 Percentile/decile descriptions*

Decile	Percentile	Description	Colour
N/A	100	Highest on record	
10	90 to 100	Very much above average	
8 and 9	70 to 90	Above average	
4, 5, 6, and 7	30 to 70	Average	
2 and 3	10 to 30	Below average	
1	0 to 10	Very much below average	
N/A	0	Lowest on record	

* Deciles and descriptions as defined by the BoM[5]

Annual streamflow data (Figure 4.2 and Figure 4.4) is presented as the deviation of each year's streamflow from the 1973 to 2021 average with the bars shaded using the BoM classification shown in Table 2.2.

2.2.2 Monthly streamflow

Monthly streamflow for the reporting year is assessed alongside the 1973 to 2021 average monthly streamflow and monthly statistics including (a) high flows (75th percentile), (b) median flows (50th percentile) and low flows (25th percentile) (Figure 4.3A and Figure 4.5A). Monthly data is presented for an extended period (July 2020 to September 2021) to capture the full flow season.

2.2.3 Daily streamflow

Daily streamflow is presented to show the detailed variability throughout the applicable year (Figure 4.3B and Figure 4.5B).

2.2.4 Flow regime

The term 'flow regime' in this document is used to describe the timing and quantity streamflow characteristics that are important in supporting water dependent ecosystems. For instance, the temporal variability of streamflow significantly influences aquatic biodiversity, with longer flowing periods linked to ecosystems with higher diversity and supporting more sensitive species. Physical and chemical processes such as nutrient transport and groundwater-surface water interactions are also heavily influenced by the flow regime.

A range of hydrological metrics have been selected to characterise and describe ecologically important parts of the flow regime. The annual number of flowing days and the annual number of flowing days above the threshold

[4] The nth percentile of a set of data is the value at which n% of the data is below it. For example, if the 75th percentile annual flow is 100 ML, 75% of the years on record had annual flow of less than 100 ML. Median streamflow: 50% of the records were above this value and 50% below. Decile: a division of a ranked set of data into ten groups with an equal number of values. In this case e.g., the first decile contains those values below the 10th percentile.

[5] Bureau of Meteorology Rainfall Map information http://www.bom.gov.au/climate/austmaps/about-rain-maps.shtml

flow rate (TFR) are the two flow regime metrics assessed and reported in this document. Evaluation of these two metrics provides a simple yet effective assessment of the waterways' flow regime. Further details for each metric are provided below:

- The annual number of flow days for the reporting year (July to June). This is measured as the number of days with total flow greater than 0.05 ML (50,000 litres).
- The annual number of flow days above the threshold flow rate (TFR) for the reporting year (July to June). Days above the TFR are defined as a 24 hr periods with flow equal to or greater than the TFR (expressed as ML/d). The recommended ecologically significant TFR is the 20th percentile exceedance non-zero daily flow. TFR is defined in the Water Allocation Plan for the WMLR and is based on a unit threshold flow rate multiplied by upstream catchment area.

Annual number of flow days and days above the TFR are presented for the reporting period (Figure 4.6 and Figure 4.7). A reporting period trend and the number of years in the last decade above the reporting period average are provided. For the assessment of both flow days and days above the TFR; years with more than 5% missing data were removed from the assessment.

2.2.5 Salinity

Monthly median salinity as total dissolved solids (TDS) in mg/L for the 2020–21 reporting period is presented along with daily streamflow (ML/d) as a reference and assessed alongside the period of record monthly salinity statistics including (a) high salinities (75^{th} percentile), (b) median salinities (50^{th} percentile) and (c) low salinities (25^{th} percentile (Figure 4.8)). The period of data availability for salinity is 2002 to 2021 for the Onkaparinga River station. The monthly data is shown for an extended period (July 2020 to September 2021) to capture the full flow season. Salinity values for periods where no flow was reported were removed for this analysis due to uncertainty about those records.

2.3 Groundwater

2.3.1 Water level

Water level[6] data were obtained from wells in the monitoring network by both manual and continuous logger measurements. All available water level data are verified and reduced to an annual maximum water level for each well for further analysis. The annual maximum level is used as this represents the unstressed or recovered water level following pumping each year for irrigation and other uses. The amount of pumping can vary from year to year and the proximity of pumping wells to monitoring wells may affect the reliability of trends and historical comparisons. Therefore, the recovered level is used as it is a more reliable indicator of the status of the groundwater resource. The period of recovery each year was reviewed for each well; in general, the aquifers in the WMLR PWRA return to a recovered maximum level between June and December.

For those wells that meet the selection criteria (see below), the annual recovered water levels are ranked from lowest to highest according to their decile range (Table 2.2) and given a description in a similar way as annual streamflow. The definition of a suitable long-term record varies depending on the history of monitoring activities in different areas; for the WMLR PWRA, in the Permian Sand and Tertiary limestone aquifers, any well with 10 years or more of recovered water level data is included, while in the fractured rock aquifers, any well with at least 7 years of data is included. The number of wells in each description class for the most recent year is then summarised for

[6] 'Water level' in this report refers to both the watertable elevation, as measured in wells completed in unconfined aquifers, and the potentiometric water level elevation, as measured in wells completed in confined aquifers where the water level or pressure in the monitoring well rises above the top of the aquifer. These are collectively referred to as the 'reduced standing water level' (RSWL).

each aquifer (e.g., Figure 5.1). Hydrographs are shown for a selection of wells to illustrate common or important trends (e.g., Figure 5.3).

Five-year trends are calculated using annual recovered water levels for those wells which have at least 5 measurements (i.e., at least one measurement a year). The trend line is calculated by linear regression and the well is given a status of 'declining', 'rising', or 'stable', depending on whether the slope of this trend line is below, above, or within a given tolerance threshold. This threshold allows for the demarcation of wells where water levels are changing at very low rates and the water level can therefore be considered stable. The threshold also accommodates for very small measurement errors. The number of rising, declining and stable wells are then summarised for each aquifer (e.g., Figure 5.2).

Moderately sized sedimentary confined and unconfined aquifers such as the Permian Sand aquifer and Tertiary limestone aquifer are given tolerance thresholds of 2 cm/y, while fractured rock aquifers with lower storages are given a tolerance threshold of 1 cm/y.

Twenty-year changes in water level are calculated as the difference between the average water level in a 3-year period 30 years ago (i.e. 1991 to 1993) and the average water level in 2021.

2.3.2 Salinity

Water samples from monitoring wells and irrigation wells are collected in the WMLR PWRA. These samples are tested for electrical conductivity (EC) and the salinity (total dissolved solids measured in mg/L, abbreviated as TDS) is calculated. Measurement of electrical conductivity of a water sample is often subject to small instrument errors.

Where more than one water sample has been collected in the course of a year, the annual mean salinity is used for analysis. An example of the results is shown in Figure 5.4. Groundwater salinity in the sedimentary aquifers of the WMLR are not currently monitored, but salinity is typically less than 1,000 mg/L in these aquifers within Myponga and Hindmarsh Tiers basins.

10-year salinity trends are calculated where there are at least 7 years of salinity data (i.e., at least one measurement per year). The trend line is calculated by linear regression and the percentage change in salinity is calculated through the following formula:

$$\text{Percentage change in salinity (\%)} = \frac{\text{Slope of linear trend line (mg/L/y)} * 10}{\text{Value of trend line at start of period (mg/L)}} * 100$$

The percentage of change over the trend period is then summarised in categories depending on the range of change for each resource (e.g., Figure 5.5).

Where available, salinity graphs are shown for a selection of wells with long-term data to illustrate common or important trends (e.g., Figure 5.6).

2.4 Water use

Meter readings are used to collate licensed extraction volumes for both surface water and groundwater sources. Where meter readings are not available, licensed or allocated volumes are used to estimate extraction from surface water sources (Figure 6.1 and Figure 6.2).

Non-licensed water use (stock and domestic) from farm dams is not metered and is estimated at 30% of dam capacity (AMLR NRM Board, 2013). Futher information on the number, type and distribution of farm dams in the PWRA is provided in Section 6.2.1. Dam capacity estimates are undertaken using different methods with data derived from aerial surveys being one of the primary sources.

2.5 Further information

Both surface water and groundwater data can be viewed and downloaded using the *Surface Water Data* and *Groundwater Data* pages under the Data Systems tab on WaterConnect[7]. For additional information related to groundwater monitoring well nomenclature, please refer to the Well Details page on WaterConnect[8].

Other important sources of information on water resources in the WMLR PWRA are:

- Summary reports are available on the surface water (DEWNR 2014) and groundwater resources of the WMLR PWRA (DEWNR 2011), as well as annual surface water status reports such as DEW (2019a) and groundwater level and salinity status reports such as DEW (2019b).
- The Water Allocation Plan for the WMLR Prescribed Water Resources Area is available (AMLR NRM Board 2013).
- Penney et al. (2020) provides details regarding the construction and calibration of hydrological models for six water supply catchments across the Western Mount Lofty Ranges).
- Green et al. (2007) provides information on groundwater recharge and flow processes in the fractured rock aquifers of WMLR PWRA.
- Background information can be found on WMLR groundwater at Piccadilly Valley (Barnett and Zulfic 1999), Upper Onkaparinga catchment (Zulfic, Barnett and van den Akker 2002), Torrens rural catchment (Barnett and Zulfic 2000), Southern Fleurieu (Barnett and Rix 2006) and South Para River catchment (Zulfic 2006); these studies were completed to support water planning for the WMLR PWRA.
- *Water Security Statement 2022 – Water for Sustainable Growth* is also available (DEW 2022)

7 https://www.waterconnect.sa.gov.au/Systems/SitePages/Home.aspx

8 https://www.waterconnect.sa.gov.au/Systems/GD/Pages/Well-Details.aspx

3 Rainfall

The WMLR PWRA climate is characterised by warm dry summers and cold wet winters. The variation in topography from the Western Mount Lofty Ranges PWRA to the Eastern Mount Lofty Ranges produces a 'rain shadow' effect, which explains the contrast in rainfall across the area. The Mount Lofty Ranges cause westerly winds to rise and cool resulting in precipitation occurring along the western side of the mountain ranges, ensuing comparatively more rainfall on west than east of the ranges.

The 1986 to 2015 average annual rainfall varies across the WMRL PWRA from 450 mm at the lower elevations to over 950 mm at the higher elevations (Figure 3.1) [9]. Rainfall in 2020–21 (July to June) is significantly lower throughout the WMLR PWRA compared to the latest available longer-term (1986 to 2015) average annual rainfall (Figure 3.1). Total rainfall for 2020–21 ranges from 700 mm to 300 mm, roughly 250 to 150 mm less than the 1986 to 2015 average annual rainfall.

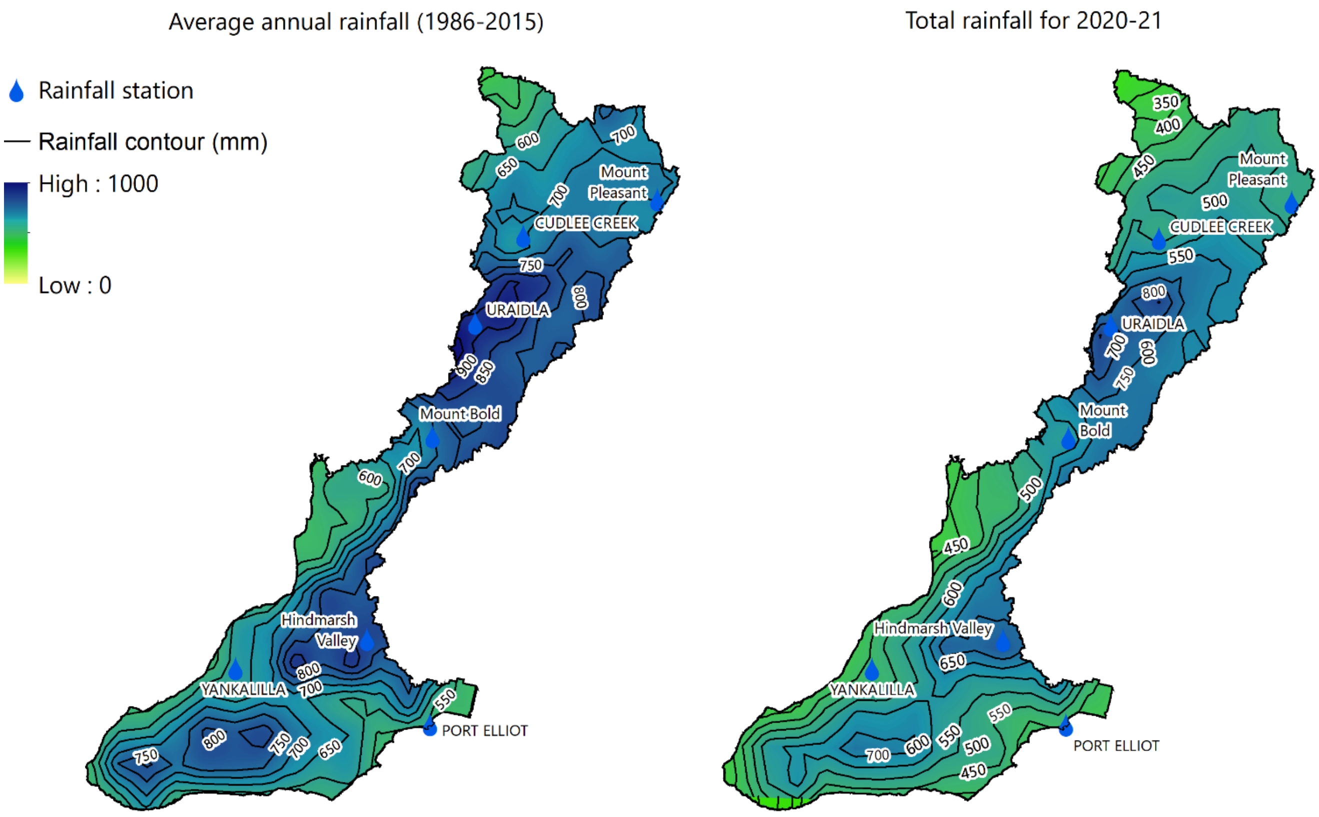

Figure 3.1 Rainfall in the WMLR PWRA for 2020–21 compared to the latest available 30-year climatological average (1986 to 2015)

Two stations were selected to represent the spatial variation of precipitation across critical areas of the WMLR PWRA. The Hindmarsh Valley rainfall station (BoM station 23823) represents the Permian Sand and Tertiary limestone aquifers and the Fleurieu surface water catchments, and the Mount Bold rainfall station (BoM station 23734) represents the Fractured Rock Aquifers and the Onkaparinga catchment (Figure 3.1).

[9] Some differences may be noticeable between the spatial rainfall maps and the annual rainfall from individual stations. This is due to the use of different data sources and time periods; further detail is provided in Section 2.1.

Total annual rainfall recorded in 2020–21 is 776 mm at Hindmarsh Valley and 755 mm at Mount Bold, both below their 1973 to 2021 average annual rainfall (Figure 3.2 and Figure 3.4). Below-average rainfall is also observed at the other rainfall stations in the PWRA (Figure 3.1).

The trend in annual rainfall (1973 to 2021) is marginally declining for the Hindmarsh Valley station while it remains stable for the Mount Bold station. Both stations have recorded average and above-average annual rainfall in 3 out of the last 5 years.

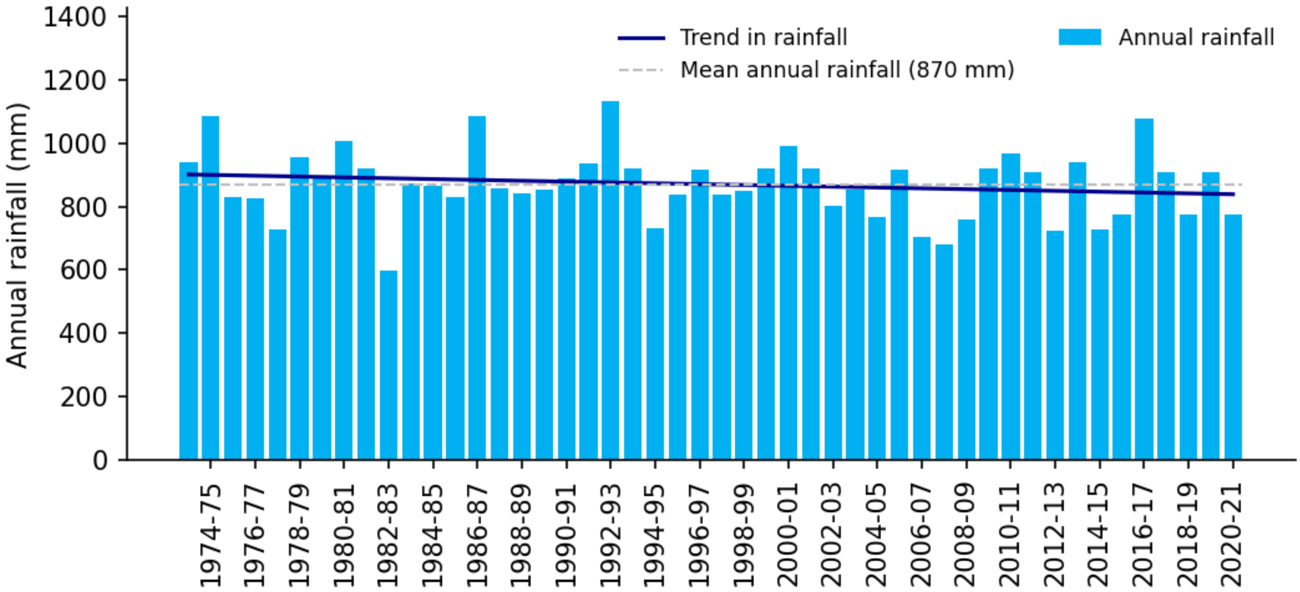

Figure 3.2 Annual rainfall for 1979–80 to 2020–21 at the Hindmarsh Valley rainfall station (BoM station 23823)

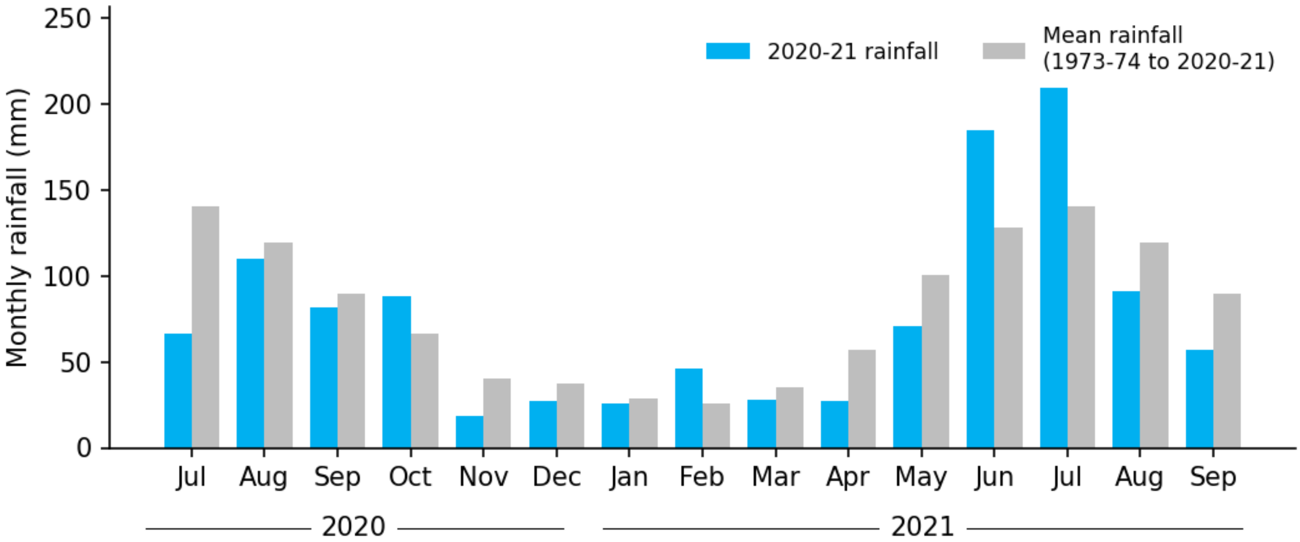

Figure 3.3 Monthly rainfall between July 2020 and September 2021 compared to the 1973 to 2021 monthly average at the Hindmarsh Valley rainfall station (BoM station 23823)

Dry conditions were prevalent throughout most of the year at both stations except for October 2020 with a slightly higher than average monthly value and early winter 2021 recording much higher than average monthly values (Figure 3.3 and Figure 3.5).

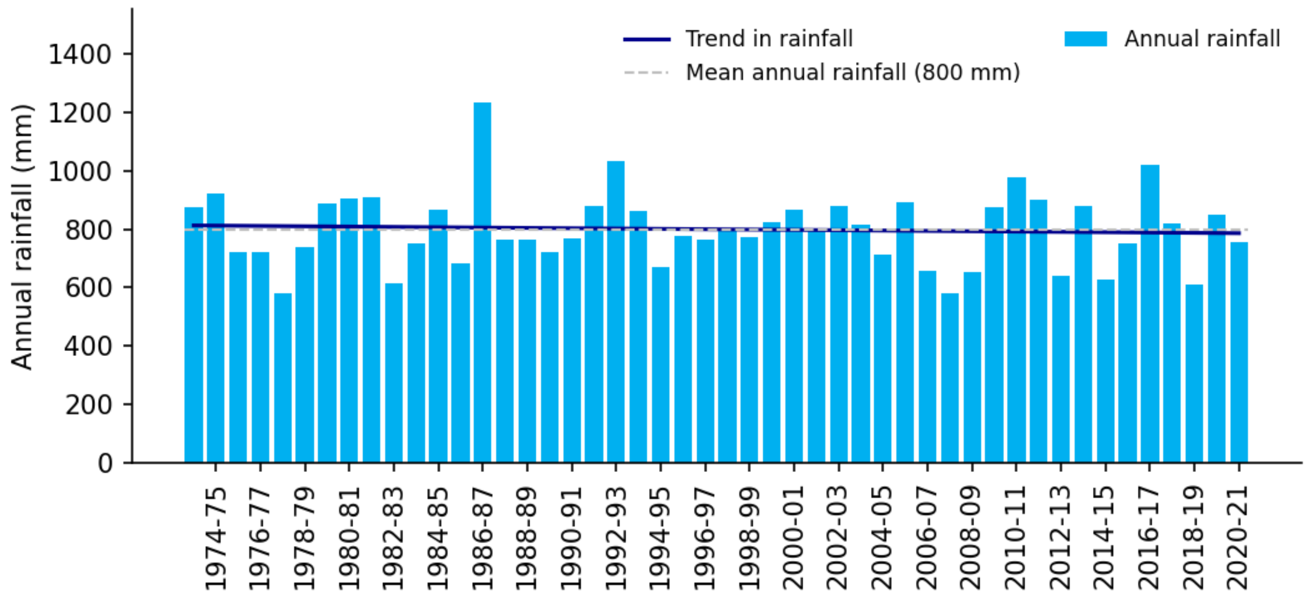

Figure 3.4 Annual rainfall for 1973–74 to 2020–21 at the Mount Bold rainfall station (BoM station 23734)

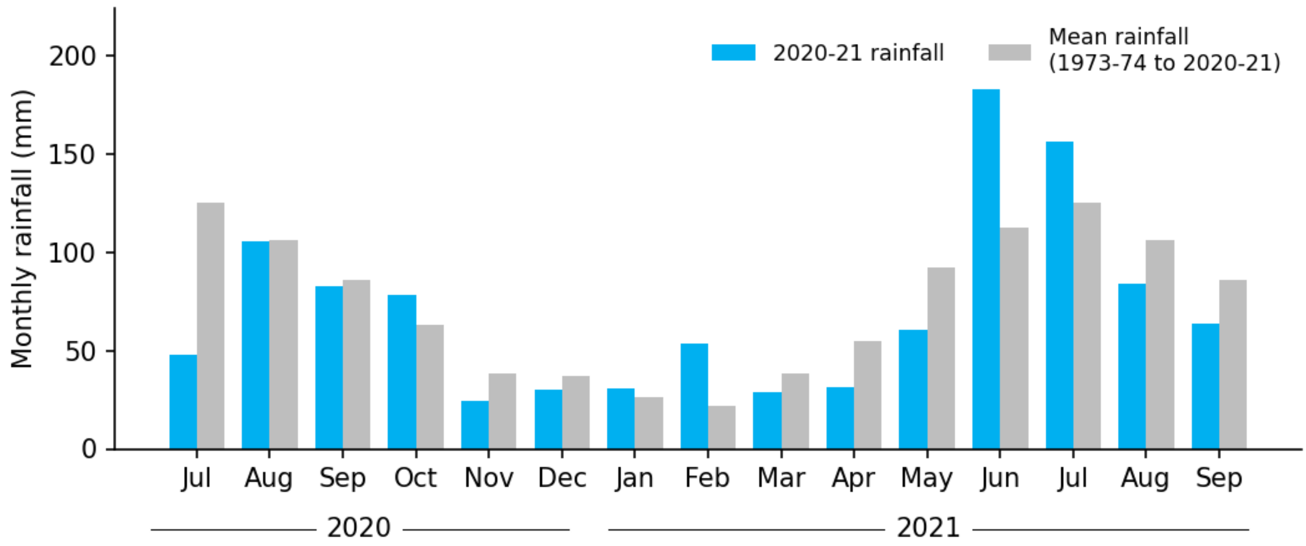

Figure 3.5 Monthly rainfall between July 2020 and September 2021 compared to the long-term monthly average at the Mount Bold rainfall station (BoM station 23734)

4 Surface water

4.1 Streamflow

Several significant watercourses drain the northern and central parts of the WMLR PWRA. Flowing west through metropolitan Adelaide and its surrounding suburbs before entering Gulf St Vincent, the main watercourses include: the South Para River, Little Para River, River Torrens, Onkaparinga River and Myponga River. The south-western part of the PWRA includes the Fleurieu Peninsula, which is characterised by smaller coastal catchments, draining a central plateau. The most south-easterly parts of the PWRA comprise the Hindmarsh River and Inman River which drain the Fleurieu Peninsula towards the south-east. Trends in streamflow are primarily rainfall driven, i.e., below average rainfall will generally result in reduced annual streamflow. Conversely, higher rainfall will generally result in increased surface water availability. Differences in precipitation and topography across the WMLR result in spatial variability of the hydrological response of surface water across different catchments. The River Torrens and Onkaparinga River catchments represent the central part, while the southern part of the region is represented by streamflow gauging stations located on the Fleurieu Peninsula. To better represent the spatially variable surface water hydrology, multiple streamflow gauging stations were used for the streamflow analysis (Figure 1.1).

The following stations were chosen to be representative of the central areas of the WMLR PWRA:

River Torrens

- Mount Pleasant (A5040512)
- Sixth Creek (A5040523)
- Kersbrook Creek (A5040525)

Onkaparinga River

- Scott Creek (A5030502)
- Baker Gully (A5030503)

The following stations were chosen to be representative of the southern areas of the WMLR PWRA:

Fleurieu Peninsula

- Myponga River (A5020502)
- Inman River (A5010503)
- Yankalilla River (A5011006)

The common streamflow data availability period is 1973 to 2021. Further detail on the methodology used for analysis can be found in Section 2.

In 2020–21, Mount Pleasant, Sixth Creek, Scott Creek and Baker Gully stations recorded ‘Below-average’ streamflow conditions, Myponga River and Inman River recorded ‘Above-average’ streamflow, and Kersbrook Creek and Yankalilla River recorded ‘Average’ conditions (Figure 4.1) Streamflow data in the charts are displayed with a dashed outline when the records are incomplete and total annual flow for each station is displayed on top of the bar charts.

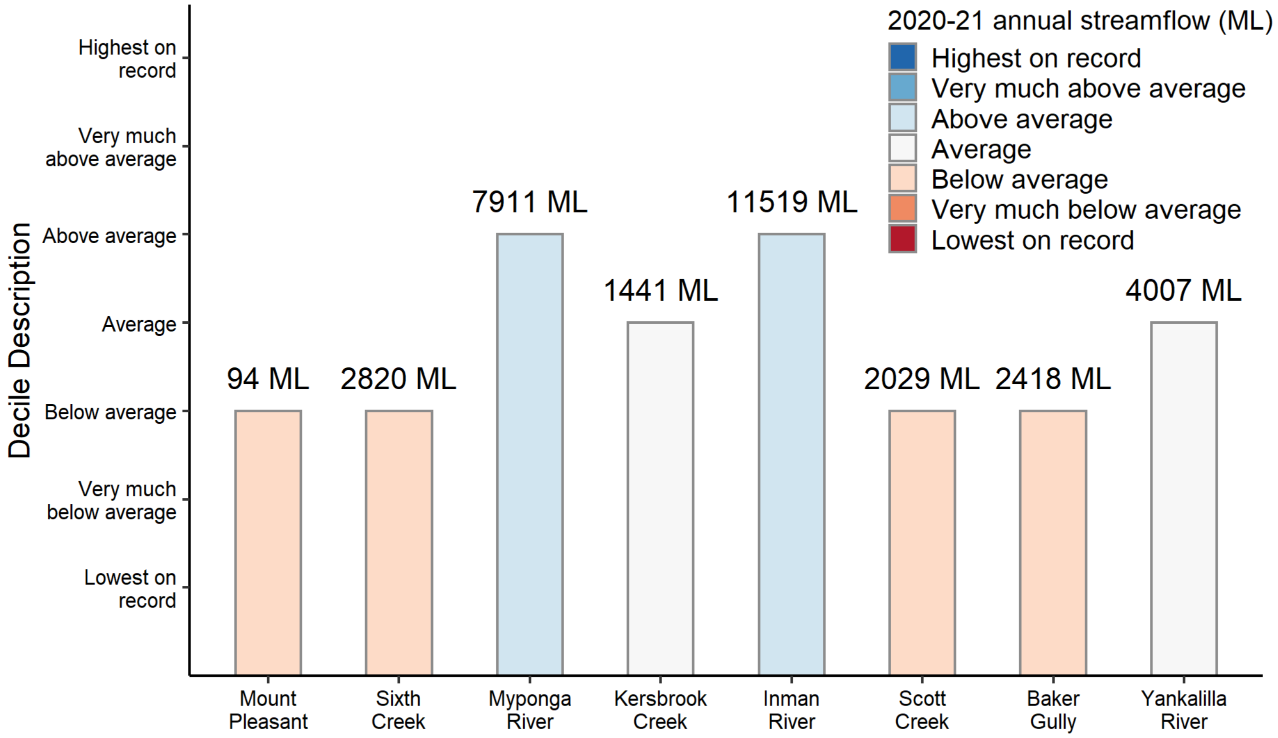

Figure 4.1 WMLR PWRA annual streamflow summary 2020–21

4.1.1 River Torrens: Mount Pleasant (A5040512)

One of the principal long-term streamflow gauging stations for the central part of the WMLR PWRA is at Mount Pleasant. This site is located in the headwaters of the River Torrens and has a catchment area of 26 km^2. The station is upstream of the Mount Pleasant dissipator where River Murray water is discharged to the River Torrens.

Total annual streamflow recorded at the station for 2020–21 (July to June) is 94 ML, 95% less than the 1973 to 2021 annual average of 2,038 ML. The deviation of each year's streamflow from the 1973 to 2021 average for the River Torrens at Mount Pleasant is shown in Figure 4.2.

The 2020–21 annual streamflow decile for River Torrens at Mount Pleasant is ranked 'Below-average' (between 10th and 30th percentile – refer to Table 2.2) calculated from the 1973 to 2021 period of record. Annual streamflow data shows a slightly declining trend, with annual streamflow values lower than the 1973 to 2021 average for 4 out of the last 5 years and decile rankings of 'Below average' and 'Very much below average' for 3 out of the last 5 years (Figure 4.2). Since 1994, there have only been 7 years where 'Above average' flow has occurred.

Figure 4.3A shows the monthly streamflow for the extended 2020–21 reporting period (July to September, grey bars) relative to the 1973 to 2021 monthly streamflow for (a) high flows (75^{th} percentile), (b) median flows (50^{th} percentile) and (c) low flows (25^{th} percentile). Monthly streamflow throughout 2020–21 is below the 1973 to 2021 low flows (25^{th} percentile).

The headwaters of the River Torrens at Mount Pleasant are ephemeral and zero or low flows are typically recorded between January and April. The majority of the flow occurs between July and October and normally accounts for roughly 90% of the total annual flow in any given year. In 2020–21, streamflow occurred from July to November 2020 and again between July and September 2021.

Figure 4.3B presents the 1973-2021 average monthly streamflow and the daily flows for the extended 2020–21 reporting period for the River Torrens at Mount Pleasant. Maximum daily flows were recorded in October 2021 and in July 2021.

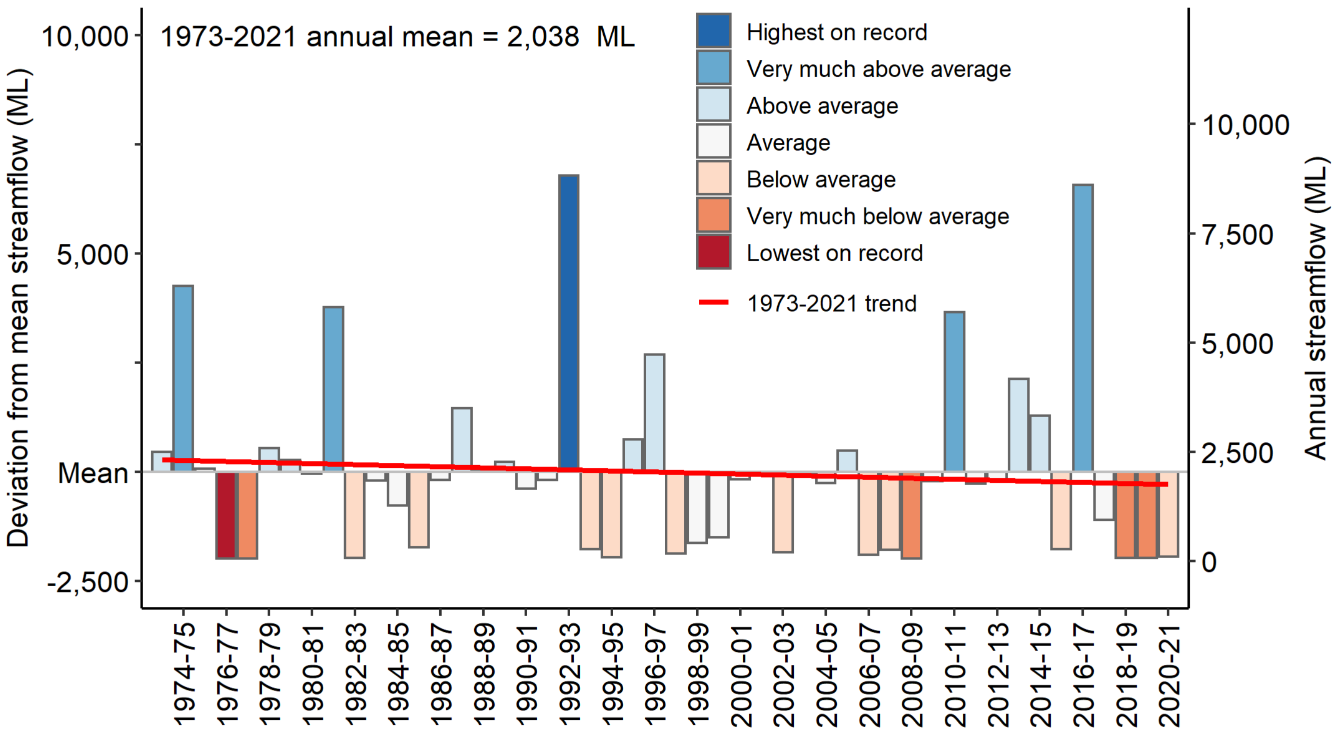

Figure 4.2 Annual deviation from mean streamflow at Mount Pleasant (1973–74 to 2020–21)

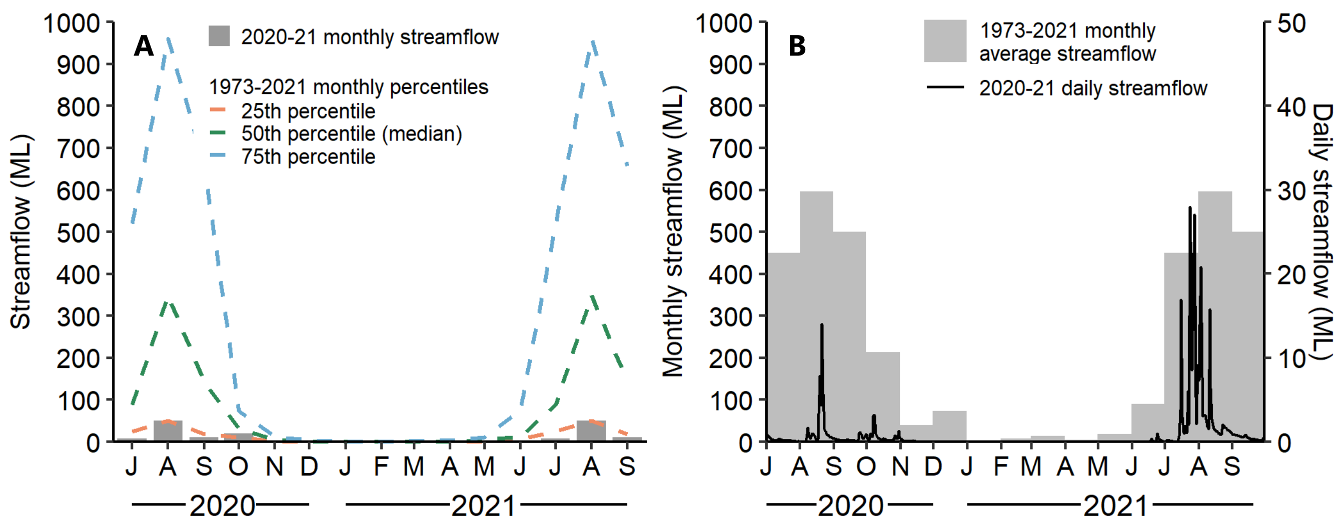

Figure 4.3 (A) 1973 to 2021 monthly statistics and 2020–21 monthly streamflow at Mount Pleasant; (B) 1973 to 2021 average monthly streamflow and 2020–21 daily streamflow at Mount Pleasant

4.1.2 Inman River (A5010503)

One of the principal long-term streamflow gauging stations in the Fleurieu Peninsula is located at the outlet of the Inman River catchment. The station is upstream of the Victor Harbor sewage treatment works, north of Victor Harbor and covers a catchment area of 164 km^2.

Total annual streamflow recorded at the station for 2020–21 (July to June) is 11,519 ML, 38% more than the 1973 to 2021 annual average of 8,359 ML. The deviation of each year's streamflow from the 1973 to 2021 average for the Inman River station is shown in Figure 4.4.

The 2020–21 annual streamflow decile of the Inman River station was ranked 'Above average' (between 70th and 90th percentile – refer to Table 2.2), calculated from the 1973 to 2021 period of record. Annual streamflow data shows a slightly increasing trend, with annual streamflow values higher than the 1973 to 2021 average for 3 out of the last 5 years and decile rankings of 'Above average' or 'Highest on record' for 3 out of the last 5 years (Figure 4.4). Since 1994, there have been 10 years where 'Above average' flow has occurred.

Figure 4.5A shows the monthly streamflow for the extended 2020–21 reporting period (July to September, grey bars) relative to the 1973 to 2021 monthly streamflow for (a) high flows (75th percentile), (b) median flows (50th percentile) and (c) low flows (25th percentile). In 2020–21, most months record median or higher-than-median monthly flows. The Inman River streamflow gauging station is at the outlet of the catchment and flows are typically recorded all year round with the lowest flows experienced from January to April. The majority of the flows occur between June and October and normally account for 95% of the total annual flow in any given year.

Figure 4.5B presents the 1973 to 2021 average monthly streamflow and the daily flows for the extended 2020–21 reporting period for Inman River. Maximum daily flows were recorded in October 2020 and in July 2021.

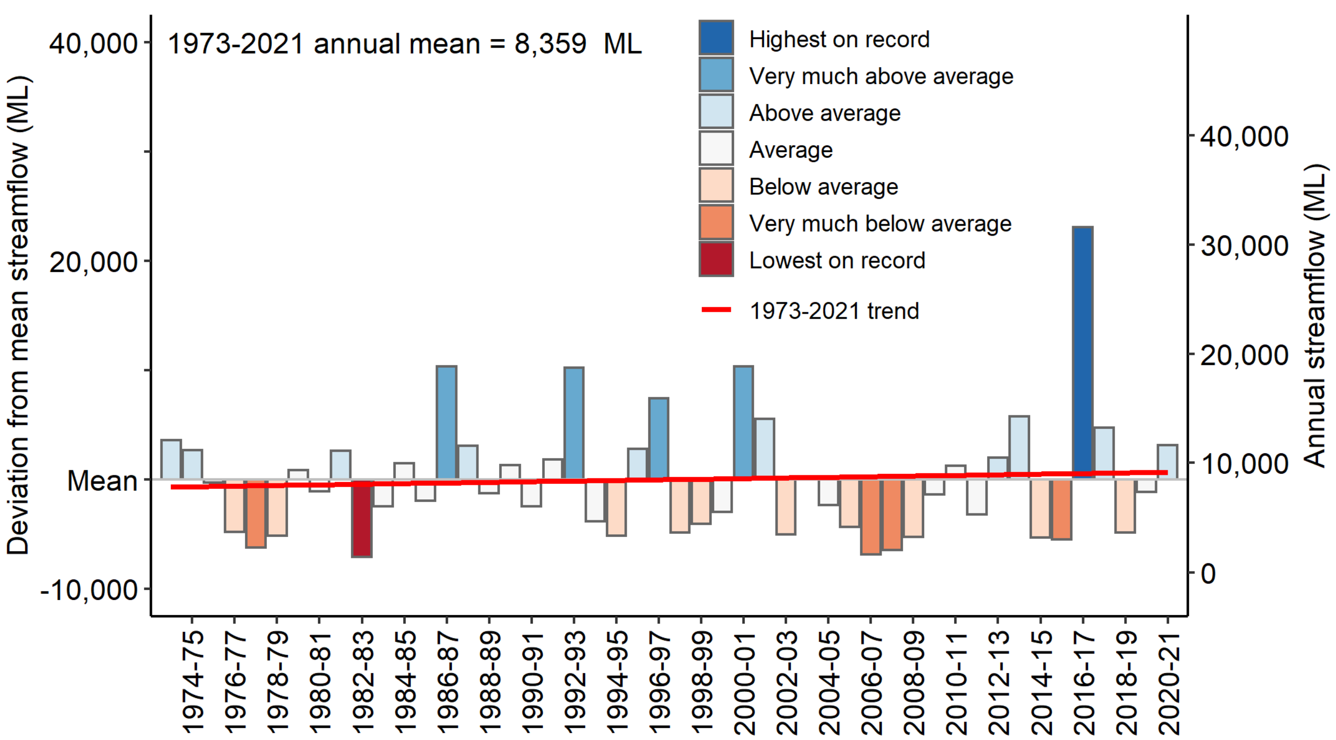

Figure 4.4 Annual deviation from mean streamflow on the Inman River (1973–74 to 2020–21)

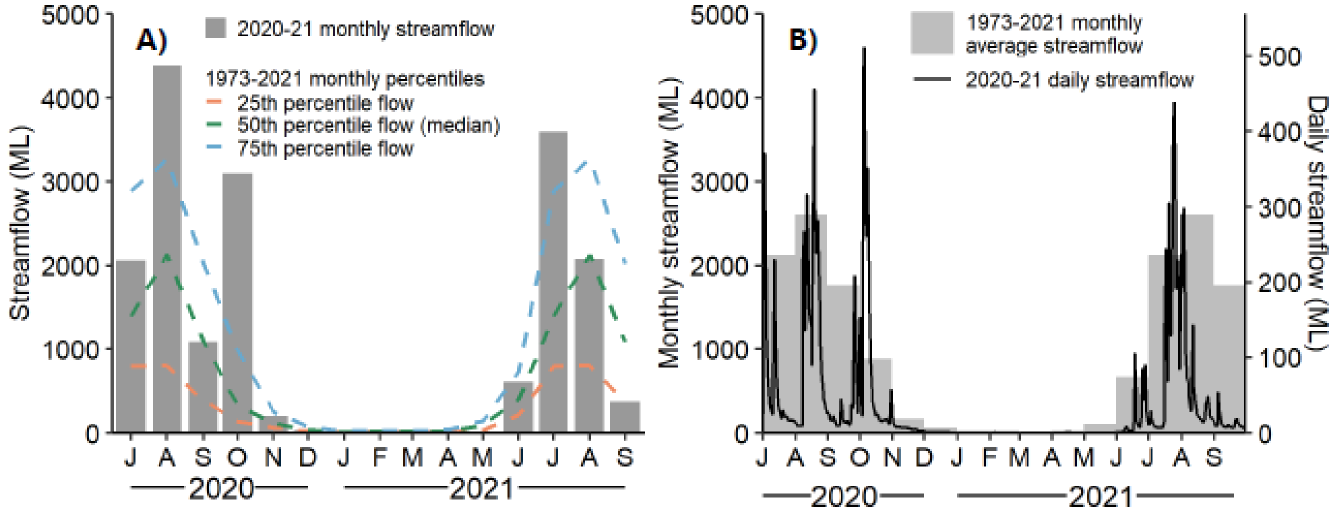

Figure 4.5 (A) 1973 to 2021 monthly statistics and 2020–21 monthly streamflow on the Inman River; (B) 1973 to 2021 average monthly streamflow and 2020–21 daily streamflow on the Inman River

4.2 Flow regime

Analysis of the flow regime was undertaken for the main WMLR PWRA watercourses mentioned in section 4.1. Flow data collected at streamflow gauging stations are used in this assessment to complement the streamflow analysis (Section 4.1). Further detail on the methods and data used in this analysis can be found in Section 2.2.4.

Baker Gully (A5030503)

The assessment of the flow regime information from the Baker Gully station for 2020–21 (July to June) shows 222 total flowing days. This is 65 days lower than 1973 to 2021 average of 287 days (Figure 4.6). The number of days with flows above the threshold flow rate (TFR) is 33 days, 5 fewer days than the 1973 to 2021 average of 38 days (Figure 4.7).

Over the last decade (2011–12 to 2020–21), only 1 out of 10 years (with sufficient data) had an above average number of flowing days. In the past decade there have been 5 years when the number of days above the TFR have been above the 1973 to 2021 average.

Inman River (5010503)

The assessment of the flow regime information from the Inman River station for 2020–21 (July to June) shows perennial flow with 365 flow days. In this case, the 1973 to 2021 reporting period average is close to the maximum given the site is perennial most years (Figure 4.6). The number of days with flows above the TFR is 76 days, 16 days higher than the 1973 to 2021 average of 60 days (Figure 4.7).

Over the last decade, all 10 years (with sufficient data) had above average number of flowing days. In the past decade there have been 5 years when the number of days above the TFR have been above the 1973 to 2021 average.

Kersbrook Creek (A5040523)

The assessment of the flow regime information from the Kersbrook Creek station for 2020–21 (July to June) shows 180 total flowing days. This is 18 days lower than the 1973 to 2021 reporting period average of 198 flowing days (Figure 4.6). The number of days with flows above the TFR is 45 days, 13 fewer days than the 1973 to 2021 average of 58 days (Figure 4.7).

Over the last decade (2011–12 to 2020–21), only 2 out of 10 years (with sufficient data) had an above average number of flowing days. In the past decade there have been 3 years when the number of days above the TFR have been above the 1973 to 2021 reporting period average.

Myponga River (A5020502)

The assessment of the flow regime information from the Myponga River station for 2020–21 (July to June) shows perennial flow with 365 flow days. This is 22 days higher than the 1973 to 2021 average of 343 flowing days (Figure 4.6). The number of days with flows above the TFR is 66 days, seven higher than the 1973-2021 average of 59 days (Figure 4.7).

Over the last decade (2011–12 to 2020–21), 8 out of 10 years (with sufficient data) had above average number of flowing days. In the past decade there have been 3 years when the number of days above the TFR have been above the 1973 to 2021 average.

Scott Creek (A5030502)

The assessment of the flow regime information from the Scott Creek station for 2020–21 (July to June) shows perennial flow with 365 flow days. This is 12 days higher than the 1973 to 2021 reporting period average of 353 flowing days (Figure 4.6). The number of days with flows above the TFR is 34 days, 21 lower than the 1973 to 2021 reporting period average of 55 days (Figure 4.7).

Over the last decade, 4 out of 10 years (with sufficient data) had above average number of flowing days. In the past decade there has been only one year when the number of days above the TFR has been above the 1973 to 2021 reporting period average.

Sixth Creek (A5040523)

The assessment of the flow regime information from the Sixth Creek station for 2020–21 (July to June) shows perennial flow with 365 flow days. This is 6 days higher than the 1973 to 2021 reporting period average of 359 flowing days (Figure 4.6). The number of days with flows above the TFR is 18 days, 37 days lower than the 1973 to 2021 reporting period average of 55 days (Figure 4.7).

Over the last decade, 9 out of 10 years (with sufficient data) had above average number of flowing days. In the past decade there have been 3 years when the number of days above the TFR have been above the 1973 to 2021 reporting period average.

Mount Pleasant (A5040512)

The assessment of the flow regime information from the Mount Pleasant station for 2020–21 (July to June) shows 142 total flowing days. This is 65 days lower than the 1973 to 2021 reporting period average of 207 flowing days (Figure 4.6). The number of days with flows above the TFR is only 4 days, 38 fewer days than the 1973 to 2021 reporting period average of 42 days (Figure 4.7).

Over the last decade (2011–12 to 2020–21), only 3 out of 10 years (with sufficient data) had above average number of flowing days. In the past decade there have been only 2 years when the number of days above the TFR have been above the 1973 to 2021 reporting period average.

Yankalilla River (A5011006)

The assessment of the flow regime information from the Yankalilla River station for 2020–21 (July to June) shows 227 total flowing days. This is 50 days lower than the 1973 to 2021 reporting period average of 277 flowing days (Figure 4.6). The number of days with flows above the TFR is 58 days, 2 fewer than the 1973 to 2021 reporting period average of 60 days (Figure 4.7).

Over the last decade (2011–12 to 2020–21), only 5 out of 10 years (with sufficient data) had above average number of flowing days. In the past decade there have been 4 years when the number of days above the TFR have been above the 1973 to 2021 reporting period average.

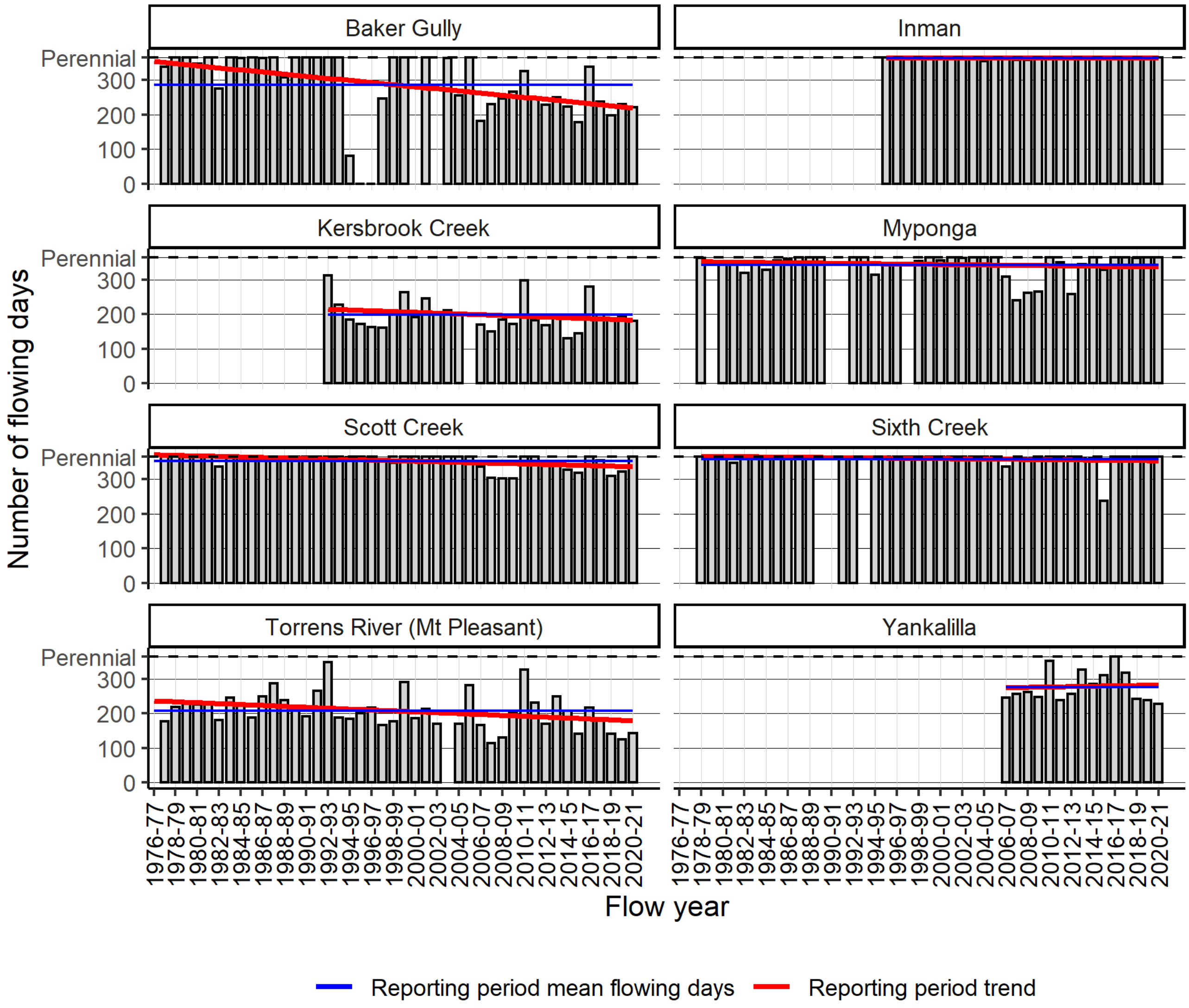

Figure 4.6 The number of flowing days (flow >0.05ML/day) for the stations assessed in the WMLR PWRA including the average and trend over the 1973 to 2021 reporting period

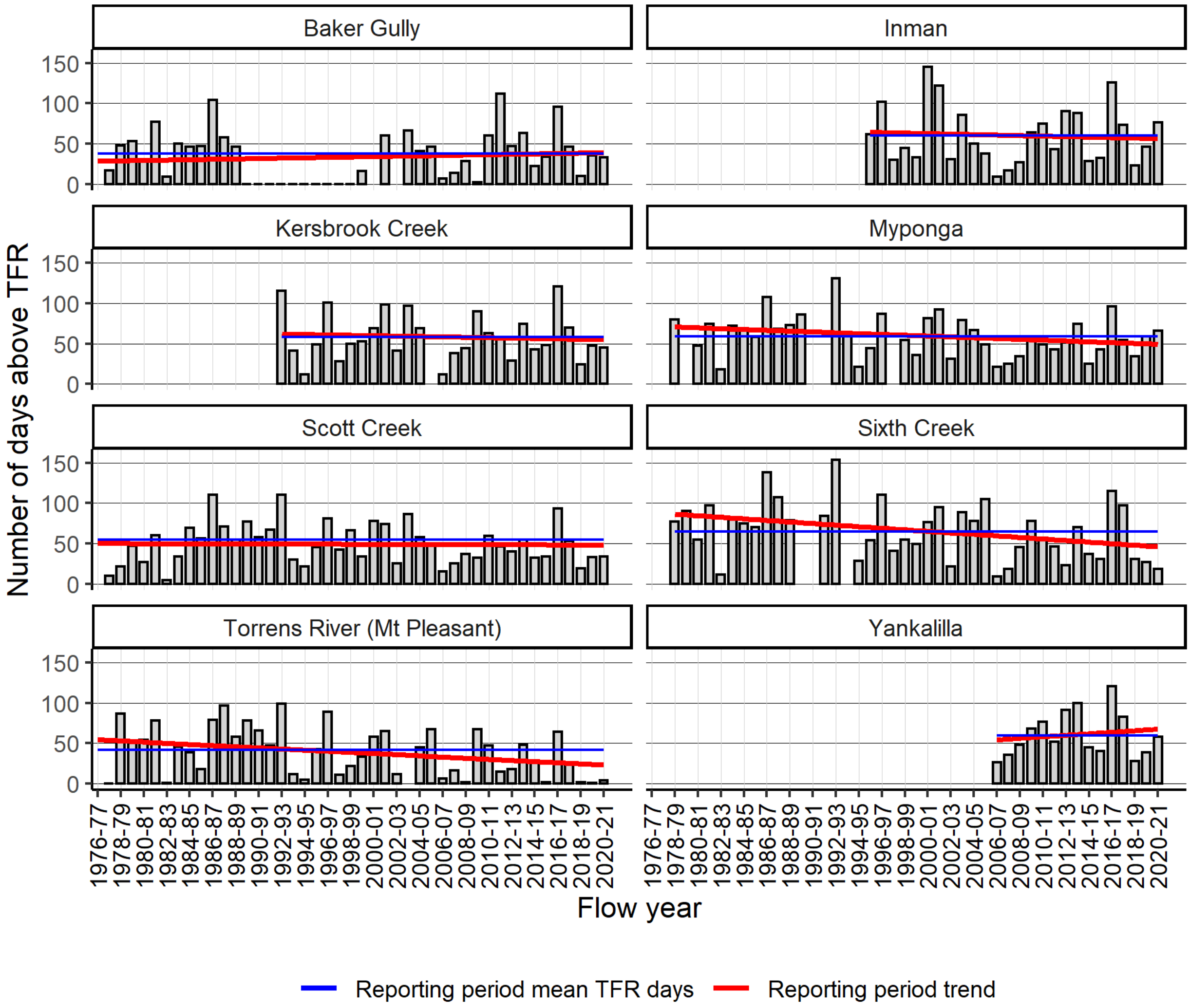

Figure 4.7 The number of days with flow above the TFR for the stations assessed in the WMLR PWRA including the average and trend over the reporting period

Implications of flow regime for aquatic ecosystems in 2020–21

The flow regime across the WMLR PWRA showed slightly worsening conditions for aquatic ecosystems than has been observed in the previous few years. While the commonly perennial rivers of Inman, Myponga, Scott and Sixth Creek, flowed year-round, only Inman and Myponga maintained a higher number of days with flows above their TFR. The rest of the stations in the WMLR PWRA maintained flow for less days than their average and less days with flows above their TFR. The perennial flow in the wetter catchments provides year-round habitat for still water and flowing water species of fish and macroinvertebrates in these areas. However, the diminished flows observed for the rest of the stations and the lower days above TFR for most of the PWRA might hinder the species movement in and out of the areas and the completion of their breeding and lifecycles. The flow regime observed in 2020–21 is likely to have worsened current aquatic species distribution and diversity.

4.3 Salinity

Below-average summer rainfall can result in increased irrigation extractions. These two elements can cause salinities to increase by reducing the amount of streamflow available to dilute mobilised salts. Conversely, higher rainfall will result in increased surface water availability and decreased irrigation extractions, resulting in a reduction or stabilisation of salinity.

Salinity is recorded routinely at many locations across the WMLR PWRA. The Onkaparinga River catchment (upstream of the Hahndorf dissipator A5031001), and the Torrens River catchment (Sixth Creek A5040523) were selected to represent salinity trends across the WMLR PWRA. The Sixth Creek station (A5040523) has been used as a representative site for the Torrens catchment as there are no imports of water into this sub-catchment that could affect the dilution of salts. However, data for the Sixth Creek station were not available for the 2020–21 reporting period and only data for the Onkaparinga River is presented herein.

Figure 4.8 shows the Onkaparinga River monthly median salinities for 2020–21 (bars) with the 2002 to 2021 data for (a) low salinities (25th percentile), (b) median salinities (50th percentile), and (c) high salinities (75th percentile). Streamflow data is provided for context.

In 2020–21 the annual median salinity for the Onkaparinga River is 406 mg/L, which is lower than the 2002 to 2021 median salinity of 566 mg/L. The longer-term monthly data for the Onkaparinga station shows high variability of salinity throughout the year, with higher median salinities generally observed during the drier months from October through April and lower median salinities during wetter months from June through September. Most of the median monthly salinity values for the Bremer River for 2020–21 are below the 2002 to 2021 median values.

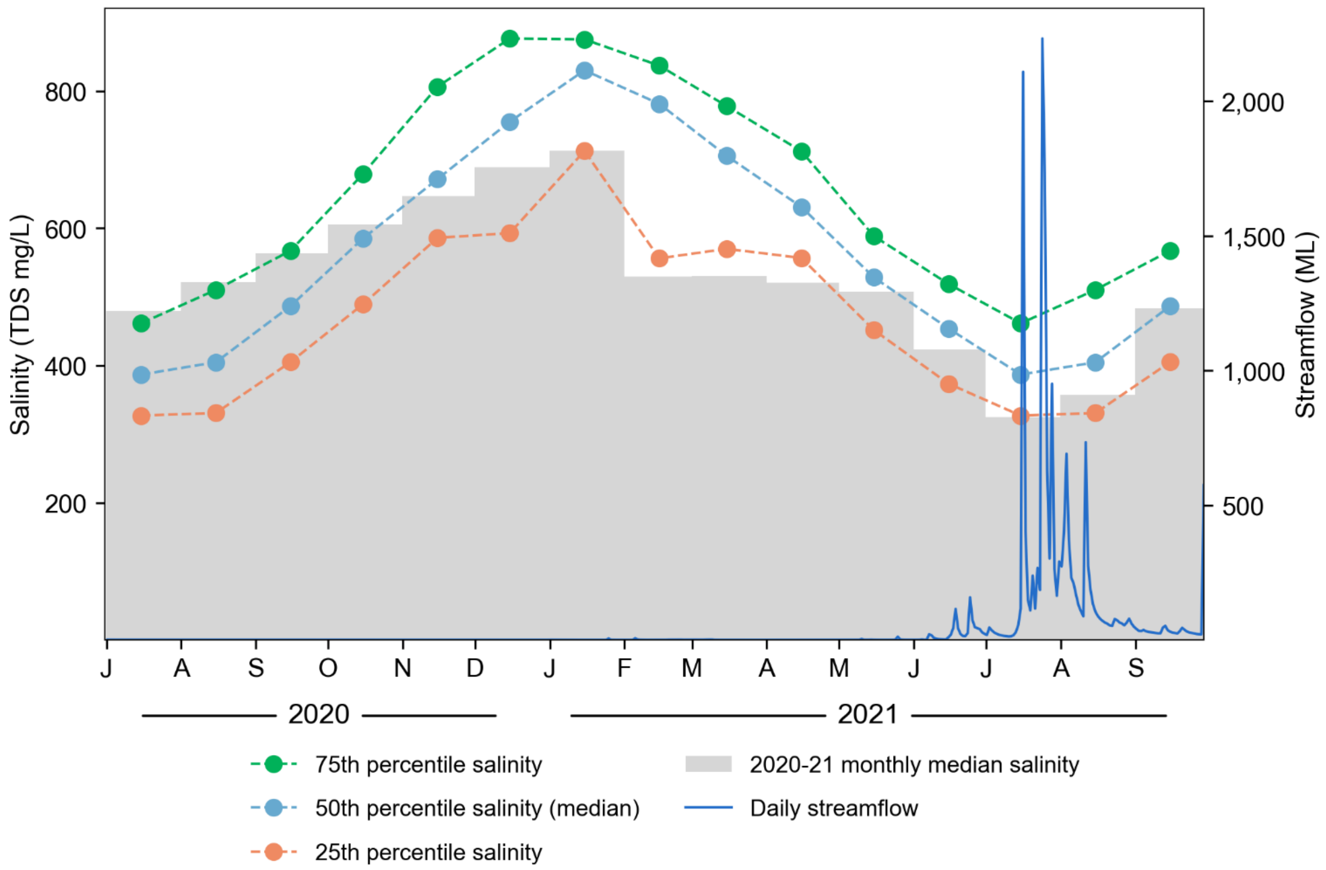

Figure 4.8 2002 to 2021 period of record and 2020–21 monthly salinity at the Onkaparinga River streamflow gauging station (A5031001)

5 Groundwater

5.1 Hydrogeology

There are two different types of aquifers in the WMLR PWRA. Fractured rock aquifers occur where groundwater is stored and moves through joints and fractures in basement rocks. Sedimentary aquifers occur in the valleys where groundwater flows through the pore spaces within the sediments. Recharge to both aquifers occurs directly from the portion of rainfall that percolates down to the water table through the soil profile or, in the case of the sedimentary aquifers, indirectly by throughflow from adjacent aquifers. The majority of groundwater extraction across the PWRA occurs from the fractured rock aquifers in the Central Hills region and sedimentary aquifers (i.e., Permian Sand aquifer and Tertiary limestone aquifer) in the Myponga and Hindmarsh Tiers basins (Figure 1.1). As a result, the groundwater monitoring network and this report is focussed on these areas of higher groundwater demand.

5.1.1 Fractured rock aquifers

The fractured rock aquifers comprise three geological units: the Barossa Complex, the Adelaidean sediments and the Kanmantoo Group. Generally, the Adelaidean sedimentary rocks are more favourable in terms of recharge, salinity and yields, while the Barossa Complex and Kanmantoo Group rocks provide groundwater of poorer quality at low yields.

The Adelaidean sedimentary rocks are the main source of groundwater extractions in the area. As these rocks have not been subjected to the heat and pressure of metamorphism, they are considered reasonably good aquifers because the joints and fractures are open and permeable, resulting in relatively high yields. In addition, these sediments occur in the west of the region where the rainfall is higher, resulting in higher recharge and lower salinities. Groundwater extraction and monitoring from the fractured rock aquifers mainly occurs in the Central Hills region as defined in the Water Allocation Plan (WAP) and as such is the main focus of this report.

5.1.2 Sedimentary aquifers

There are three types of sedimentary aquifers in the area: Permian Sand, Tertiary limestone and Quaternary sediments. Tertiary limestone aquifers provide good quality water and high yields, while the Permian Sand aquifers display a wide variation in characteristics. Quaternary sediments are found at the lowest points in the catchments adjacent to drainage lines and consist of dark grey silts and clays, but these are not discussed in this report.

5.1.2.1 Permian Sand aquifer

The Permian sediments consist of unconsolidated sands, silts and clays with occasional gravel beds that are known as the Cape Jervis Formation. This aquifer is generally low-yielding, except in the northern Myponga Basin where the Tertiary limestone aquifer, which otherwise overlies the Permian Sand aquifer, is absent. Here, the aquifer shows generally good yields and low salinity; however, high clay content in some areas can lead to lower yields and higher salinities.

5.1.2.2 Tertiary limestone aquifer

The Tertiary limestone aquifer is restricted in extent to isolated basins, such as Myponga and Hindmarsh Tiers. The Tertiary limestone aquifer is an important source of water where it contains good quality groundwater and is confined by the overlying Quaternary clays, which may cause seasonal artesian conditions. This aquifer is widely developed for irrigation, primarily of dairy pasture in the Myponga and Hindmarsh Tiers Basins in the south of the PWRA on the Fleurieu Peninsula.

5.2 Fractured rock aquifers water level

In 2021, winter-recovered water levels in 48 out of 79 monitoring wells (61%) in the fractured rock aquifers of the WMLR PWRA are classified as 'Average' or higher (see Section 2.3.1 for details of the classification; Figure 5.1).

Over the past 20 years, variations in water level in 52 wells range from a decline of 16.76 m to a rise of 33.76 m (median is a decline of 1.0 m).

Five-year trends show declining water levels in the majority of wells (83%), with rates of decline ranging between 3.35 and 0.02 m/y (median is a decline of 0.37 m/y); (Figure 5.2).

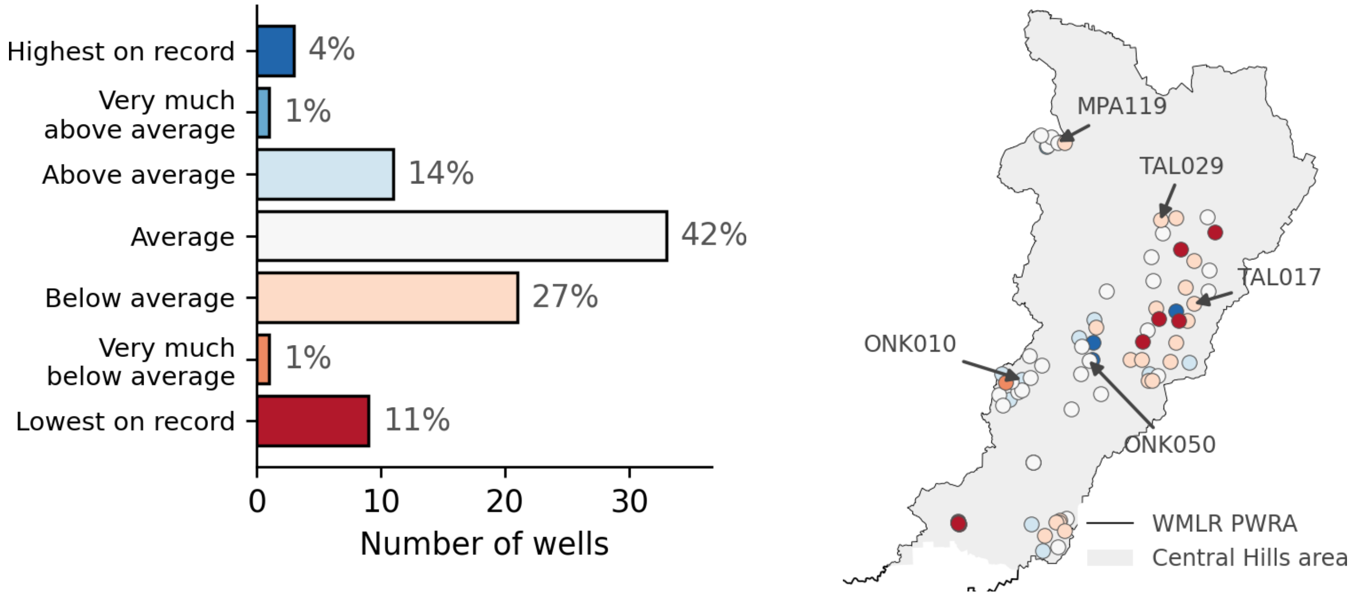

Figure 5.1 2021 recovered water levels for wells in the fractured rock aquifers

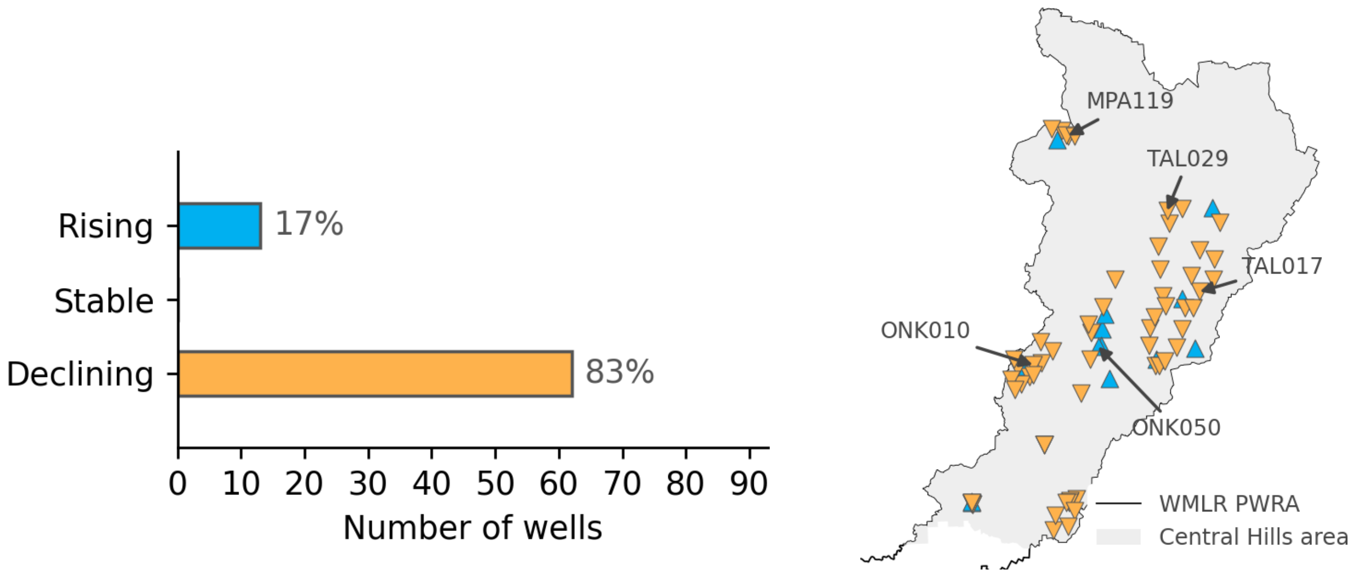

Figure 5.2 2017 to 2021 trend in recovered water levels for wells in the fractured rock aquifers

Hydrographs from a selection of fractured rock aquifer monitoring wells illustrate common or important trends (Figure 5.3). Monitoring well ONK010 is located at Uraidla and displays large seasonal variations. Groundwater levels were generally stable from the start of monitoring until 2000 when levels gradually rose up to the highest levels on record in 2016, in response to high rainfall events. In 2021, the water level is 'Above average' at this site. Monitoring well ONK050, located south of Lenswood, shows stable water levels since monitoring began in 2002.

TAL017 and TAL029 are located at Mount Torrens and north of Gumeracha and show a gradual decline since monitoring began. These wells showed their lowest levels in 2020 with a slight recovery in 2021. The length of record is relatively short (around 10 to 20 years) for these wells.

At MPA119, located at One Tree Hill, water levels reached 'Lowest on record' around 1999. Since that time a period of recovery has been followed by relative stability; water levels here are currently classified 'Average'.

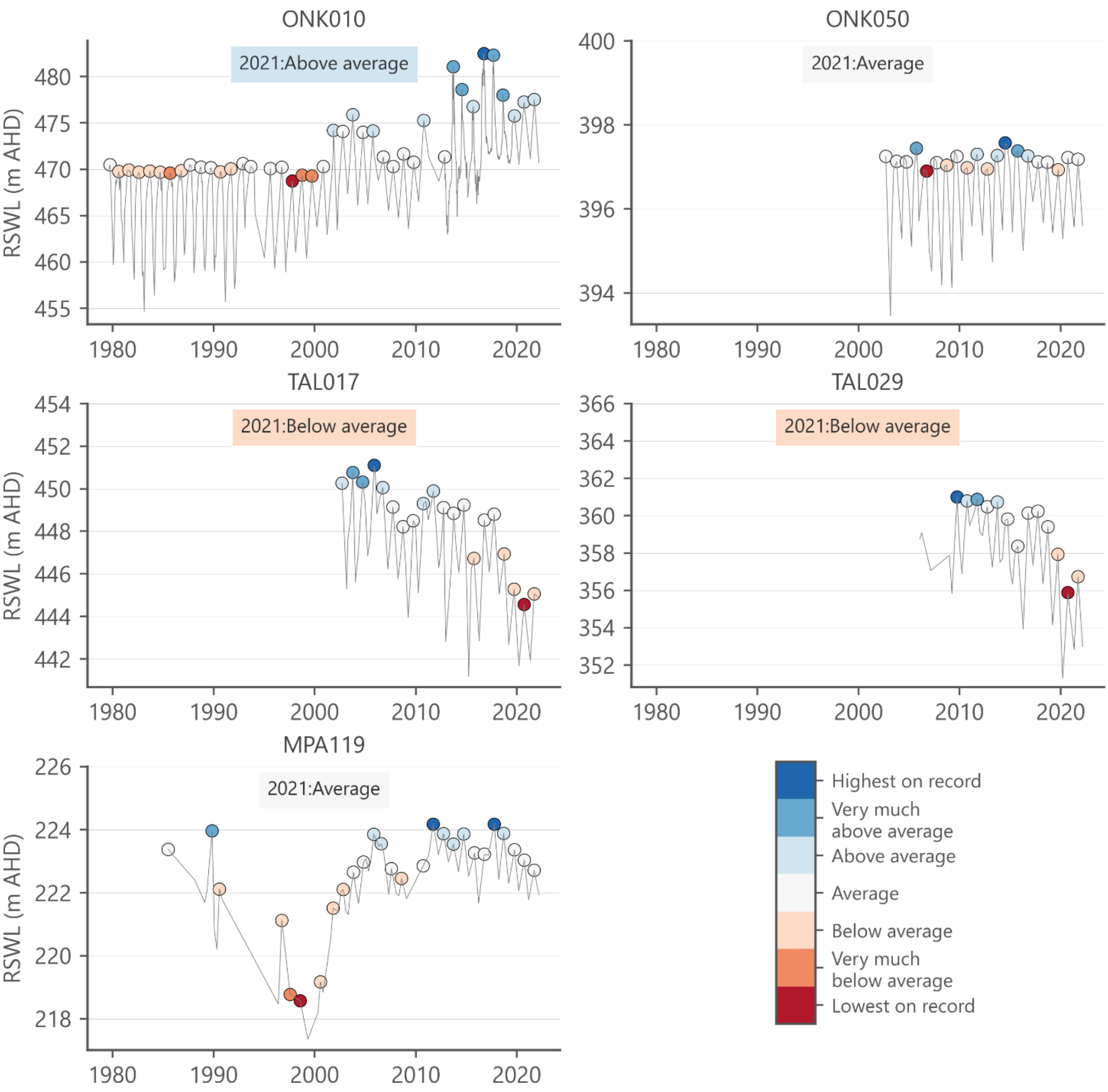

Figure 5.3 Selected fractured rock aquifer hydrographs

5.3 Fractured rock aquifers salinity

Groundwater salinity is highly variable in the fractured rock aquifers of the WMLR PWRA and is influenced by the type of rock in which fractures occur and complex systems of preferential flow paths that affect groundwater recharge, transport and mixing through the aquifer. In 2021, sampling results from 34 wells in the fractured rock aquifers of the WMLR PWRA range between 158 mg/L and 2,773 mg/L with a median of 741 mg/L (Figure 5.4).

In the ten years to 2021, 16 of 23 wells (64%) show a decreasing trend in salinity (Section 2.3.2). Ten-year trends show that rates of change in salinity vary from a decrease of 6.5% per year to an increase of 2.4% per year, with a median rate of 0.5% decrease per year (Figure 5.5).

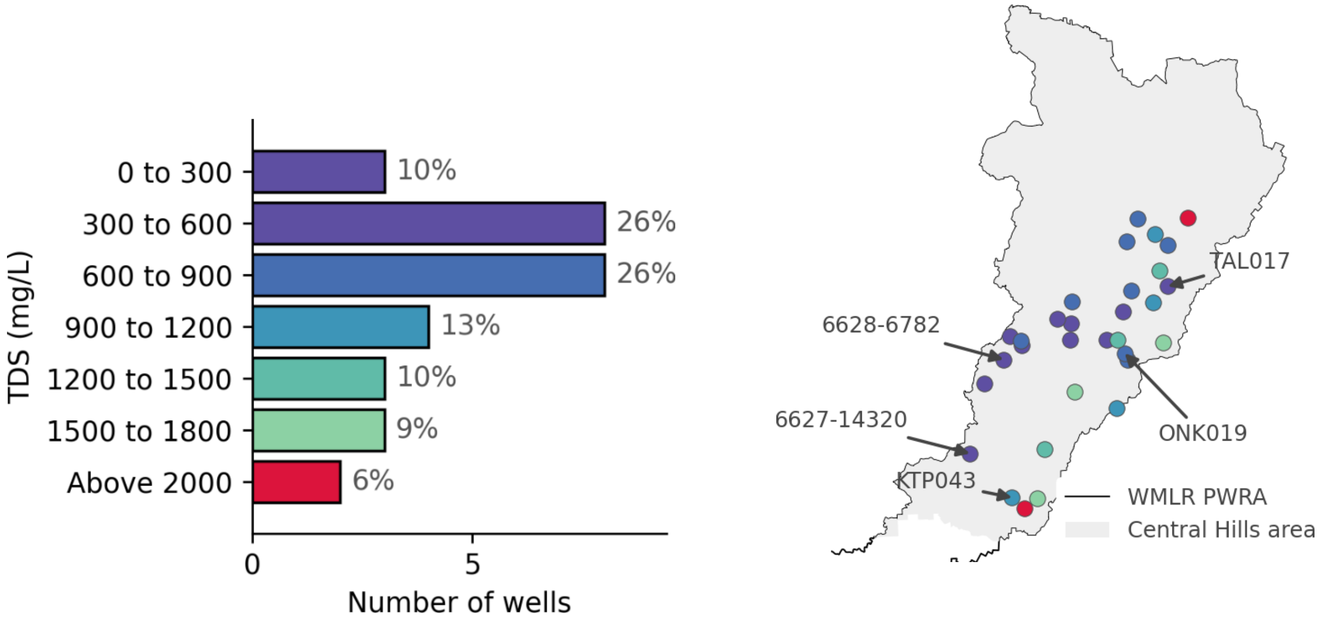

Figure 5.4 2021 salinity observations from wells in the fractured rock aquifers

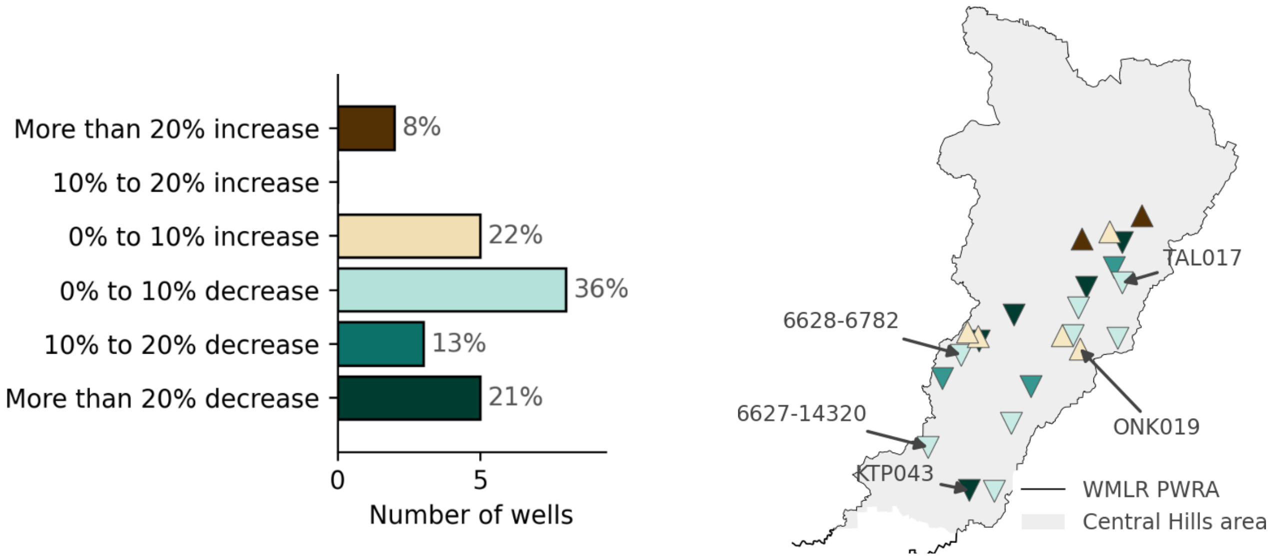

Figure 5.5 Salinity trends in the 10 years to 2021 for wells in the fractured rock aquifers

Groundwater salinities within the Adelaidean fractured rock aquifers of the Central Hills region have been largely stable over the period of record, as shown by representative salinity graphs from a selection of fractured rock aquifer monitoring wells (Figure 5.6).

Observation well 6628-6782 is located at Uraidla and from 1960, salinity is relatively stable. ONK019 at Woodside shows a gradual increase of salinity from early 2000, while TAL017 at Mount Torrens and 6627-14320 at Bradbury show gradual decreases of salinity over the same period. KTP043 is located to the west of Echunga and shows seasonal fluctuations in salinity with a gradual increasing trend over the past 20 years.

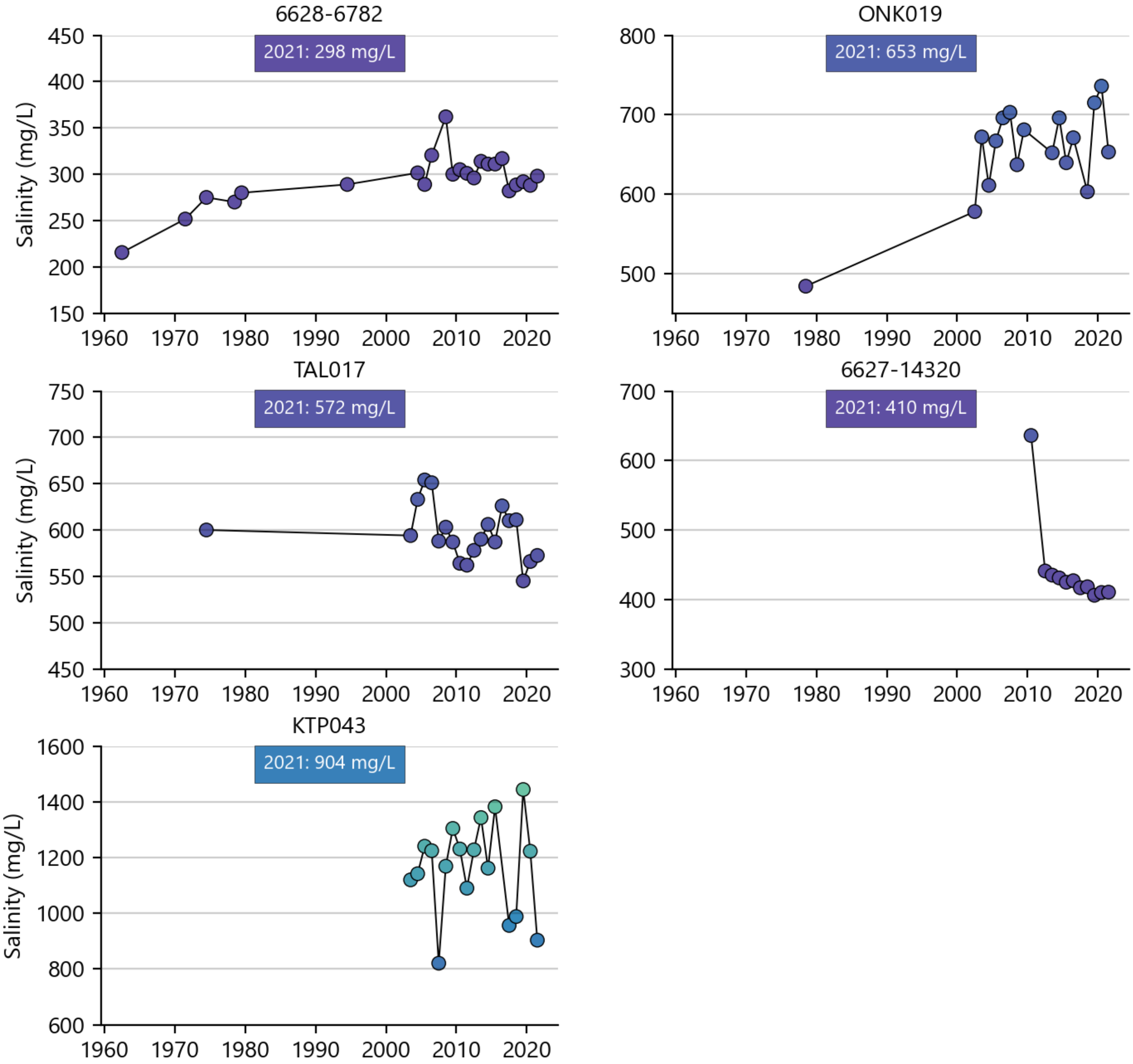

Figure 5.6 Selected fractured rock aquifer salinity graphs

5.4 Permian Sand aquifer water level

In 2021, winter-recovered water levels in 6 out of 7 monitoring wells (86%) in the Permian aquifer of the WMLR PWRA are classified as 'Average' or higher (see Section 2.3.1 for details of the classification; Figure 5.7).

Over the past 20 years, variations in water level in 9 wells range from a decline of 1.55 m to a rise of 0.33 m (median is a decline of 0.3 m).

Five-year trends show declining water levels in the majority of wells (62%), with rates of decline ranging between 0.09 and 0.03 m/y (median is a decline of 0.04 m/y); (Figure 5.8).

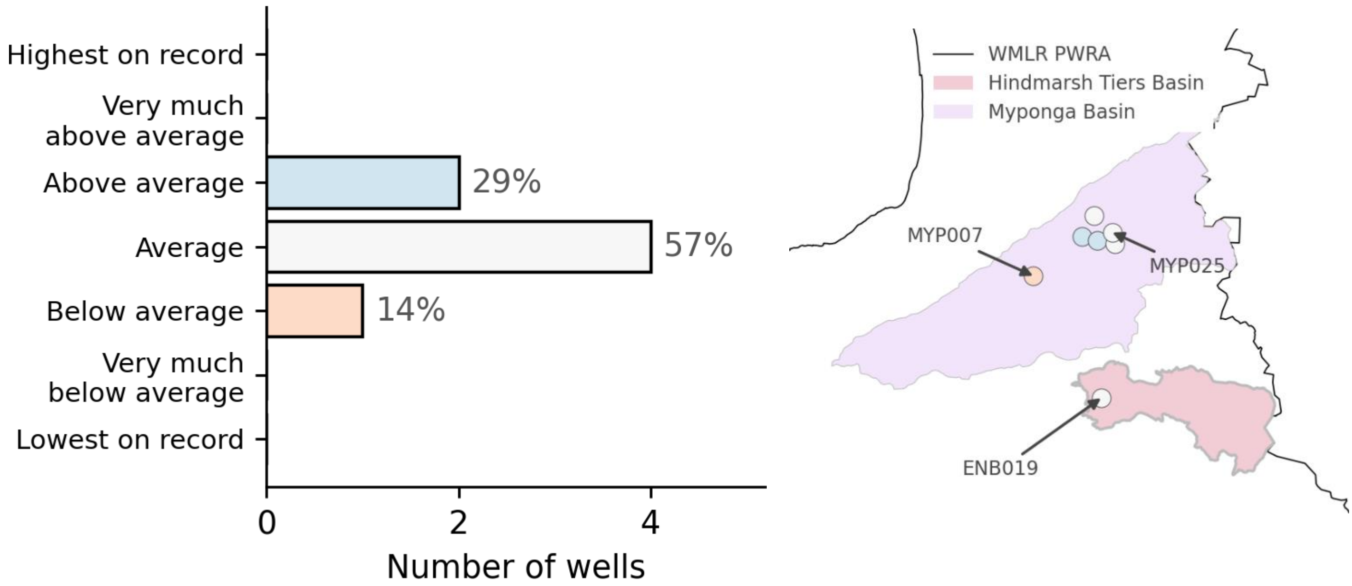

Figure 5.7 2021 recovered water levels for wells in the Permian Sand aquifer

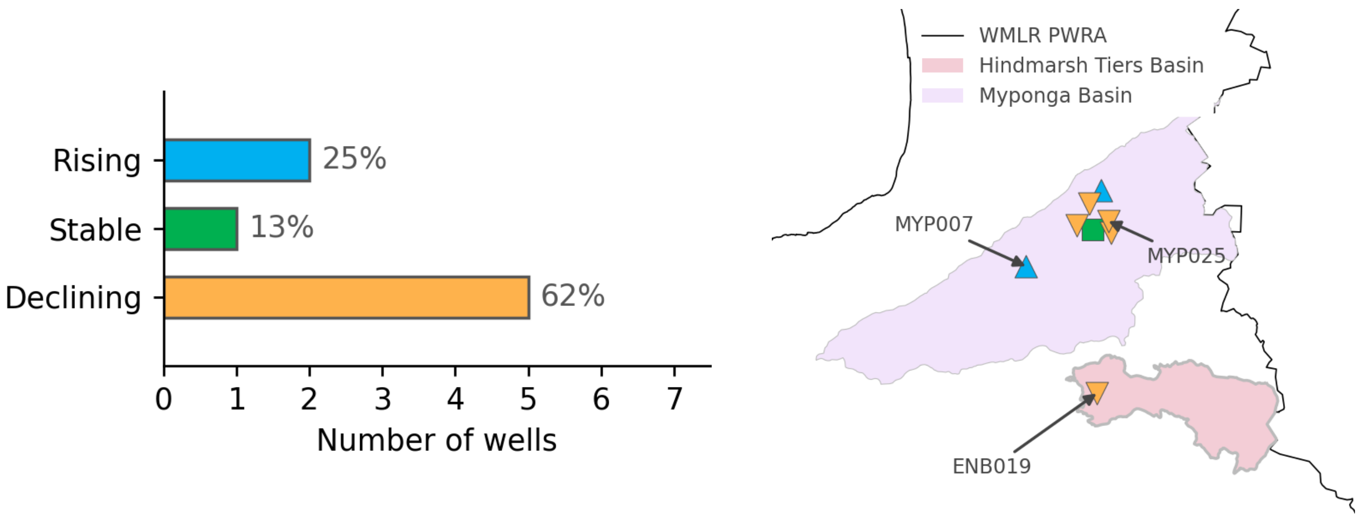

Figure 5.8 2017 to 2021 trend in recovered water levels for wells in the Permian Sand aquifer

Hydrographs from a selection of Permian Sand aquifer monitoring wells illustrate common or important trends (Figure 5.9). The Permian Sand aquifer displays large seasonal variations in groundwater levels in both the Myponga and Hindmarsh Tiers Basins because it is confined.

Groundwater levels in the Myponga Basin (e.g., MYP007 and MYP025) declined between 2001 and 2015, correlating with below-average rainfall during the period, which likely reduced recharge to the aquifer and increased the demand for groundwater. Groundwater levels recovered during 2016 (when above-average annual rainfall was recorded) and have been relatively stable since.

In the Hindmarsh Tiers Basin (e.g., ENB019) higher groundwater levels were observed during the 1980s and early 90s, followed by a decline. 'Lowest on record' levels were observed during 2015 followed by a recovery in 2016 (following trends in rainfall). Relatively stable water levels have been observed in the last 5 years and the current water level classification is 'Average'.

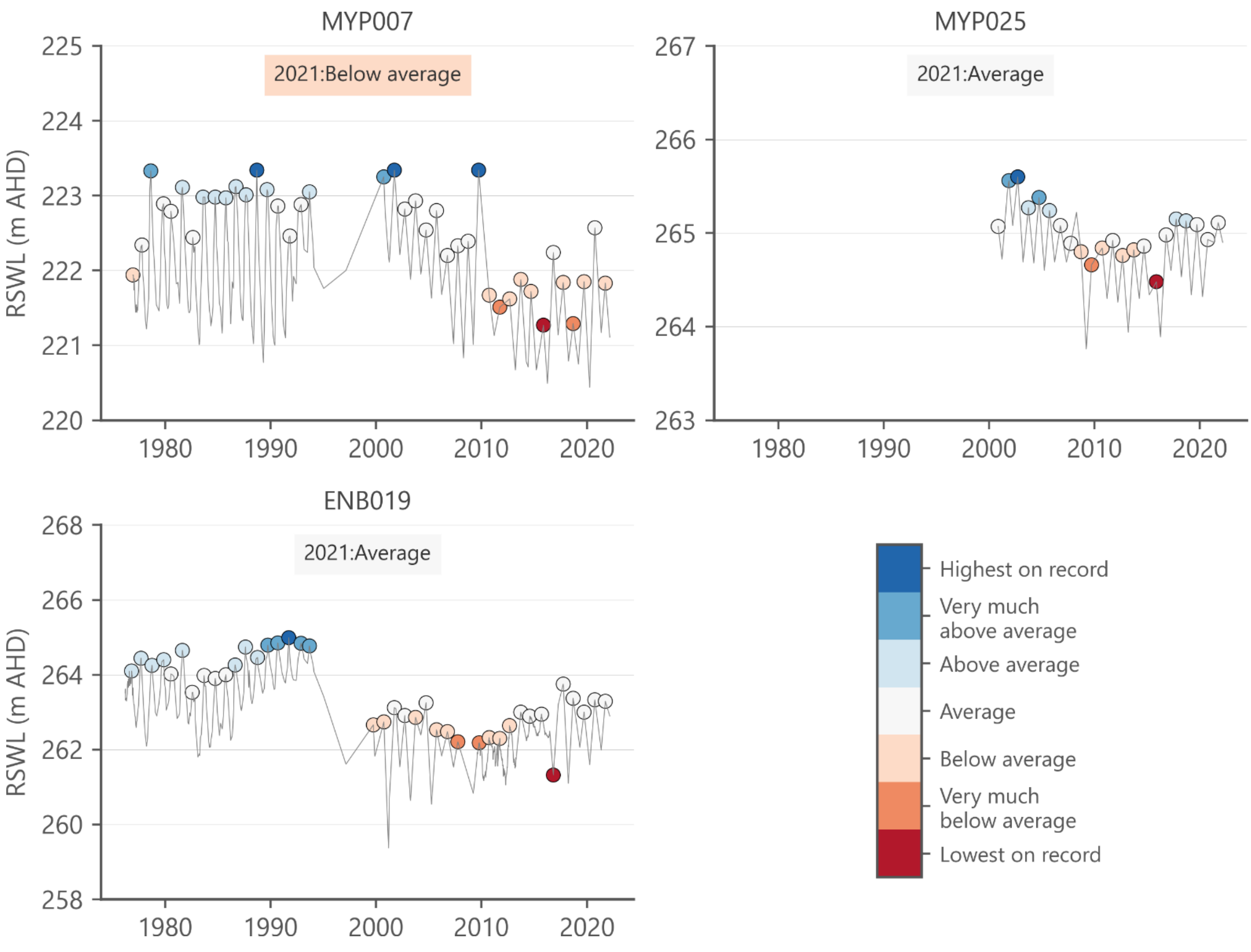

Figure 5.9 Selected hydrographs for the Permian Sand aquifer

5.5 Tertiary limestone aquifer water level

In 2021, winter recovered water levels in 15 out of 16 monitoring wells (93%) in the Tertiary limestone aquifer of the WMLR PWRA are classified as 'Average' or higher (see Section 2.3.1 for details of the classification; Figure 5.10).

Over the past 30 years, variations in water level in 17 wells range from a decline of 1.36 m to a rise of 1.03 m (median is a rise of 0.2 m).

Five-year trends show declining water levels in 50% of wells, with rates of decline ranging between 0.32 and 0.07 m/y (median is a decline of 0.19 m/y); (Figure 5.11). Five-year water level trends in the Myponga Basin are predominantly rising while in the Hindmarsh Tiers Basin are predominantly declining.

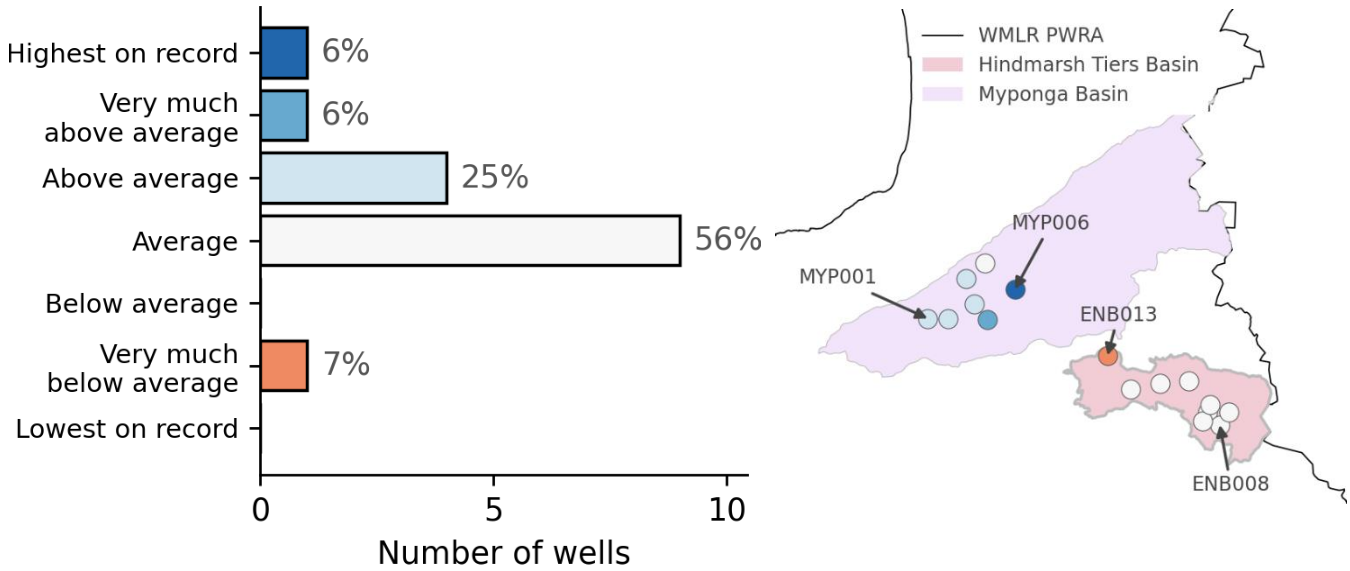

Figure 5.10 2021 recovered water levels for wells in the Tertiary limestone aquifer

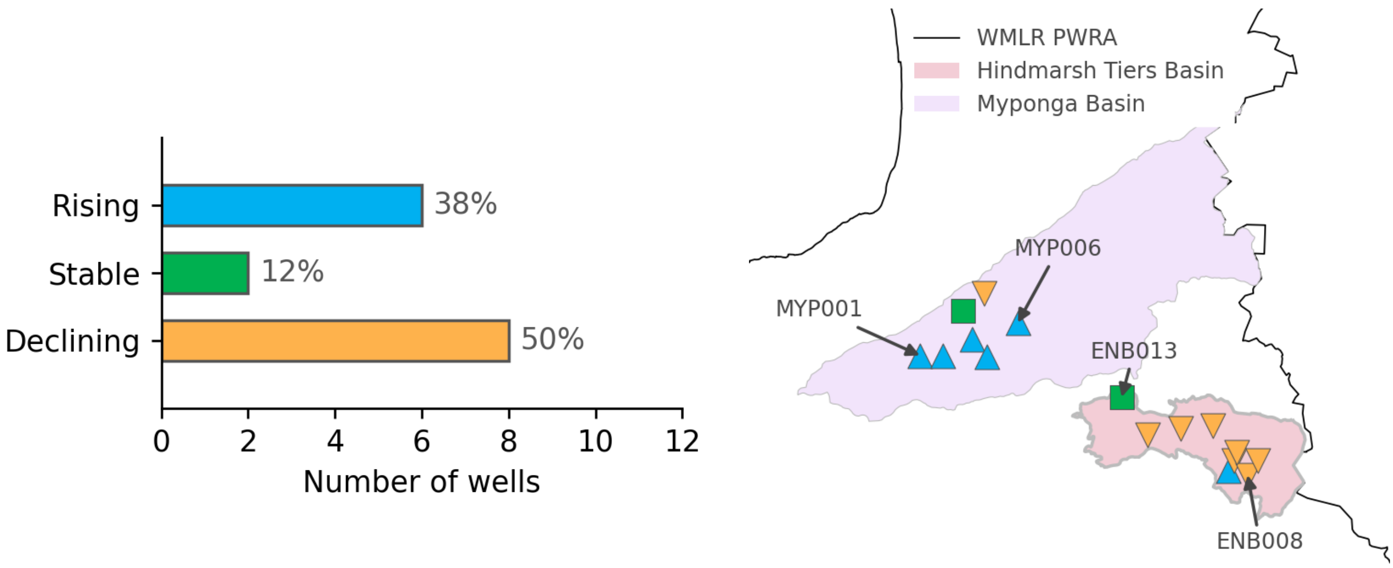

Figure 5.11 2017 to 2021 trend in recovered water levels for wells in the Tertiary limestone aquifer

Hydrographs from a selection of Tertiary limestone aquifer monitoring wells illustrate common or important trends (Figure 5.12). Groundwater levels display large seasonal fluctuations from annual extractions due to the confined nature of the Tertiary limestone aquifer where it occurs within the Myponga and Hindmarsh Tiers Basins.

Winter-recovered groundwater levels in the Myponga Basin have remained stable since monitoring began in 1975, with a period of lower-than-average levels between 2005 and 2009 (e.g., MYP001 and MYP006).

Towards the eastern margin of the Hindmarsh Tiers Basin, groundwater levels have steadily declined since 1975 (e.g., ENB008), followed by a recovery in levels between 2008 and 2016. The increase in groundwater levels may be attributed to the wetter conditions during 2009 to 2011, particularly the unusually wet summer of 2010–11. The groundwater level in 2021 is classified as 'Average' when compared with the historical record. Towards the western side of the basin, ENB013 indicates that winter-recovered water levels have remained relatively stable since monitoring began in 1975.

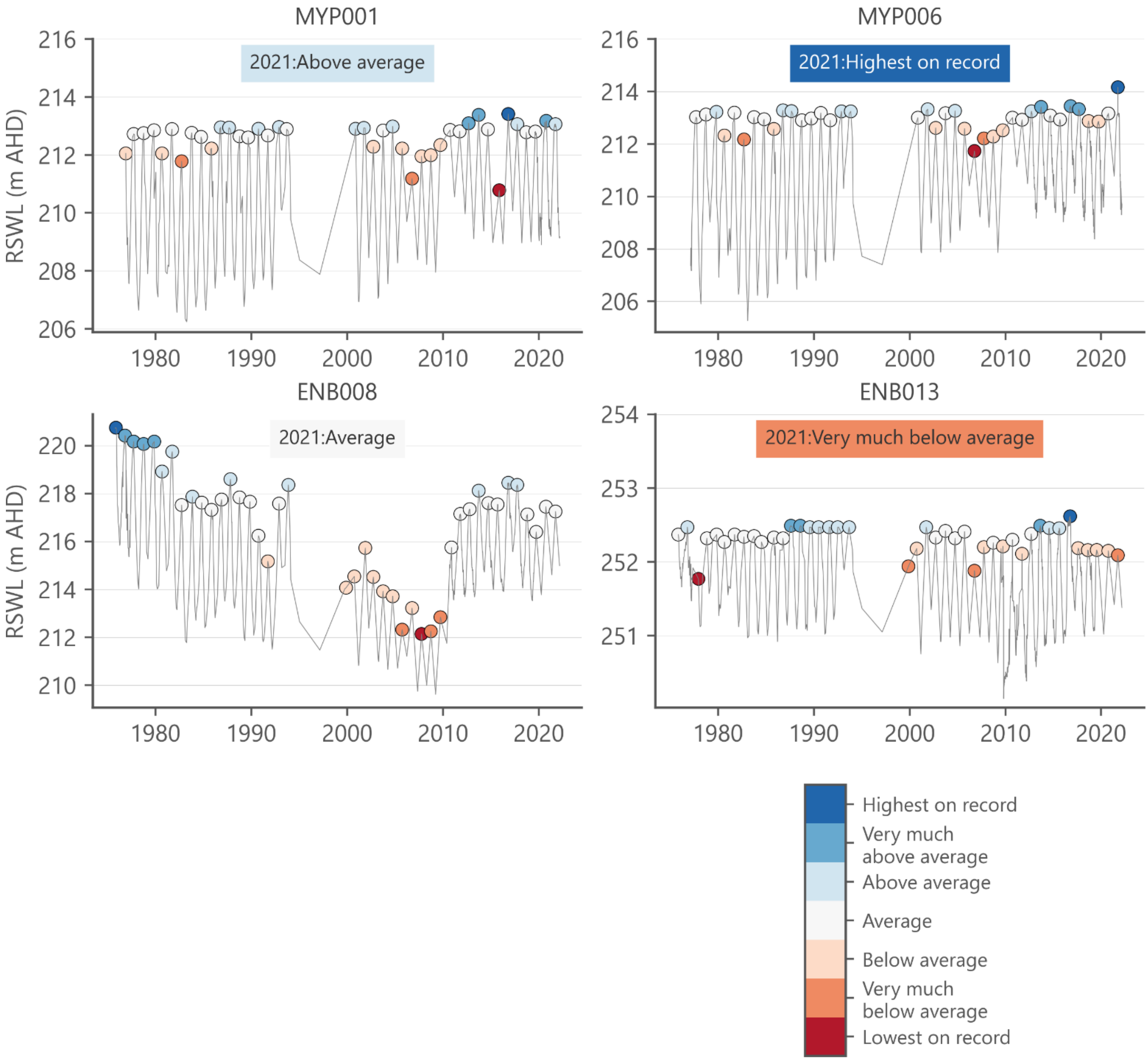

Figure 5.12 **Selected hydrographs for wells in the Tertiary limestone aquifer**

6 Water use

The WMLR PWRA contains approximately 11,500 wells (2,860 are recorded as stock and domestic wells), 13,000 dams and 250 watercourse extraction points (AMLR NRM Board 2013). The PWRA contains 8 water-supply reservoirs distributed throughout the Little Para River, South Para River, River Torrens, Onkaparinga River and Myponga River catchments.

Demand for water across the PWRA includes crop irrigation (particularly viticulture), intensive animal farming, mining, forestry, aboriginal water needs, commercial, industrial, town water supply and recreational uses. There is high demand for consumptive uses of the water resources and as such, the needs of water-dependent ecosystems are accounted for by determining environmental water requirements and provisions, as outlined in the WMLR Water Allocation Plan (WAP) (AMLR NRM Board 2013). The watercourses, wetlands and swamps (including the Fleurieu Peninsula swamps) are often of high conservation value.

The total volume of licensed water use in 2020–21 is 116,677 ML. This includes metered groundwater extraction (Section 6.1) and surface water volumes (Section 6.2).

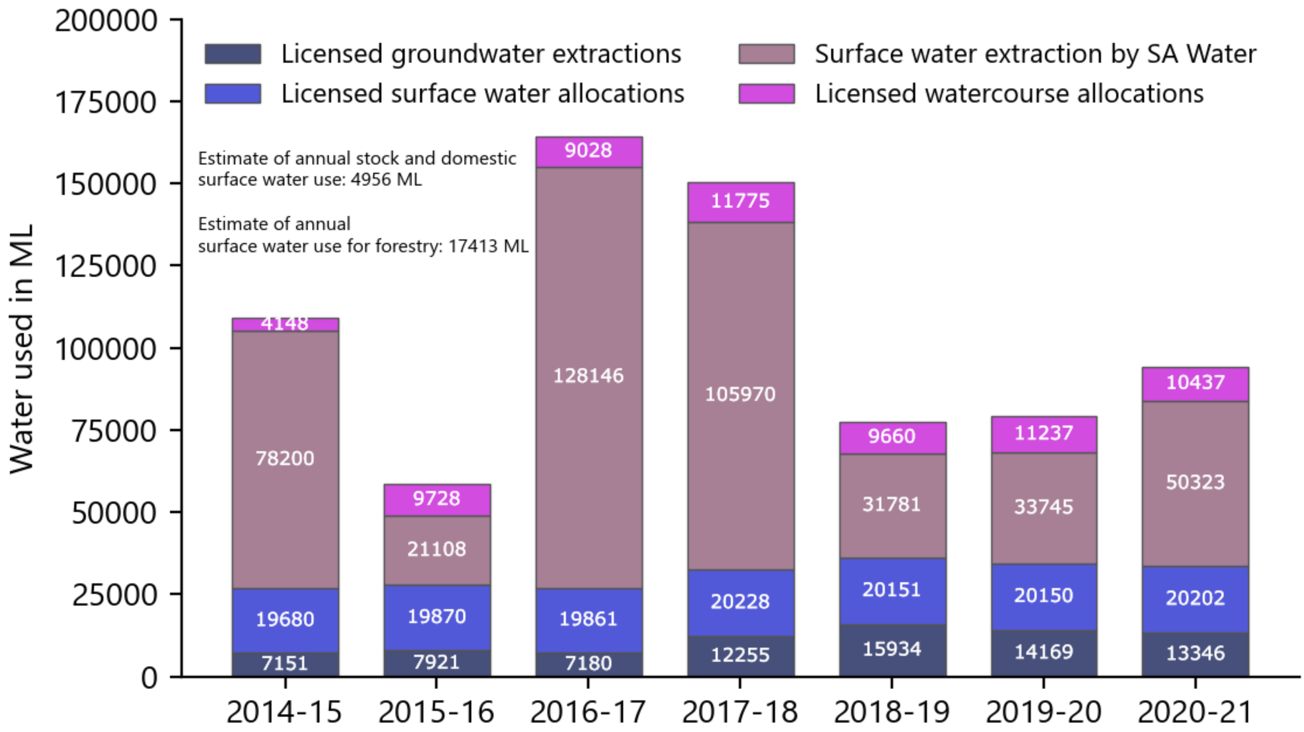

Figure 6.1 Licensed water use from 2014–15 to 2020–21 for the WMLR PWRA

6.1 Groundwater use

Groundwater is extracted for a range of purposes, such as irrigation of crops, town water supply and stock and domestic use. Licensed water take for irrigation and town water supply is metered, while water take for stock and domestic purposes is generally exempt from this requirement.

In 2020–21, a total volume of 13,346 ML is extracted from all groundwater sources across the PWRA (Figure 6.2). This comprises:

- 76% from fractured rock aquifers
- 2% from the Permian Sand aquifer in the Myponga and Hindmarsh Tiers Basins
- 22% from the Tertiary limestone aquifer in the Myponga and Hindmarsh Tiers Basins.

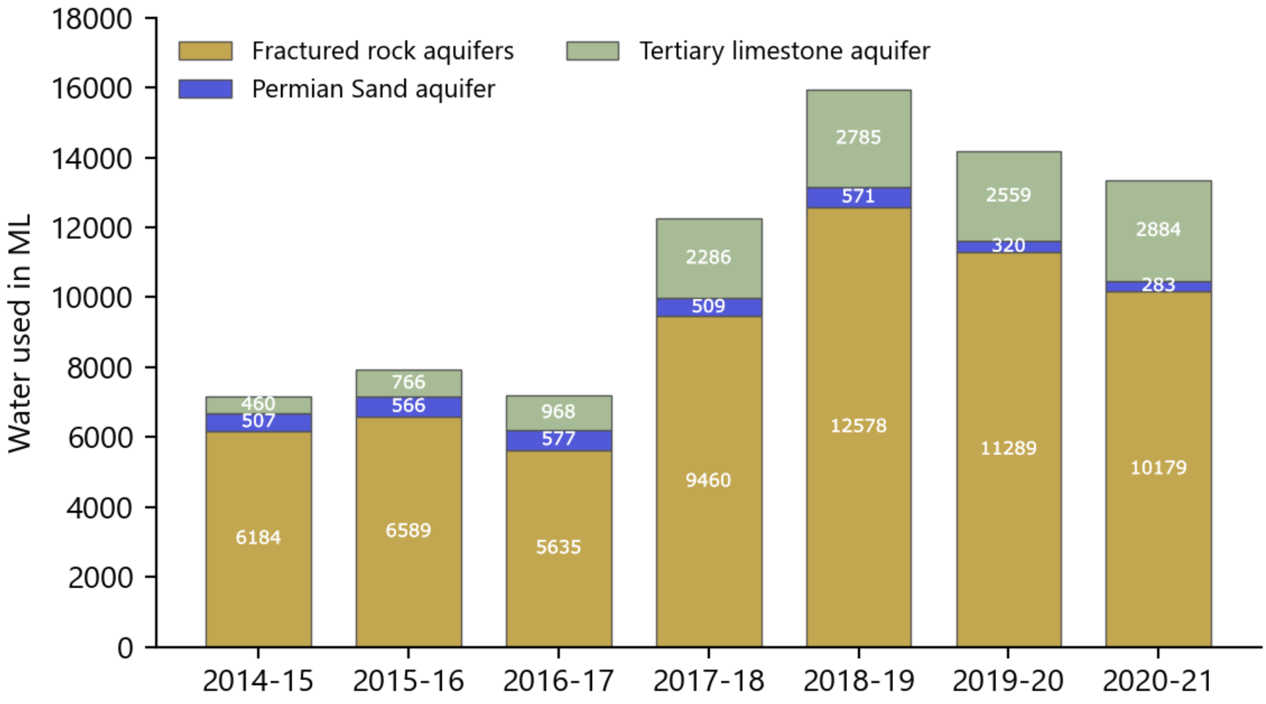

Figure 6.2 Metered groundwater extraction for the WMLR PWRA

6.2 Surface water use

Surface water use in the WMLR PWRA is not comprehensively metered and therefore this report uses licensed allocations to provide an indication of the volumes of water being used where metered data is not available.

In 2020–21, the total surface water allocation for the WMLR PWRA is estimated to be 103,331 ML (compared to 87,501 ML in 2019–20). This consists of:

- 20,202 ML licensed surface water take from dams
- 10,437 ML licensed surface water take from watercourses
- 4,956 ML water demand for stock and domestic, which is not required to be licensed (approximated at 30% of dam capacity and based on analysis in the Water Allocation Plan (AMLR NRM Board 2013)
- 17,413 ML from plantation forestry (estimate based on analysis in the Water Allocation Plan (AMLR NRM Board 2013)
- 50,323 ML from SA Water extraction from water supply reservoirs (compared to 33,745 ML in 2019–20). SA Water's extraction is related to rainfall. In high rainfall years, SA Water extracts the majority of its public water supply from the WMLR, while in dry years the River Murray provides a larger percentage of SA Water's total extraction. This data is based on metered values. These values are shown in Figure 6.1.

6.2.1 Farm dams

Based on the information contained in the WMLR WAP (AMLR NRM Board 2013), there are approximately 13,000 farm dams in the PWRA. 1,700 of these are used for licensed purposes and the remainder are for stock and domestic or other non-licensed purposes. The total capacity of non-licensed dams is 16,516 ML, and the estimated total surface water demand for stock and domestic use is approximately 4,956 ML.

The Onkaparinga River catchment is one of the main water supply catchments in the WMLR. Detailed analysis of the farm dams in the catchment (Figure 6.3) shows that there are 3,476 farm dams (764 licensed) in the Onkaparinga with a total storage capacity of 14,605 ML. Approximately 84% of dams in the Onkaparinga have a storage capacity of less than 5 ML, while contributing to only 24% of the total storage capacity. Larger dams (5 ML or greater capacity) make up only 16% of the total dam count but account for 76% of total storage capacity.

Farm dam density (i.e., ML of dam storage per $km^{2)}$ in the WMLR PWRA is shown in Figure 6.3. Average farm dam density for the Onkaparinga upstream of Mount Bold is 35 ML/km^2. This is high compared to some of the other catchments across the WMLR: River Torrens upstream of the Gumeracha weir (26 ML/km^2), Little Para upstream of the gauging station A5040503 (13 ML/km^2) and South Para (10 ML/km^2). Dam density varies greatly across the catchment, with headwater zones and high rainfall areas such as Lenswood Creek and the Western Branch sub-catchment having much higher farm dam density (>58 ML/km^2) in comparison to some downstream receiving zones like Cox Creek (6 ML/km^2).

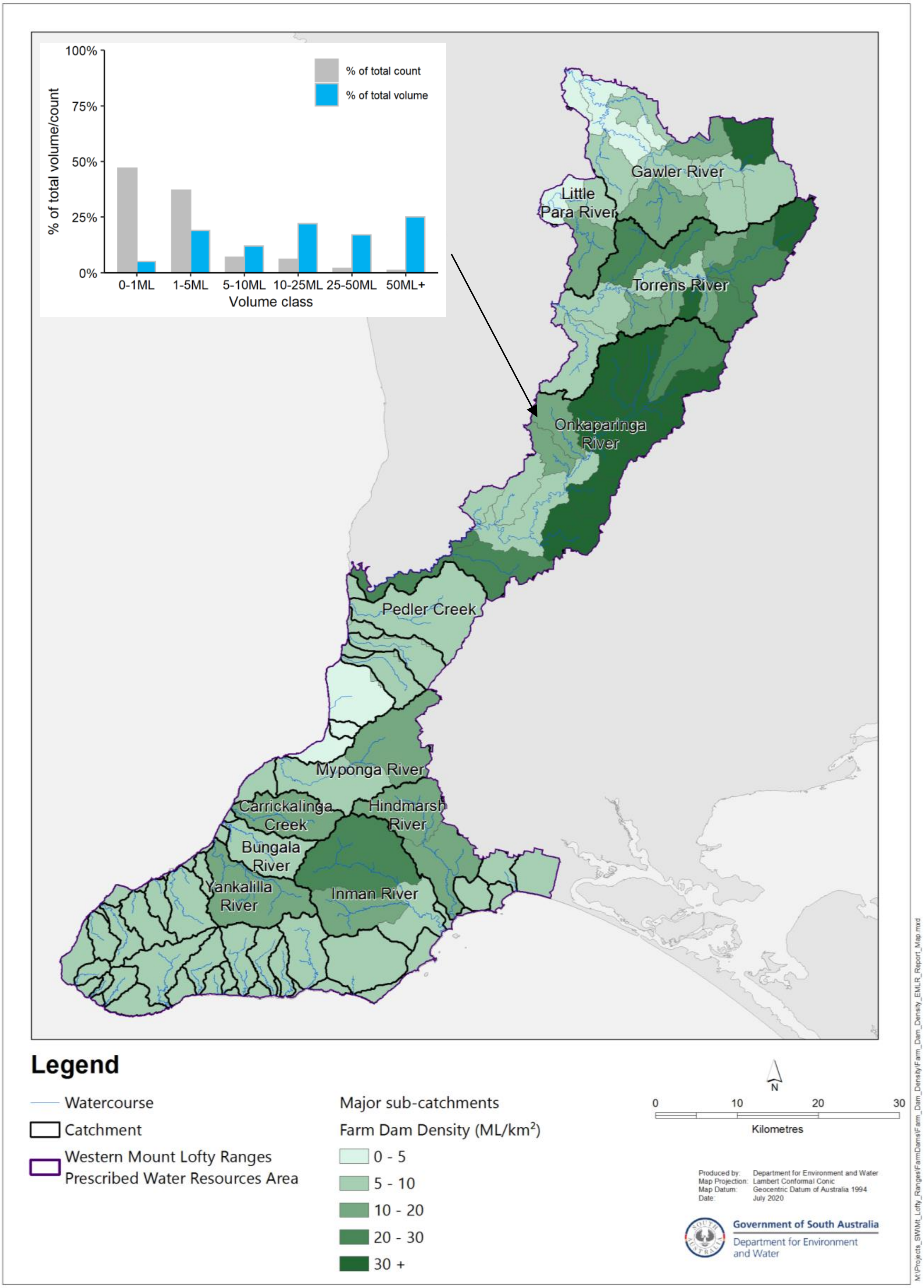

Figure 6.3 Farm dam density in the WMLR PWRA (Inset: farm dam volume and count in the Onkaparinga River catchment)

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