Prescribed areas of the Limestone Coast 2019–20 water resources assessment

Department for Environment and Water
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DEW Technical Note 2021/10

Government of South Australia
Department for Environment and Water

Department for Environment and Water

Government of South Australia

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81-95 Waymouth St, ADELAIDE SA 5000

Telephone +61 (8) 8463 6946

Facsimile +61 (8) 8463 6999

ABN 36702093234

www.environment.sa.gov.au

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Contents

1 Summary

Lower Limestone Coast PWA	Confined aquifer		Average
	Unconfined aquifer	Highlands	Very much below average
		Lowlands	Below average
Morambro PA	Surface water	Morambro Creek	Lowest on record
Padthaway PWA	Confined aquifer		Below average
	Unconfined aquifer	Flats	Below average
		Range	Average
Tatiara PWA	Confined aquifer		Lowest on record
	Unconfined aquifer	Highlands	Very much below average
		Plains	Very much below average
Tintinara-Coonalpyn PWA	Confined aquifer		Average
	Unconfined aquifer	Mallee Highlands	Very much below average
		Plains	Below average

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

Rainfall

- Total annual rainfall in 2019–20 was 753 mm at Mount Gambier in the Lower Limestone Coast Prescribed Wells Area (PWA), and 461 mm at Frances in the north-east. Long-term trends (1970–2020) show relatively stable annual rainfall at Mount Gambier, but declining annual rainfall at Frances.
- In 2019–20, rainfall was below average in the Padthaway, Tatiara and Tintinara-Coonalpyn PWAs. Trends from long-term data (1970–2020) indicate a decline in annual rainfall in these areas.
- Above-average monthly rainfall occurred in February and May 2020, while December 2019 and March 2020 were considerably below average at all representative rainfall stations.

Surface water

- There is one streamflow gauging station in the Morambro Creek prescribed surface water area (PSWA) but, streamflow was insufficient to enable measurement in 2019–20. Long-term streamflow data show a declining trend.
- Due to the lack of streamflow, salinity could not be measured in the Morambro Creek in 2019–20.

Groundwater

- In the Lower Limestone Coast PWA, unconfined aquifer water levels in the coastal plains are mainly classified 'Below average' (46%), or 'Average' (36%), when compared to their respective historical record. The median ranked well is classified 'Below average'. In the eastern highlands area, levels are mostly 'Below average' or lower (87%). In the confined aquifer, pressure levels are mainly classified 'Average'.
- In the Padthaway PWA, water levels in the unconfined Padthaway Flats GMA are mainly classified 'Below average', while those in the eastern Padthaway Range GMA are classified mainly 'Average'.
- In the Tatiara PWA, water levels in both the unconfined and confined aquifers, in both the plains and highlands areas, are below their respective historical average. Median ranked wells in unconfined aquifers are classified 'Very much below average', while 80% of wells in confined aquifers are 'Lowest on record'.
- In the Tintinara-Coonalpyn PWA, water levels in the unconfined aquifer are generally classified 'Below average or lower. Pressure levels in the confined aquifer are mainly classified 'Below average'.
- In the 10 years to 2020, the majority of monitoring wells across all PWAs (57%) show increasing groundwater salinity.

Water use

- Groundwater is used widely in the Limestone Coast Landscape region for irrigation, industry, stock and domestic uses and town water supplies, with small volumes of surface water typically diverted from Morambro Creek. In 2019–20, a lack of streamflow prevented any watercourse extraction.
- Licensed groundwater extraction from all aquifers in 2019–20 was 380 148 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) provide a detailed information and assessment for each resource area, helping to identify the resource condition in further detail
- **Fact sheets**: provide summary information for each resource area with an Annual Resource Status Overview
- **State-wide summary**: this summarises information for the main water resources across most regions in a quick-reference format.

This document is the Technical Note for the prescribed areas of the Limestone Coast Landscape region for 2019–20 and collates rainfall, surface water and water use (i.e. surface water and groundwater) data collected between July 2019 and September 2020, and groundwater level and salinity data collected between July 2019 and December 2020.

1.2 Regional context

The Limestone Coast Landscape Region encompasses much of the south-eastern part of South Australia, stretching southwards and eastwards from the area near Lake Albert to the Victorian border (Figure 1.1). The area incorporates coastal plains, dunes and inter-dunal flats, with highlands and ranges in the eastern areas. There is also an extensive network of drains across the landscape to assist in the management of water, soils and biodiversity. There are seven different areas and watercourses that are prescribed under the *Landscape South Australia Act 2019*, which together constitute this assessment. These prescribed water resources are managed by principles in five separate water allocation plans, namely the:

- Water Allocation Plan for the Lower Limestone Coast PWA (SE NRM Board, 2013), which covers an area of approximately 14 500 km^2 between Kingston South East (SE), Naracoorte and Mount Gambier
- Water Allocation Plan for the Padthaway PWA (SE NRM Board, 2009), which covers an area of approximately 700 km^2 and is centred on the township of Padthaway
- Water Allocation Plan for the Tatiara PWA (SE NRM Board, 2010), which covers an area of approximately 3500 km^2 between Keith and Bordertown, extending north to Ngarkat Conservation Park
- Water Allocation Plan for the Tintinara-Coonalpyn PWA (SE NRM Board, 2012), which covers an area of approximately 3400 km^2 between Tintinara and Coonalpyn, extending eastward across the southern part of Ngarkat Conservation Park
- Water Allocation Plan for the Morambro Creek and Nyroca Channel Prescribed Watercourses including Cockatoo Lake and the Prescribed Surface Water Area (SE NRM Board, 2006), which covers the two prescribed watercourses, and the Morambro Creek Prescribed Surface Water Area (PSWA) that is located approximately 20 km south-east of Padthaway, encompassing an area of around 225 km^2 and extending to South Australia's state border with Victoria.

Groundwater is the main water resource in the Limestone Coast Landscape region and is used for irrigation, industrial, stock and domestic and town water supplies. There are two main groundwater systems: the upper unconfined Tertiary Limestone Aquifer (known generally as the unconfined aquifer) and the underlying Tertiary Confined Sand Aquifer (known generally as the confined aquifer) (SE NRM Board, 2013). The confined and unconfined aquifers are generally separated by a low-permeability aquitard.

Morambro Creek is the only prescribed surface water resource in the Lower Limestone Coast PWA. The headwaters of Morambro Creek are located in the Wimmera region in western Victoria. The topography of the Morambro Creek area is predominantly characterised by coastal plains that become increasingly undulating in the highlands, towards the north-western margin of the PWA (Figure 1.1).

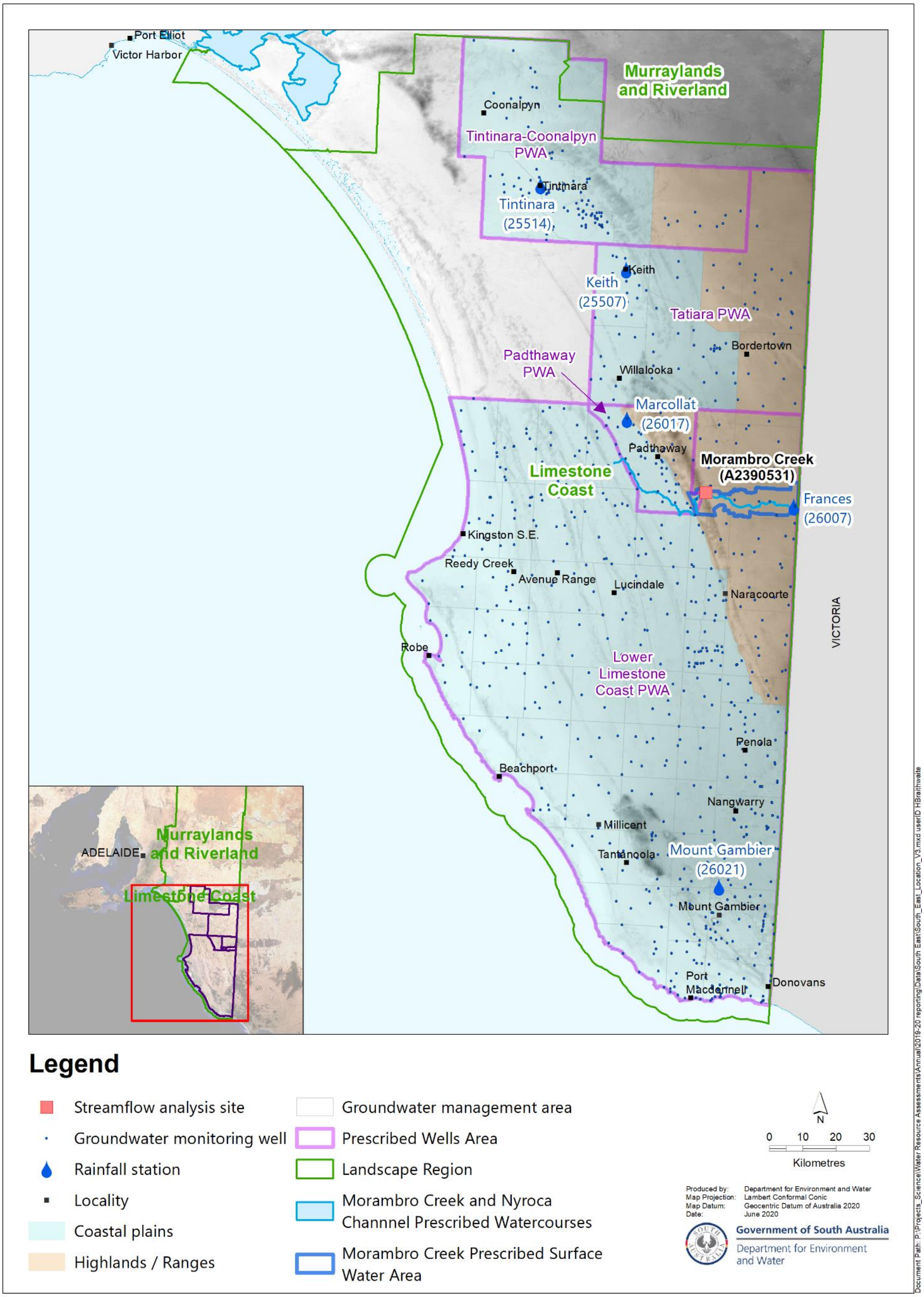

Figure 1.1. Location of prescribed areas of the Limestone Coast Landscape region

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.

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 any gaps in observations. Rainfall maps were compiled using gridded datasets obtained from the BoM (Figure 3.11). The long-term average annual rainfall map (1986–2015) was obtained from Climate Data Online[2]. The map of total rainfall in 2019–20 was compiled from monthly rainfall grids obtained for the months between July 2019 and June 2020 from the Australian Landscape Water Balance[3] website.

2.2 Surface water

2.2.1 Annual streamflow

Low reliability of streamflow in Morambro Creek has meant there has been no systematic development of the surface water resource and consequently, there is limited surface water monitoring in the prescribed area. The status of the sole streamflow gauging station on the Morambro Creek (A2390531) is determined by expressing the annual streamflow for the applicable year as a percentile[4] of the total period of data availability (1979–20). Streamflow data were then given a description based on their percentile and decile[1] (Table 2.1 and Figure 4.1).

Table 2.1. 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]

[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/

[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] BoM Annual climate statement

Annual streamflow data (Figure 4.2) is presented as the deviation of each year's streamflow from the long-term average with the bars shaded using the BoM classification shown in Table 2.1.

2.2.2 Monthly streamflow

Monthly streamflow for the applicable year is assessed alongside the long-term monthly average streamflow (Figure 4.3A), for the period 1979–20 and long-term monthly statistics including (a) high flows (25th percentile), (b) median flows (50th percentile) and low flows (75th percentile).

2.2.3 Daily streamflow

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

2.2.4 Salinity

Box plots on a monthly basis are used to assess surface water salinity (Figure 2.1 and Figure 4.4). This enables the salinity (TDS; total dissolved solids in mg/L) for the applicable year to be presented against long-term salinity statistics (maximum, 75th percentile, median or 50th percentile, 25th percentile and minimum).

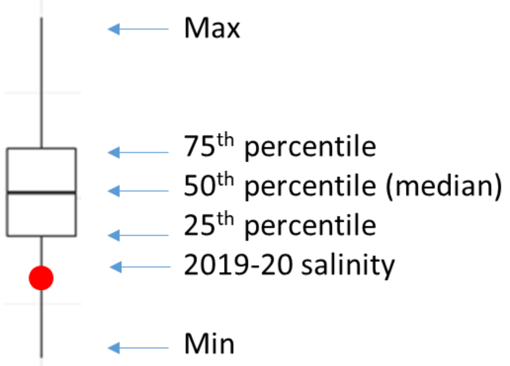

Figure 2.1 Box and whisker plot

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 return to a maximum level varies across the area, but mostly occurs between July and December, although some wells do not recover until as late as March of the following year depending on irrigation patterns.

[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).

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 2.1) and given a description in a similar way as annual streamflow. The thresholds for criteria by which wells are selected varies depending on the history of monitoring activities in different areas; for the Limestone Coast Landscape region PWAs, any well with 10 years or more of recovered water level data is included with the exception of unconfined aquifer monitoring wells in the Lower Limestone Coast PWA and in the coastal plains of the Tatiara PWA, where only those wells with 20 years or more of data are included. This is due to more extensive historical monitoring data in those areas. The number of wells in each description class for the most recent year is then summarised for 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 five measurements (i.e. at least one measurement a year). The trend line was 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). Sedimentary confined and unconfined aquifers such as those in the Limestone Coast Landscape region are given tolerance thresholds of 2 cm/y.

Thirty-year changes in water level were calculated as the difference between the average water level in a three-year period thirty years ago (i.e. 1988–1990) and the average water level in 2020. Twenty-year changes in water level were calculated in a similar way, using a comparison from the average water level in a three-year period twenty years ago (i.e. 1998–2000).

2.3.2 Salinity

Water samples are collected from monitoring wells located across the four PWAs by a variety of methods. Samples are collected from operating irrigation pumps, from flowing artesian wells in the confined aquifer, or by pumping samples from wells where necessary. These samples are tested for electrical conductivity (EC) and the salinity (total dissolved solids measured in mg/L, abbreviated as TDS) is calculated. Where multiple samples were submitted from a well in a calendar year, the mean salinity is used for analysis. The results are shown for each aquifer (e.g. Figure 5.4). Ten-year salinity trends are calculated where there are at least seven 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. The salinity measurements are based on the measurement of the electrical conductivity of a water sample and are often subject to small instrument errors (e.g. Figure 5.5).

Salinity graphs are shown for a selection of wells to illustrate common or important trends (e.g. Figure 5.6).

2.4 Water use

Meter readings are used to estimate licensed extraction volumes for both surface water and groundwater sources. Where meter readings are not available, licensed or allocated volumes are used for surface water sources (Section 6).

Further information on the number and type of farm dams in the prescribed surface water area is provided in Section 6.3. Dam capacity estimates are undertaken using different methods with data derived from aerial surveys 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 Limestone Coast Landscape region are listed in Section 7, and include:

- Summary reports on the surface water (DEWNR, 2014) and groundwater resources (DEWNR, 2012a,b,c,d) of the South East NRM region, and annual groundwater level and salinity status reports (such as DEW 2019a,b,c,d,e) and the annual surface water status report (such as DEW, 2019f).
- The Water Allocation Plan for the Lower Limestone Coast PWA, as amended in June 2019 (SE NRM Board, 2013).
- Wood (2017), Cranswick (2018), Cranswick and Herpich (2018), Harding et al. (2018) and Simmons et al. (2019), which provide detailed assessments of the hydrogeology and interaction between groundwater and surface water resources in the Lower Limestone Coast PWA.
- The Water Allocation Plan for the Padthaway PWA (SE NRM Board, 2009).
- The Water Allocation Plan for the Tatiara PWA (SE NRM Board, 2010).
- Li and Cranswick (2017) and Cranswick and Li (2018), which provide details of the hydrogeology and groundwater modelling for the Tatiara WAP.
- The Water Allocation Plan for the Tintinara-Coonalpyn PWA (SE NRM Board, 2012).
- Cranswick and Barnett (2017), which provides details of the conceptual groundwater system in the Tintinara-Coonalpyn and Tatiara PWAs.
- The Water Allocation Plan for the Morambro Creek and Nyroca Channel Prescribed Watercourses, including Cockatoo Land and the Prescribed Surface Water Area (SE NRM Board, 2006).
- Whiting and Savadamuthu (2018) provides a technical review of the current farm dam policy in the South East NRM Plan and reviews and revises other hydrological principles underlying this plan.

[7] https://www.waterconnect.sa.gov.au/Systems/GD/Pages/default.aspx

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

3 Rainfall

Average annual rainfall in the Limestone Coast Landscape region varies from approximately 750 mm/y in the southern coastal areas to around 450 mm/y in the north. The highest annual rainfall totals can be up to 1000 mm/y around Mount Burr. The past forty years of annual and monthly rainfall are shown below for Mount Gambier (in the Lower Limestone Coast PWA; Figure 3.1 and Figure 3.2), Frances (in the Morambro Creek PSWA; Figure 3.3 and Figure 3.4), Marcollat (in the Padthaway PWA; Figure 3.5 and Figure 3.6), Keith (in the Tatiara PWA; **Error! Reference source not found.** and **Error! Reference source not found.**), and Tintinara (in the Tintinara-Coonalpyn PWA; Figure 3.9 and Figure 3.10).

3.1 Lower Limestone Coast PWA and Morambro Creek PSWA

The rainfall station at Mount Gambier's airport (BoM station 26021) is used as a representative rainfall station for the southern part of the Lower Limestone PWA. The Frances rainfall station (BoM station 26007), located 30 km north-east of Naracoorte, is representative of both the Morambro Creek PSWA and the lower rainfall areas in the northern part of the Lower Limestone Coast PWA.

Total annual rainfall recorded at Mount Gambier in 2019–20 is 753 mm (Figure 3.1), which is 5% above the average annual rainfall of 717 mm/y (1970–2020). The annual rainfall at Frances was 461 mm, which is 10% below the average annual rainfall of 514 mm/y (1970–2020; Figure 3.3). Above-average rainfall occurred in February and May 2020 at both Mount Gambier and Frances (Figure 3.2 and Figure 3.4), with April 2020 also above the monthly average at Frances. Both December 2019 and March 2020 were considerably drier than average at both rainfall stations.

The long-term trend in annual rainfall (1970–2020) is stable at Mount Gambier, with a declining trend at Frances.

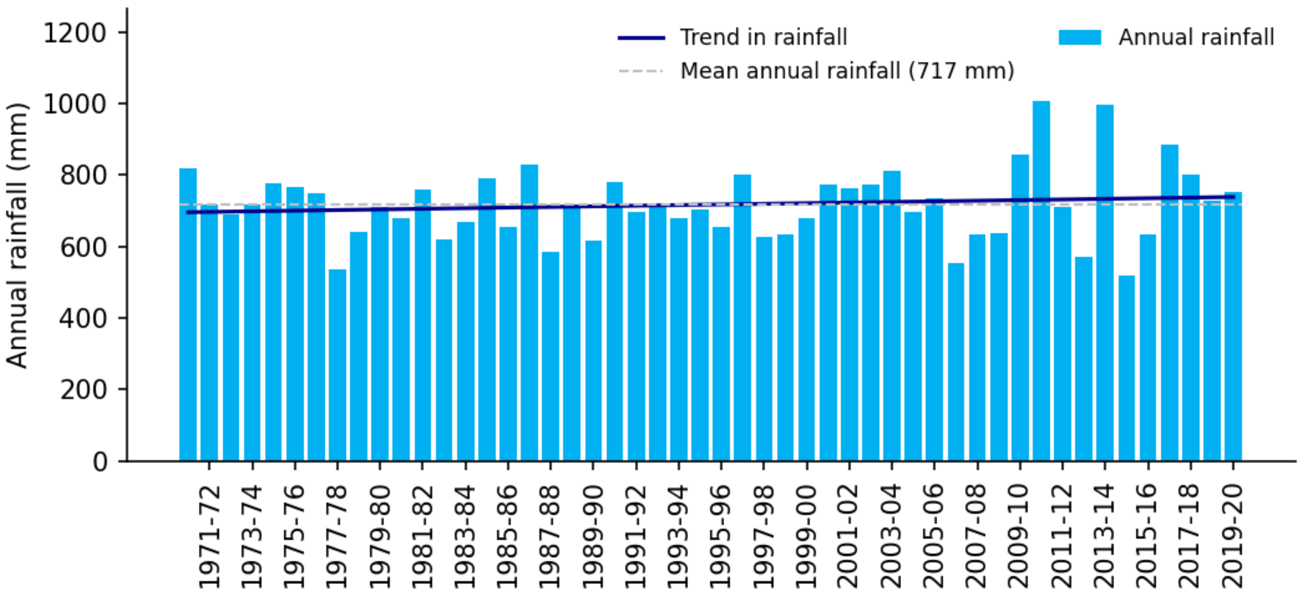

Figure 3.1. Annual rainfall for 1970–71 to 2019–20 at the Mount Gambier rainfall station (26021)

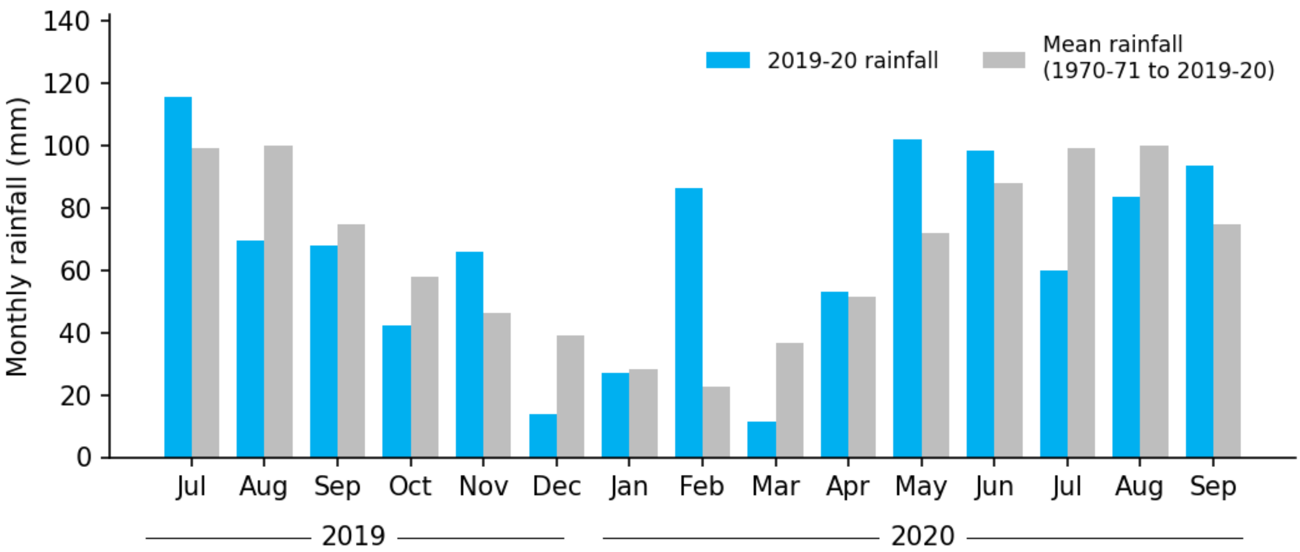

Figure 3.2. Monthly rainfall between July 2019 and September 2020 at the Mount Gambier rainfall station (26021)

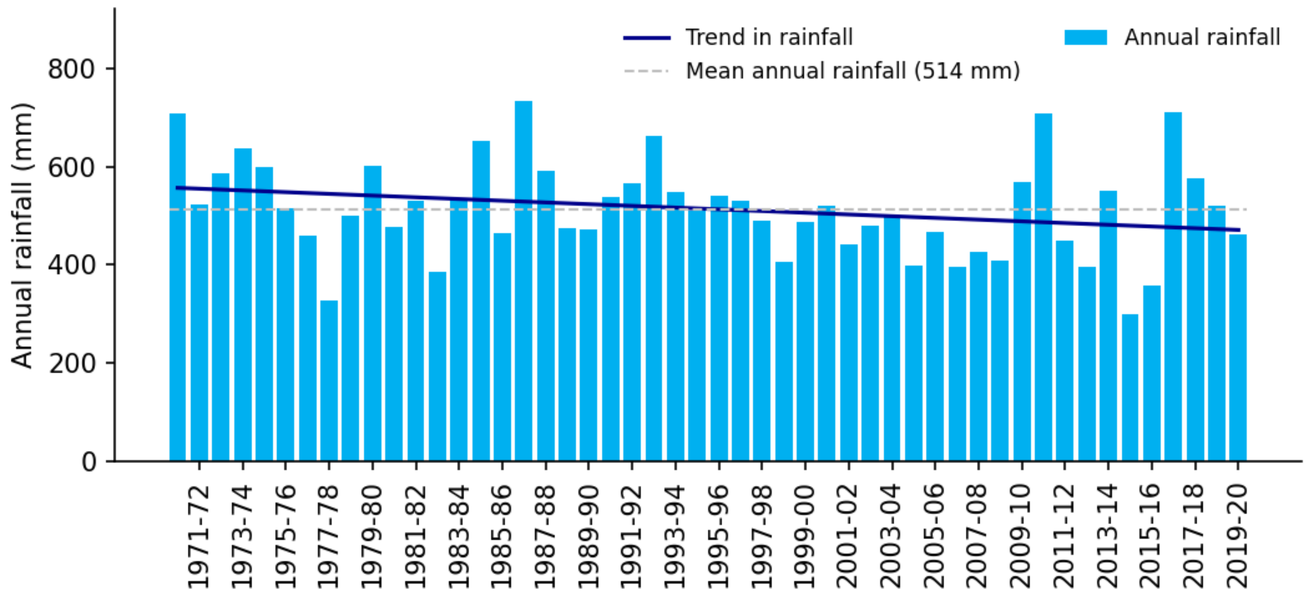

Figure 3.3. Annual rainfall for 1970–71 to 2019–20 at the Frances rainfall station (26007)

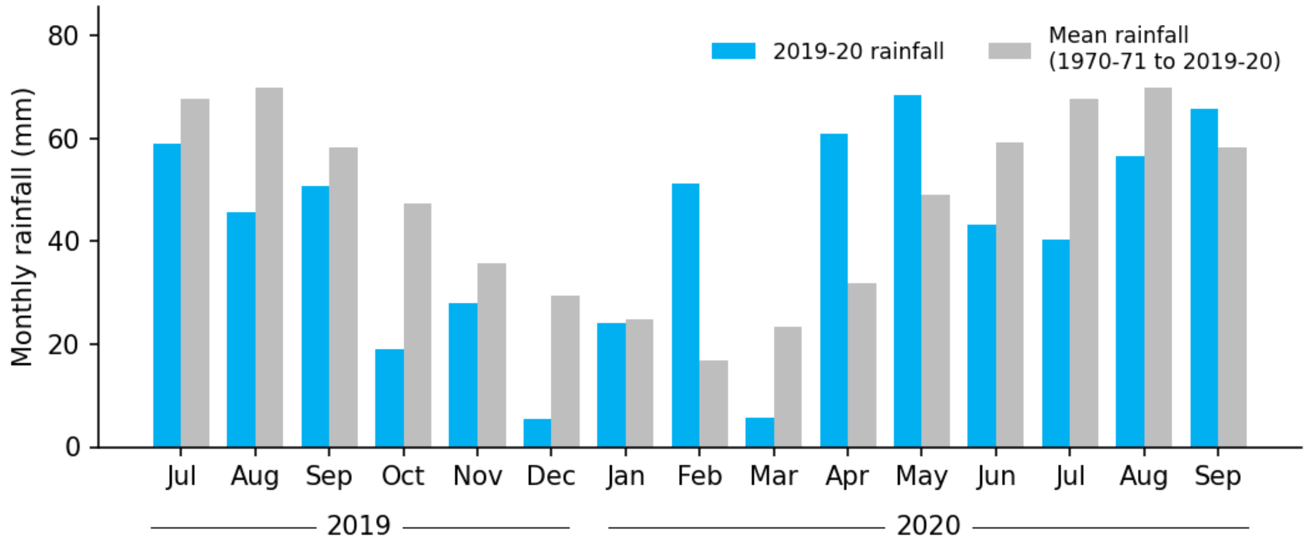

Figure 3.4. Monthly rainfall between July 2019 and September 2020 at the Frances rainfall station (26007)

3.2 Padthaway PWA

The Marcollat rainfall station (BoM station 26017) is located 15 km north-west of Padthaway and is used as a representative station for the area. The annual total recorded in 2019–20 is 446 mm (Figure 3.5), which is 12% below the annual average of 508 mm/y (1970–2020). Above-average rainfall occurred in February and April 2020, while below-average rainfall occurred in December 2019 and March 2020 (Figure 3.6).

The long-term trend in annual rainfall (1970–2020) is declining for the Marcollat rainfall station.

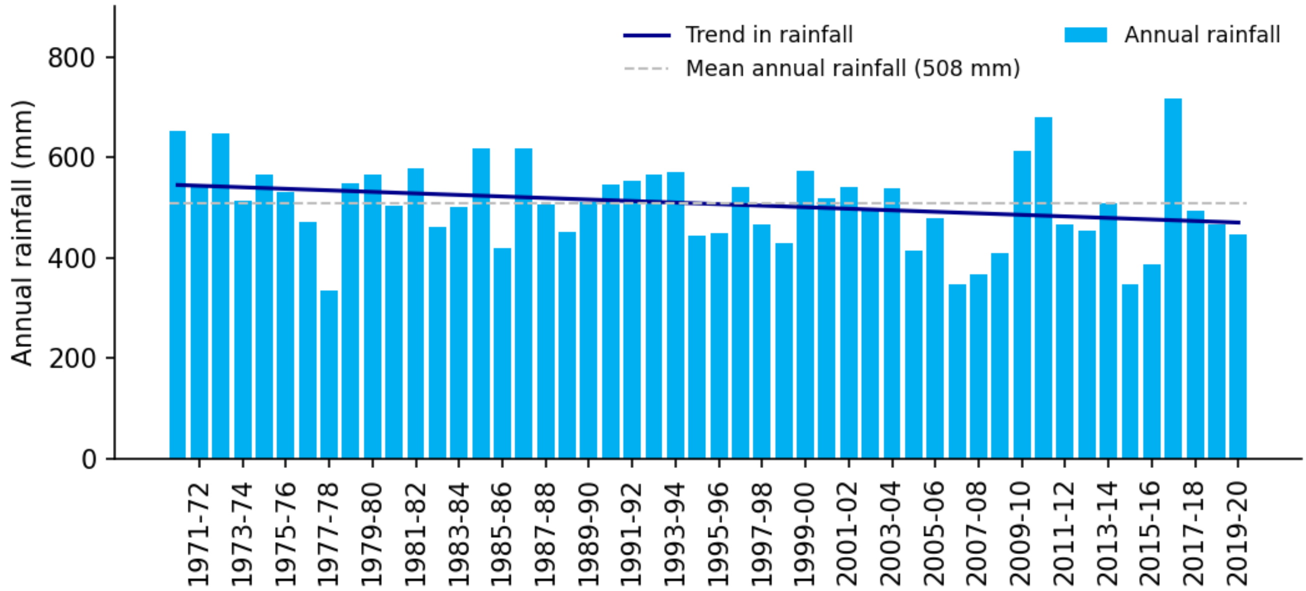

Figure 3.5. Annual rainfall for 1970–71 to 2019–20 at the Marcollat rainfall station (26017)

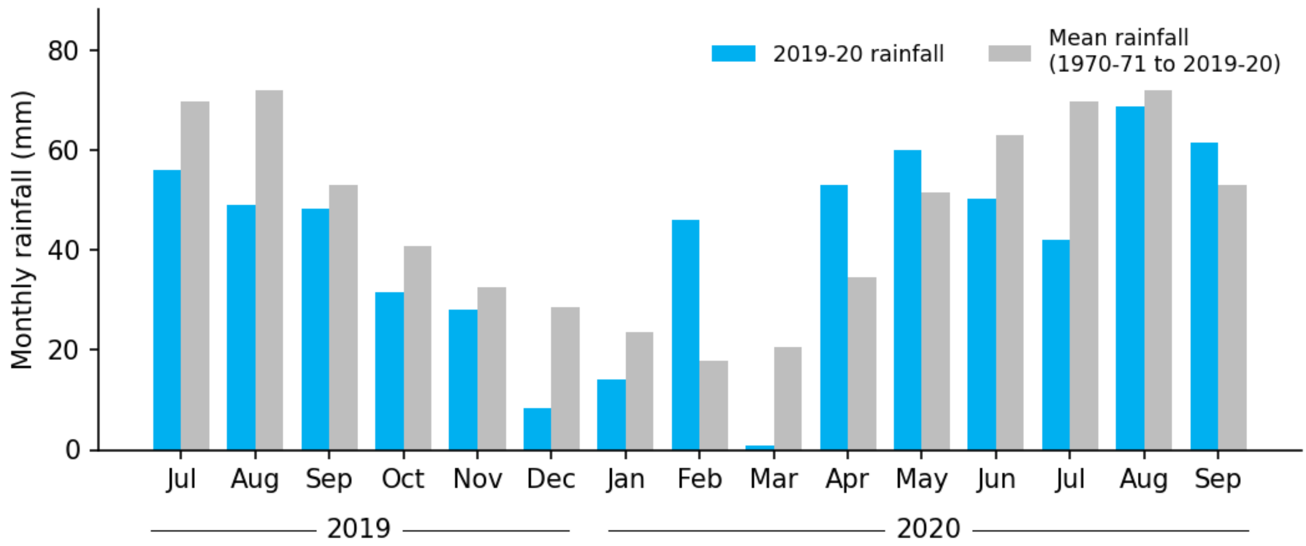

Figure 3.6. Monthly rainfall between July 2019 and September 2020 at the Marcollat rainfall station (26017)

3.3 Tatiara PWA

The rainfall station at Keith (BoM station 22507) is used as a representative station for the Tatiara PWA. The annual total recorded for 2019–20 is 439 mm (**Error! Reference source not found.**), which is 3% below the annual average of 455 mm/y (1970–2020). Above average rainfall occurred in February and April 2020 (**Error! Reference source not found.**). Monthly rainfall in December 2019 and March 2020 is markedly below-average.

The long-term trend in annual rainfall (1970–2020) is declining for the Keith rainfall station.

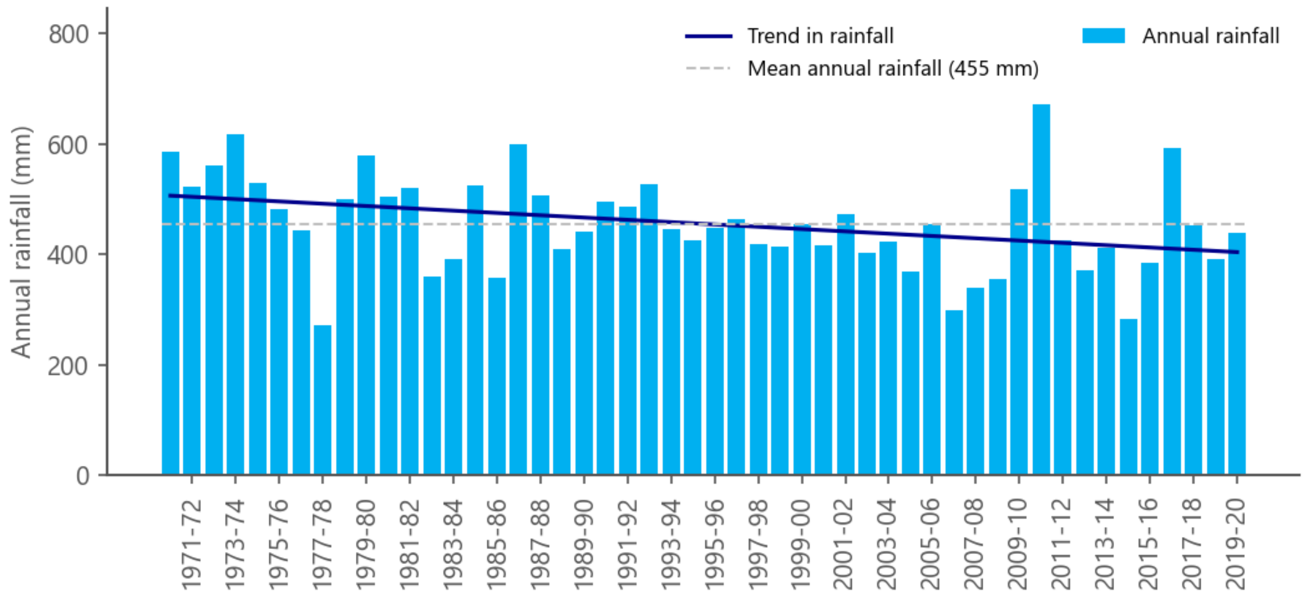

Figure 3.7. Annual rainfall for 1970–71 to 2019–20 at the Keith rainfall station (25507)

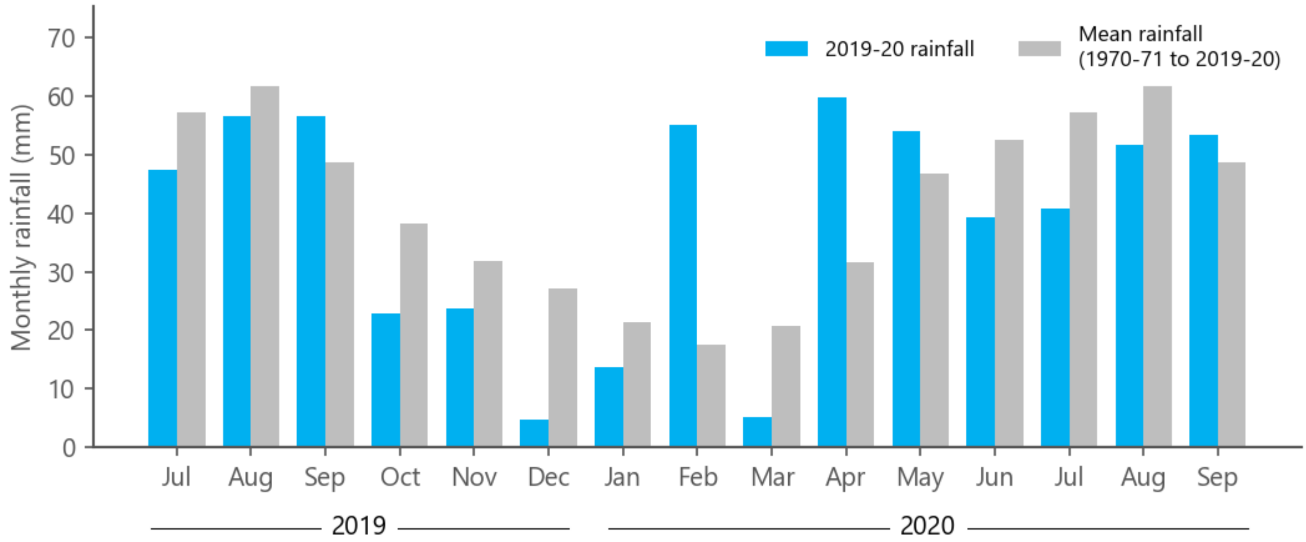

Figure 3.8. Monthly rainfall between July 2019 and September 2020 at the Keith rainfall station (25507)

3.4 Tintinara-Coonalypn PWA

The rainfall station at Tintinara (BoM station 25514) is used as a representative station for the Tintinara-Coonalpyn PWA. The annual total recorded for 2019–20 is 429 mm (Figure 3.9), which is commensurate with the annual average of 428 mm/y (1970–2020). Above-average rainfall occurred in February, April and May 2020 (Figure 3.10), while December 2019, and January and March 2020 recorded rainfall that is considerably below average.

The long-term trend in annual rainfall (1970–2020) is declining for the Tintinara rainfall station.

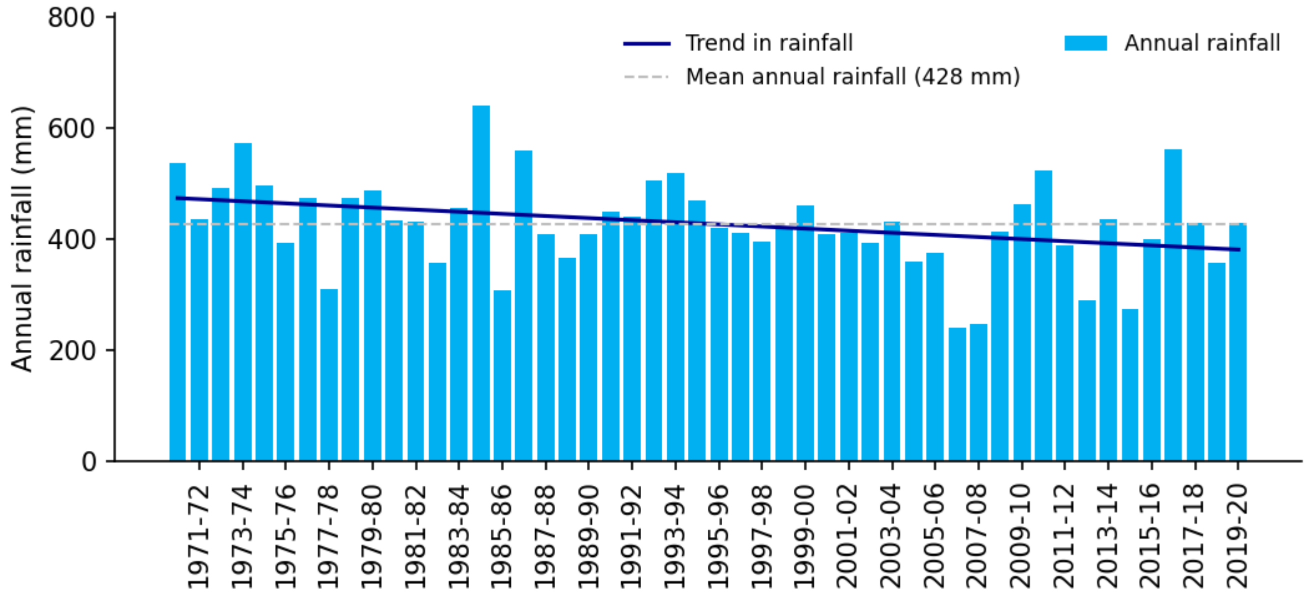

Figure 3.9. Annual rainfall for 1970–71 to 2019–20 at the Tintinara rainfall station (25514)

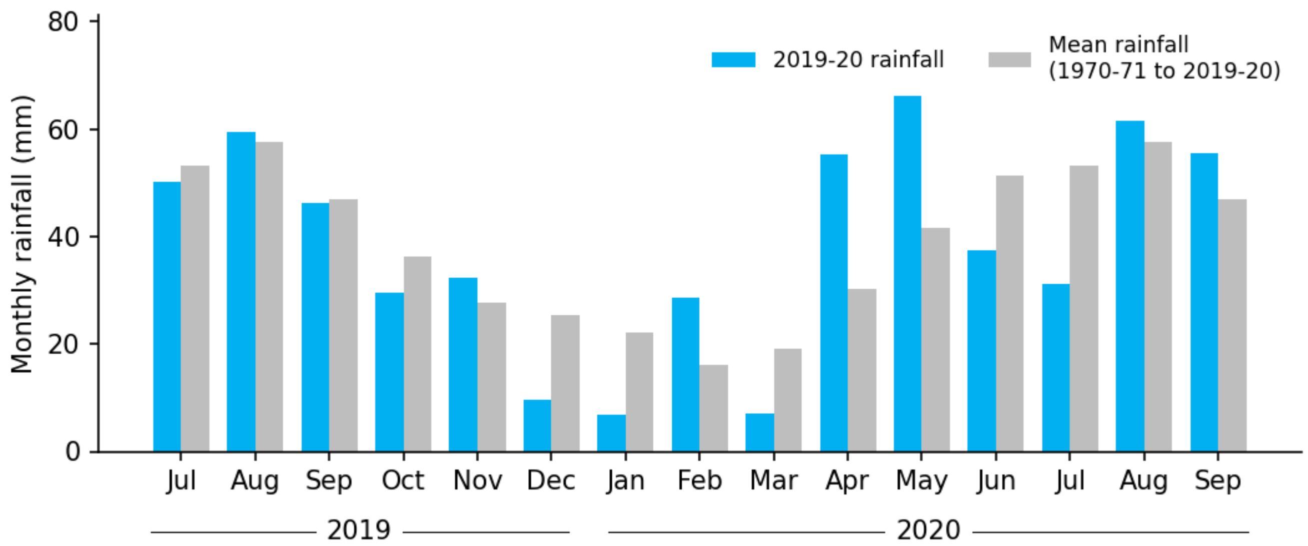

Figure 3.10. Monthly rainfall between July 2019 and September 2020 at the Tintinara rainfall station (25514)

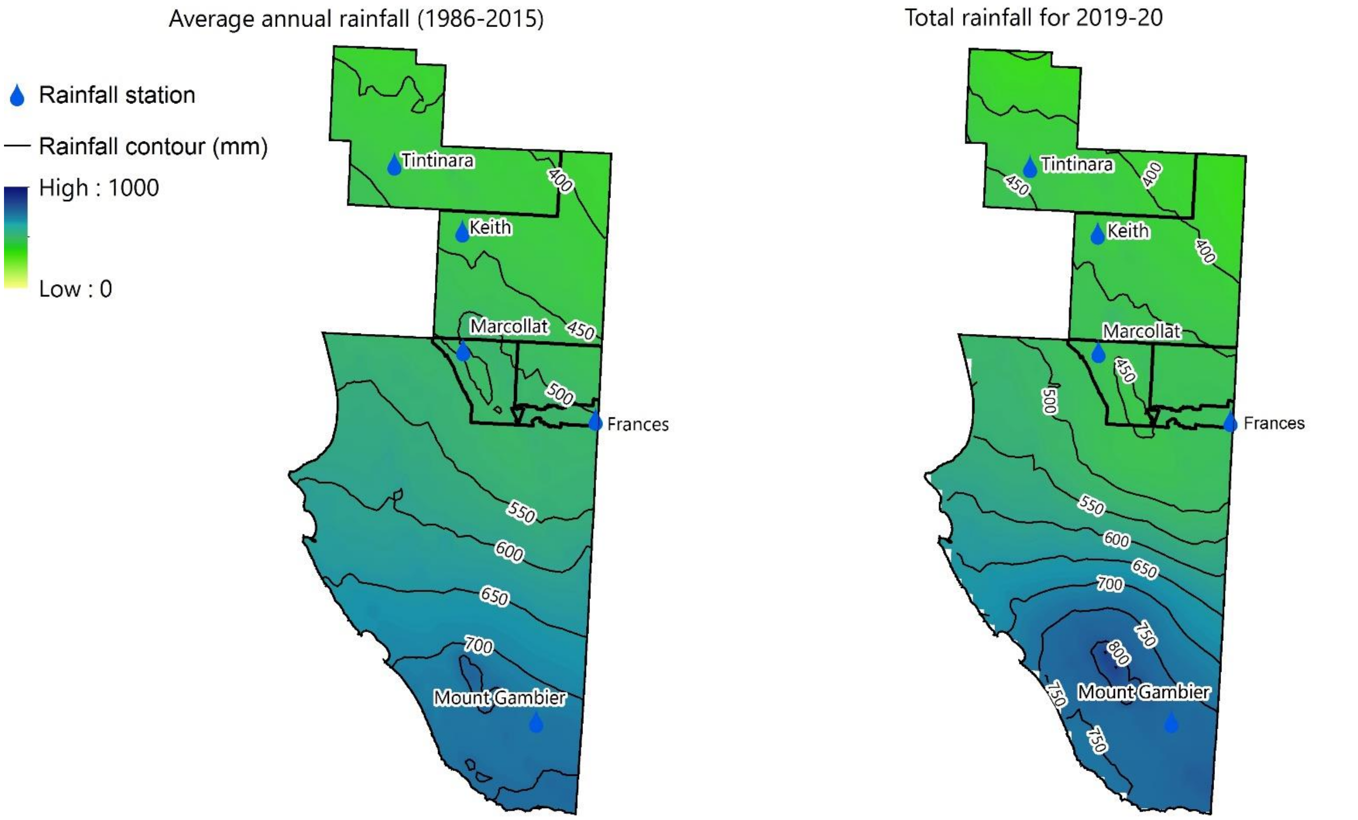

Figure 3.11. Rainfall in the Limestone Coast Landscape region PWAs for 2019–20 compared to the 30-year average (1986–2015)

Rainfall in 2019–20 is similar to the long-term average in the northern and central parts of the Limestone Coast Landscape region (Figure 3.11)[9]. Annual rainfall totals are higher than the long-term average around the southern townships of Millicent and Mount Gambier, where average annual rainfall is greatest.

[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 (Section 2.1).

4 Surface water

4.1 Streamflow

The main watercourse within the prescribed surface water area (PSWA) is the Morambro Creek, an ephemeral system with headwaters originating in the Wimmera region of western Victoria, it travels east to west through the prescribed area before terminating in Cockatoo Lake. From here, a spillway allows water to enter the Nyroca Channel, flowing for approximately 30 km in a north-westerly direction before discharging into the Marcollat watercourse. Analysis of available data indicates that 70-90% of the Morambro Creek's flow originates from the headwater catchment area in Victoria. The characteristics of creek flows are influenced by the occurrence of dams, drainage wells and natural runaway holes west of Frances. Surface water resources in the Morambro Creek PSWA are highly dependent on rainfall, with trends in streamflow and salinity primarily climate driven, i.e. lower than average winter rainfall will result in reduced annual streamflow volumes. Conversely, higher rainfall will result in increased surface water availability.

Morambro Creek streamflow gauging station (A2390531) at Bordertown-Naracoorte Road Bridge is the only station located within the PSWA. Streamflow was historically recorded at Cockatoo Lake, 15 km downstream of Morambro Creek gauging station, but this site has been decommissioned. Data from this site is not presented in this report.

In 2019–20, nil streamflow was recorded in the Morambro Creek and this was classified as 'Lowest on record' (Figure 4.1). Further detail on the methodology used for analysis can be found in Section 2.

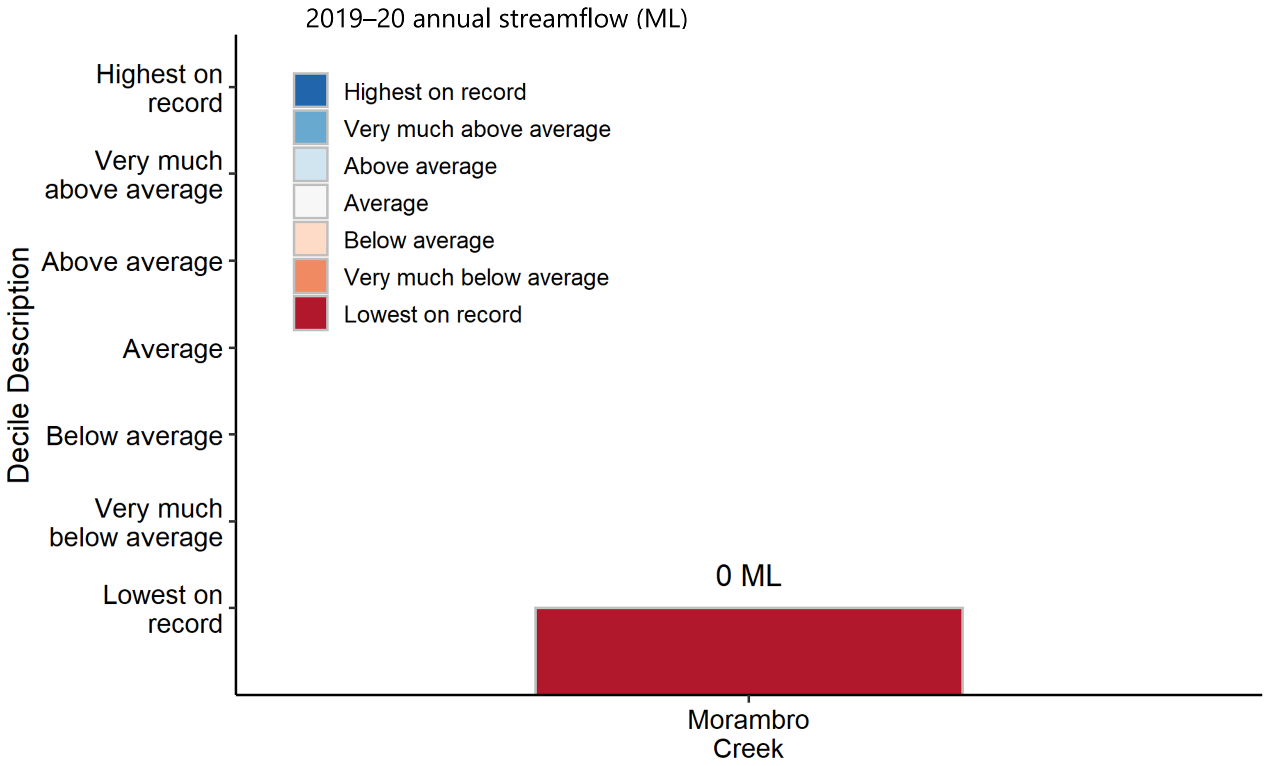

Figure 4.1. Morambro Creek PSWA annual streamflow summary 2019–20

4.1.1 Morambro Creek (A2390531)

The Morambro Creek streamflow gauging station has a catchment area of 1169 km^2 (301 km^2 is located within South Australia), and is located towards the western boundary of the PSWA prior to Morambro Creek entering Cockatoo Lake.

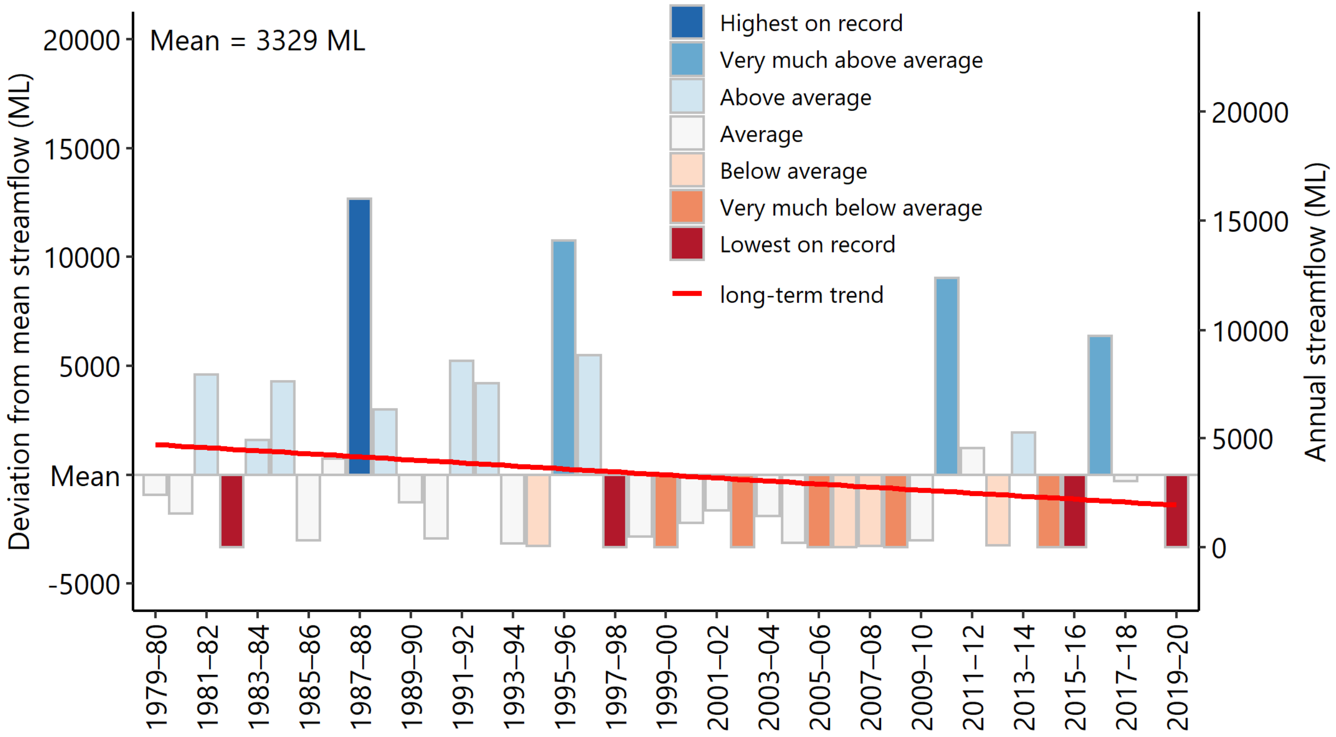

Figure 4.2. Annual deviation from mean streamflow at Morambro Creek (1979–80 to 2019–20)

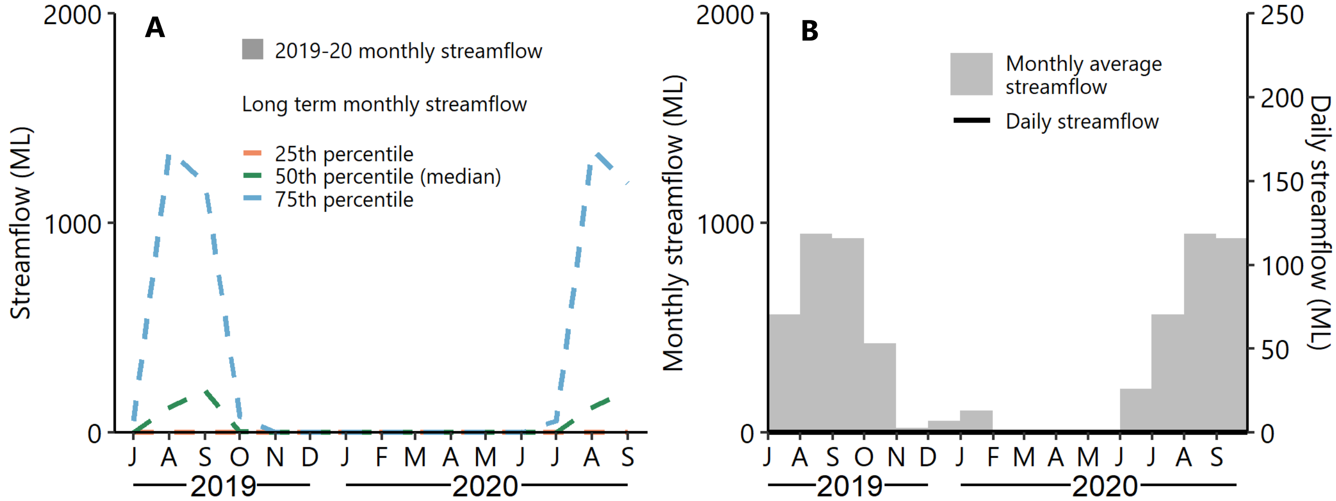

Figure 4.3. (A) Long-term monthly statistics and 2019–20 monthly streamflow at Morambro Creek; (B) Long-term average monthly streamflow and 2019–20 daily streamflow at Morambro Creek

The deviation of each individual year's streamflow from the long-term average is shown in Figure 4.2. No streamflow was recorded in the Morambro Creek in 2019–20 and this was classified as 'lowest on record'. The average annual streamflow is 3329 ML (1979–20) and the data indicates long-term declining trend.

Figure 4.3A shows the monthly streamflow for 2019–20 (grey bars) relative to the long-term monthly streamflow (1979–20) for (a) low flows (25th percentile), (b) median flows (50th percentile) and high flows (75th percentile). Morambro Creek is an ephemeral system and flows are not typically recorded between December and May. The majority of streamflow occurs between July and October and typically accounts for over 90% of the total annual flow in any given year. Figure 4.3B presents the long-term average monthly streamflow (1979–20) and the daily flows for 2019–20. In 2019–20, no streamflow was recorded throughout the year and this was based on unverified telemetry data with flows remaining below the recordable range.

4.2 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 in the PSWA at the Morambro Creek streamflow gauging station (A2390531). Due to the ephemeral nature of Morambro Creek, at times the watercourse is dry and salinity cannot be recorded. This has been the case for the entirety of 2019–20 as no streamflow was recorded. Figure 4.4 shows the long-term monthly salinity statistics for the period 2007–20 at the Morambro Creek streamflow gauging station. The box-and-whisker plots are not presented between November and June due to unreliable data. The majority of the salinity data is less than 250 mg/L over the period of record, indicating a very fresh section of watercourse.

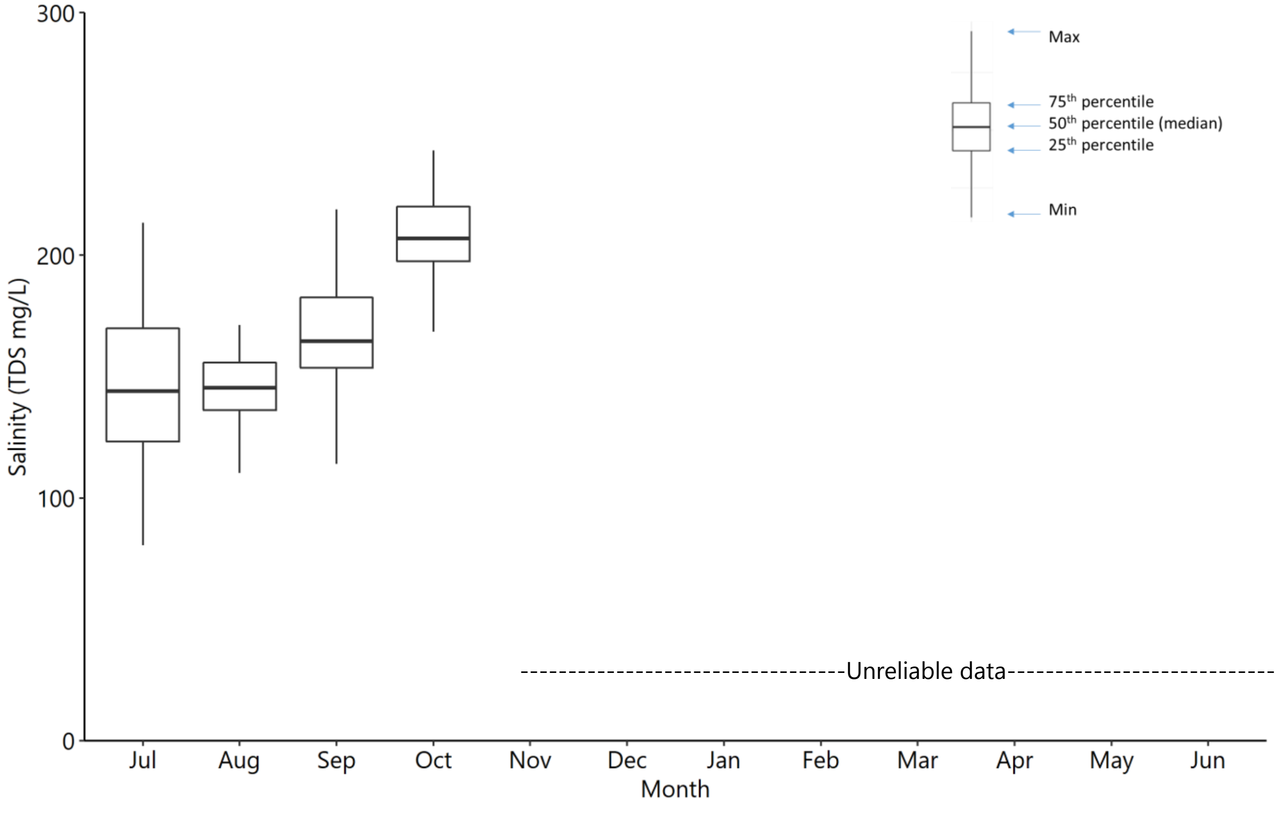

Figure 4.4. Long-term monthly salinity at Morambro Creek streamflow gauging station (A2390531)

5 Groundwater

5.1 Hydrogeology

The Limestone Coast Landscape region is underlain by Tertiary sediments of the Otway Basin in the south, with a continuous transition to equivalent sediments of the Murray Basin in the north. Groundwater occurs within two regional-scale sedimentary groundwater systems (SE NRM Board, 2013):

- the upper unconfined Tertiary Limestone Aquifer (known generally as the unconfined aquifer), which comprises Quaternary and Tertiary limestone
- the underlying Tertiary Confined Sand Aquifer (known generally as the confined aquifer), which consists of quartz sands, interbedded with dark brown carbonaceous clays.

The confined and unconfined aquifers are generally separated by a low permeability aquitard. The main source of recharge to the unconfined aquifer is the direct infiltration of local rainfall. Groundwater in both systems flows from the topographic high of the Dundas Plateau, located in western Victoria, to the south east in a radial direction, heading westward and southward towards the coast.

The Limestone Coast Landscape region can be divided topographically into two landforms with different hydrogeological characteristics, where each requires a tailored approach to groundwater management. There are low-lying coastal plains or flats in the south and west, with highlands or ranges to the east and north. The northern and central parts of the Lower Limestone Coast PWA are characterised by northwest-trending remnants of former coastal dunes, separated by inter-dunal flats.

For the purpose of this assessment, each prescribed area is split into plains and highlands sub-areas based on unconfined aquifer groundwater management areas (Table 5.1).

Table 5.1. Groundwater management areas used for the plains and highlands areas

Prescribed Wells Area	Sub-area	Groundwater management areas (GMAs)
Lower Limestone Coast	Highlands	Comaum, Joanna, Zone 5A, Hynam East, Frances, Beeamma, Bangham, Western Flat
	Coastal Flats and Donovans	*All other unconfined management areas*
Padthaway	Flats	Padthaway Flats
	Ranges	Padthaway Range
Tatiara	Coastal Plain	Willalooka, Stirling, North Pendleton, Wirrega
	Highlands	Cannawigara, Shaugh, Zone 8A Senior, Tatiara
Tintinara-Coonalpyn	Coastal Plain	Coonalpyn, Boothby, Tintinara
	Mallee highlands	Sherwood

5.1.1 Unconfined aquifer

The Quaternary Padthaway, Coomandook and Bridgewater Formations form the unconfined aquifer in the northern and central parts of the Limestone Coast Landscape region. In the southern part of the Lower Limestone Coast PWA, the Tertiary Gambier Limestone forms the main unconfined aquifer and generally comprises a creamy bryozoal limestone which varies in thickness and is up to 400 m thickness offshore to the south. The permeability of the aquifer is highly variable, with very high transmissivities that are associated with karstic solution features. Beneath the highlands, the unconfined aquifer is contained in the Tertiary Murray Group Limestone, which is in the Murray Basin and is equivalent to the Gambier Limestone of the Otway Basin.

5.1.2 Confined aquifer

The confined aquifer in the Murray Basin, which is located towards the north of the Lower Limestone Coast PWA, occurs in the Renmark Group. Here, the confined aquifer consists of interbedded sands, silt and carbonaceous clay up to 100 m thickness.

In the northern part of the Lower Limestone Coast PWA, the confined aquifer is thin or absent due to the presence of shallow basement rocks around the Padthaway Ridge. In these areas it is not widely used due to comparatively low well yields of 10–20 L/s and the greater availability of groundwater in the overlying unconfined aquifer.

Over most of the southern and central parts of the Lower Limestone Coast PWA, the main confined aquifer occurs in the Dilwyn Formation, which consists of quartz sands interbedded with dark brown carbonaceous clays. The confined aquifer in these areas is a complex multi-aquifer system; however, for management and reporting purposes at the regional scale, it is considered a single aquifer.

5.2 Unconfined aquifer

5.2.1 Lower Limestone Coast PWA – Coastal Flats and Donovans area – water level

During 2019–20, 46% of unconfined aquifer monitoring wells were classified 'Below average' (Section 2.3.1) compared to historical levels (Figure 5.1). The majority of these wells are located where the watertable is shallow (i.e. less than 10 m below ground level) and within the inter-dunal flats. A small number of wells (7%) show their lowest winter-recovered water level on record; these were generally located south of Mount Gambier near areas of intensive irrigation, forestry plantations or near drainage networks.

Five-year trends show declining water levels for 283 wells (78%) with rates of decline ranging from 0.02 m/y to 0.88 m/y (median 0.10 m/y; Figure 5.2). Over the period 19902020, water levels have declined in 146 of 152 wells (96%); the median change in water level is a decline of 1.11 m.

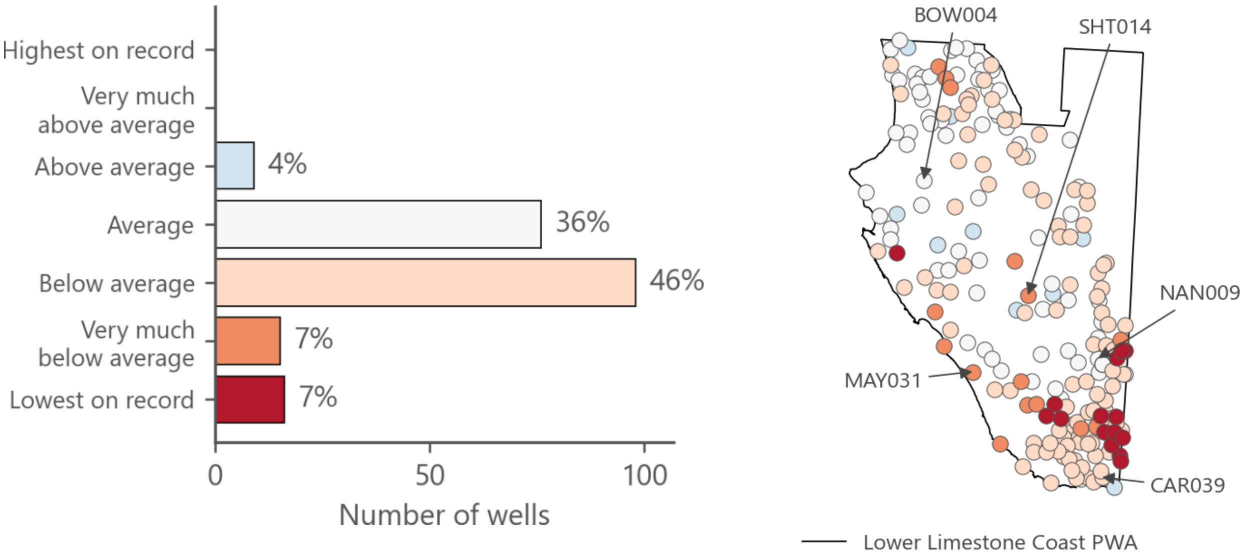

Figure 5.1. 2020 winter-recovered water levels for wells in the unconfined aquifer in the Coastal Flats and Donovans area of the Lower Limestone Coast PWA

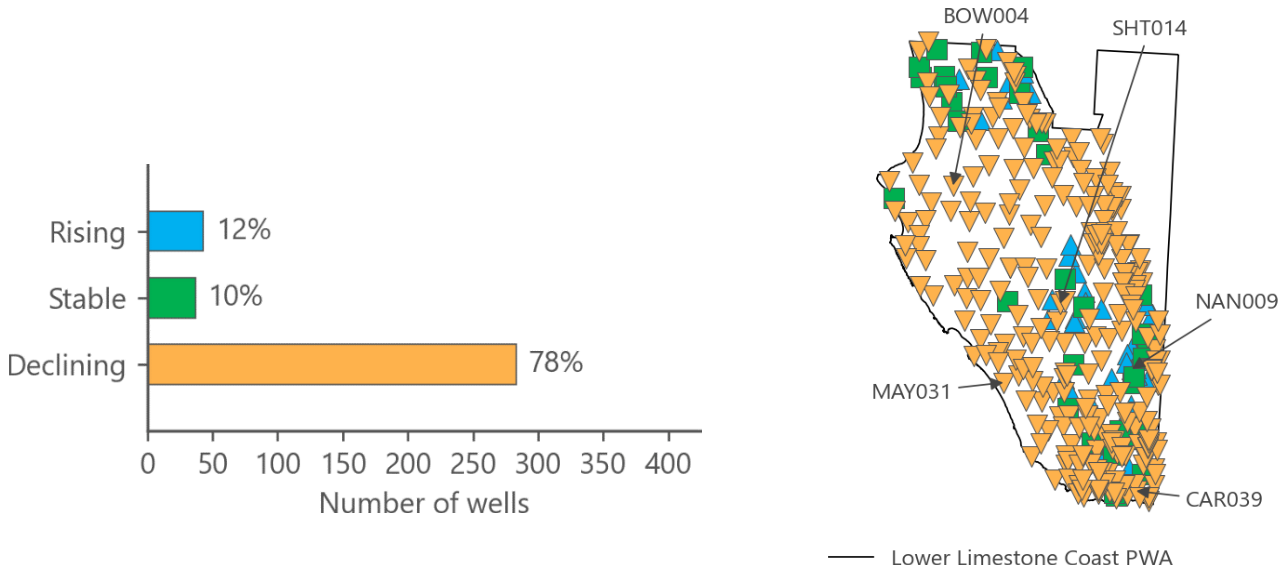

Figure 5.2. Five-year trend in winter-recovered water levels (201620) for wells in the unconfined aquifer in the Coastal Flats and Donovans area of the Lower Limestone Coast PWA

Since 1993, groundwater levels from monitoring wells located in those parts of the coastal plain with a shallow watertable show a consistent decline in groundwater levels (e.g. MAY031; Figure 5.3). Wetter conditions since 2009 have led to recovery of some water levels in these areas (e.g. BOW004).

Monitoring wells SHT014 and NAN009 are located near commercial forestry plantations and show water table declines of several metres. NAN009 shows a rise in water level, which is likely due to increased recharge after the 1983 Ash Wednesday bushfires (Harrington and Lamontagne, 2013).

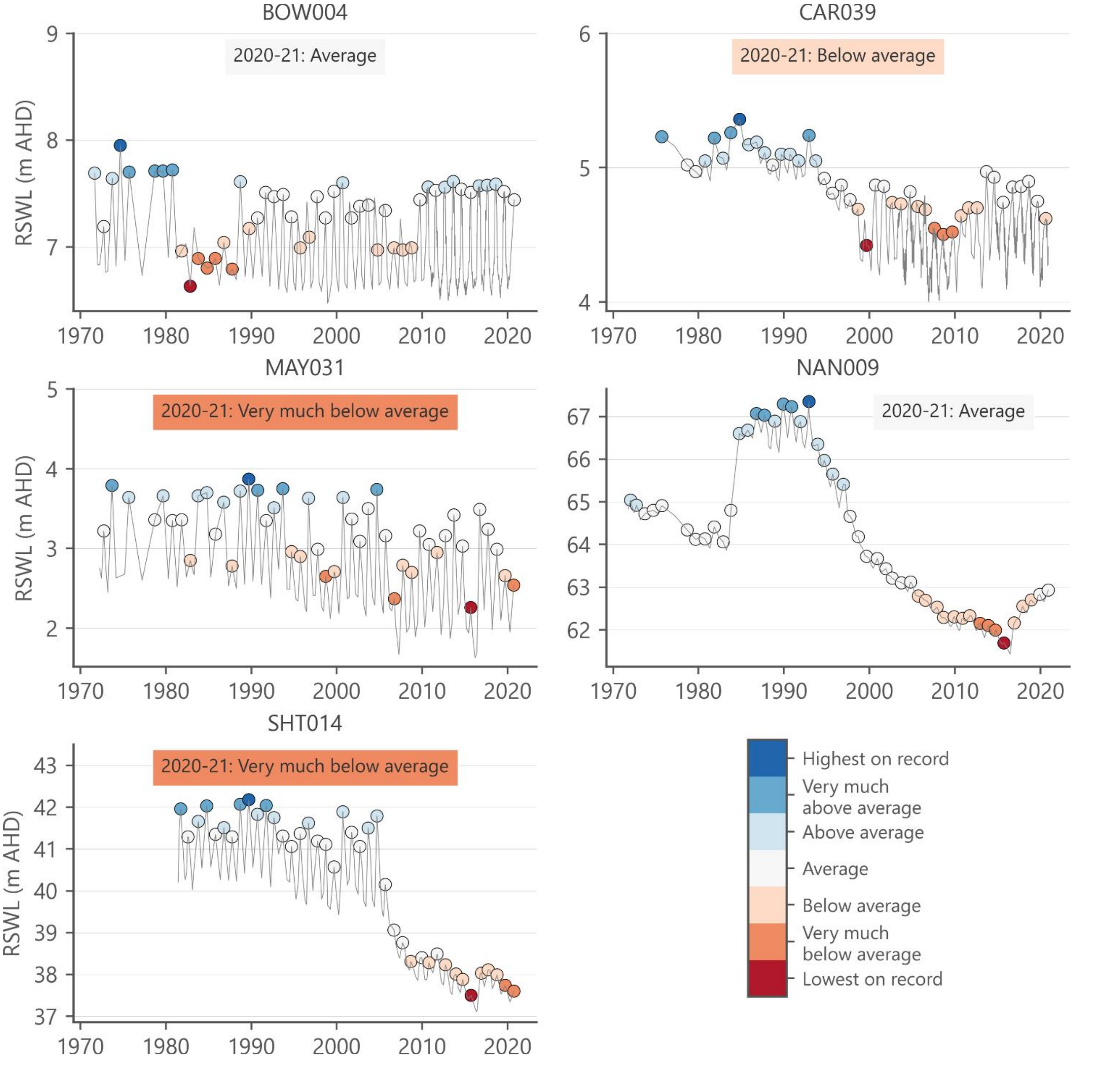

Figure 5.3. Selected hydrographs for wells in the unconfined aquifer in the Coastal Flats and Donovans area of the Lower Limestone Coast PWA

5.2.2 Lower Limestone Coast PWA – Coastal Flats and Donovans area – salinity

In 2020, unconfined groundwater salinity in the Coastal Flats and Donovans area ranges from around 177 mg/L to 32 269 mg/L, although 95% of wells show salinity of less than 3000 mg/L and 79% of wells show salinity of less than 1000 mg/L (Figure 5.4). The majority of wells with salinity less than 1000 mg/L are located towards the south of the PWA. The median salinity from all wells is 629 mg/L.

Trends in salinity across the coastal plains are variable due mainly to the large area, and spatial variations in aquifer properties and depth to groundwater. In the 10 years to 2020, greater than half of monitoring wells (52%) show a decreasing trend in groundwater salinity. Trends in salinity vary from a decrease of 19.84% per year to an increase of 5.75% per year, with a median rate of 0.07% decrease per year (Figure 5.5).

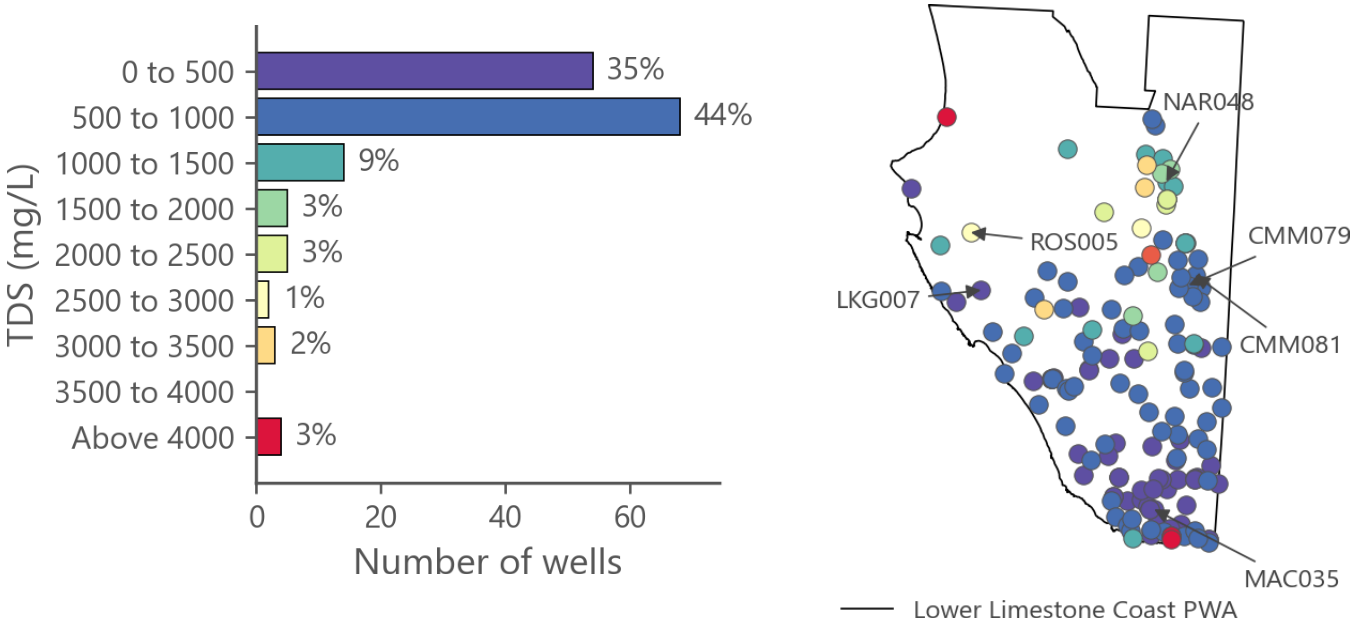

Figure 5.4. 2020 salinity observations from wells in the unconfined aquifer in the Coastal Flats and Donovans area of the Lower Limestone Coast PWA

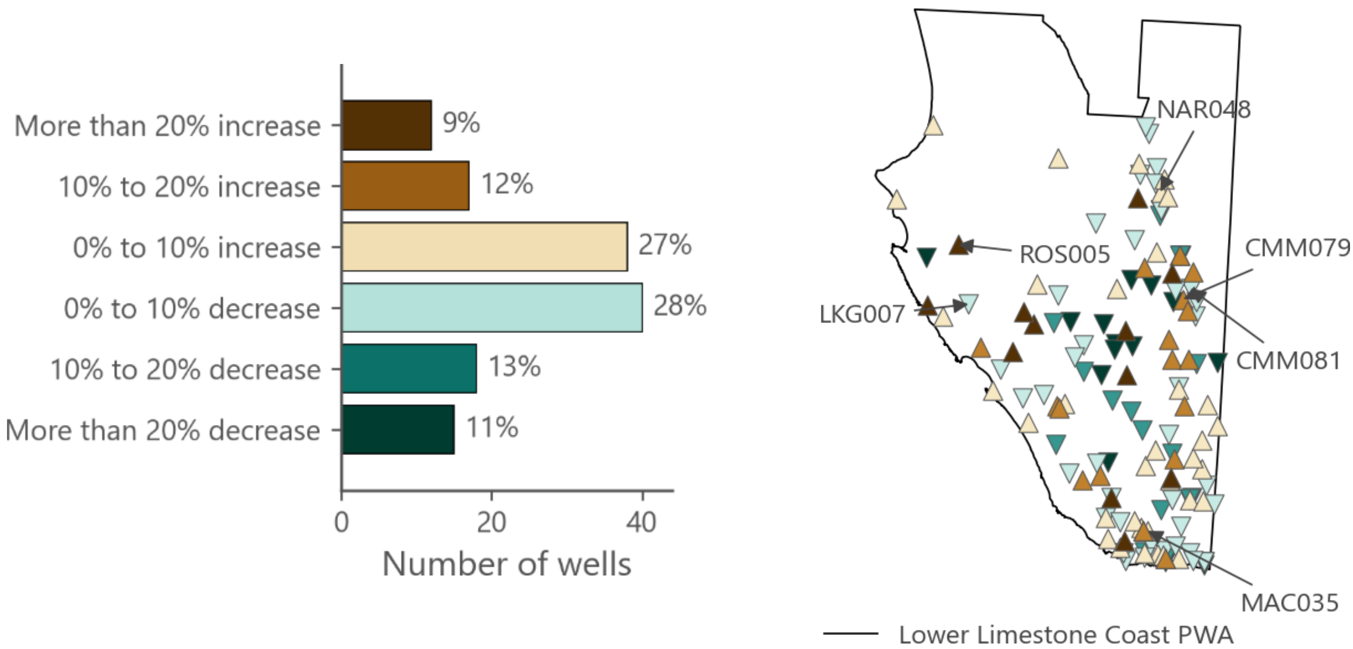

Figure 5.5. Salinity trend in the 10 years to 2020 for wells in the unconfined aquifer in the Coastal Flats and Donovans area of the Lower Limestone Coast PWA

Groundwater salinity in the unconfined aquifer around the inter-dunal flats is generally stable (e.g. NAR048, Figures 5.5 and 5.6) or decreasing. Areas of flood irrigation (e.g. ROS005) may increase groundwater salinity at the local scale, through the evapoconcentration of irrigation drainage water in processes such as those studied on the Padthaway Flat (Harrington et al., 2006).

Where stresses on the groundwater system are absent (e.g. from intensive extraction or land use change), salinity is generally stable, while some wells display decreasing salinity in the longer term (e.g. LKG007).

Observation well CMM079 is located near Coonawarra within an area of intensive irrigation. Long-term monitoring data show increasing salinity, primarily from the late-1990s. This increase could be due to flushing of concentrated salt in the soil profile down to the watertable. However, CMM081 (located north of Coonawarra) and MAC035 (located north of Port MacDonnell) show relatively stable salinity over the same period, despite also being in areas of intensive irrigation.

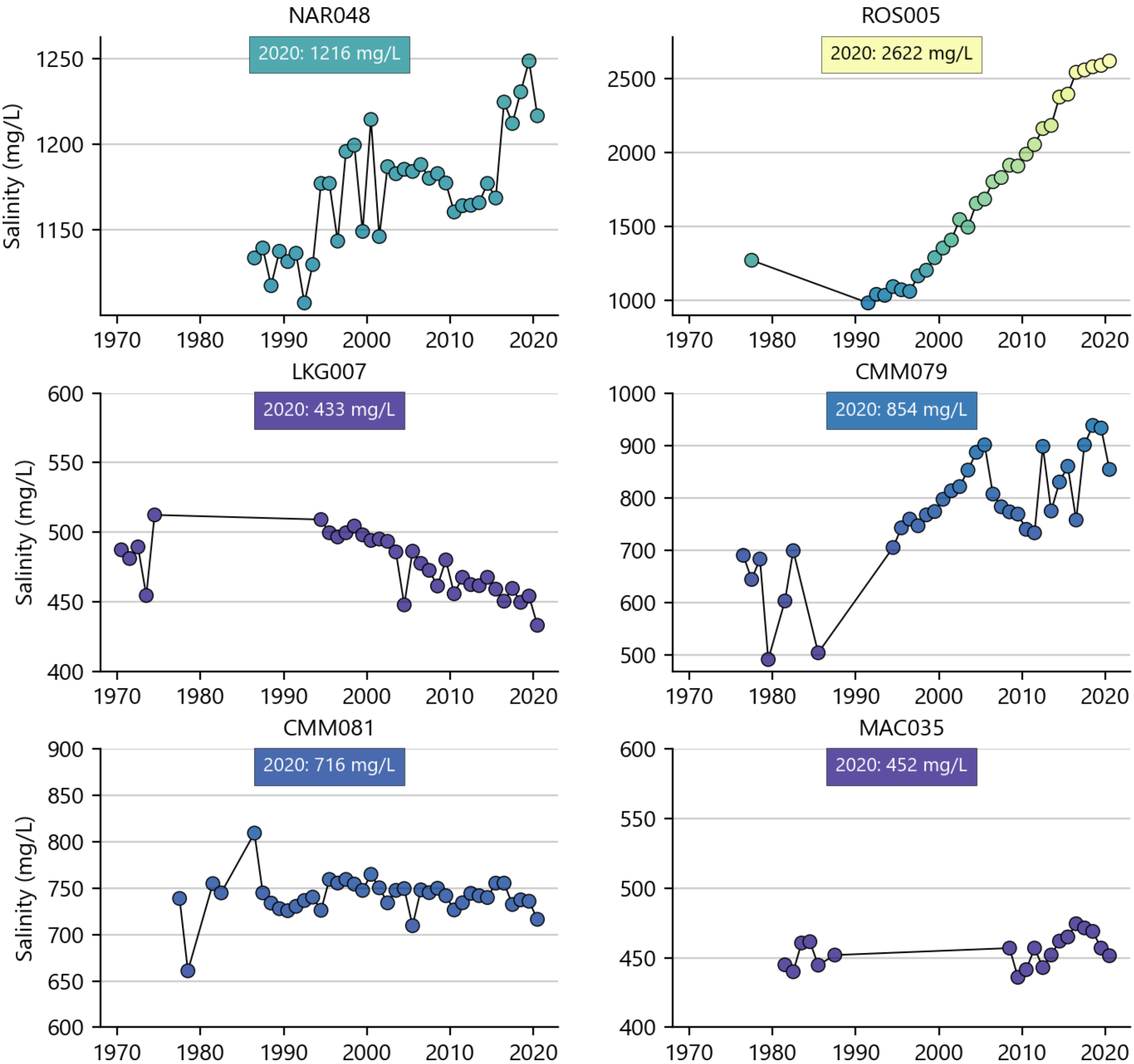

Figure 5.6. Selected salinity graphs for wells in the unconfined aquifer in the Coastal Flats and Donovans area of the Lower Limestone Coast PWA

5.2.3 Lower Limestone Coast PWA – Highlands area – water level

During 2019–20, the majority (87%) of wells show winter-recovered water levels which are classified lower than 'Average' (Section 2.3.1; Figure 5.7), while 39% of wells show their lowest winter-recovered level on record. Only 13% of wells recovered to levels classified 'Average'; these wells are mostly located in a transitional zone between the Highlands and the Coastal Flats and Donovans areas. In the past 30 years, 20 of 21 wells show declines in water level of up to 4.22 m (the median change is a decline of 1.81 m).

Five-year trends, which are calculated from 31 wells, show mainly declining water levels (82%), with rates of decline ranging from 0.03 m/y to 0.28 m/y (median 0.07 m/y; Figure 5.8).

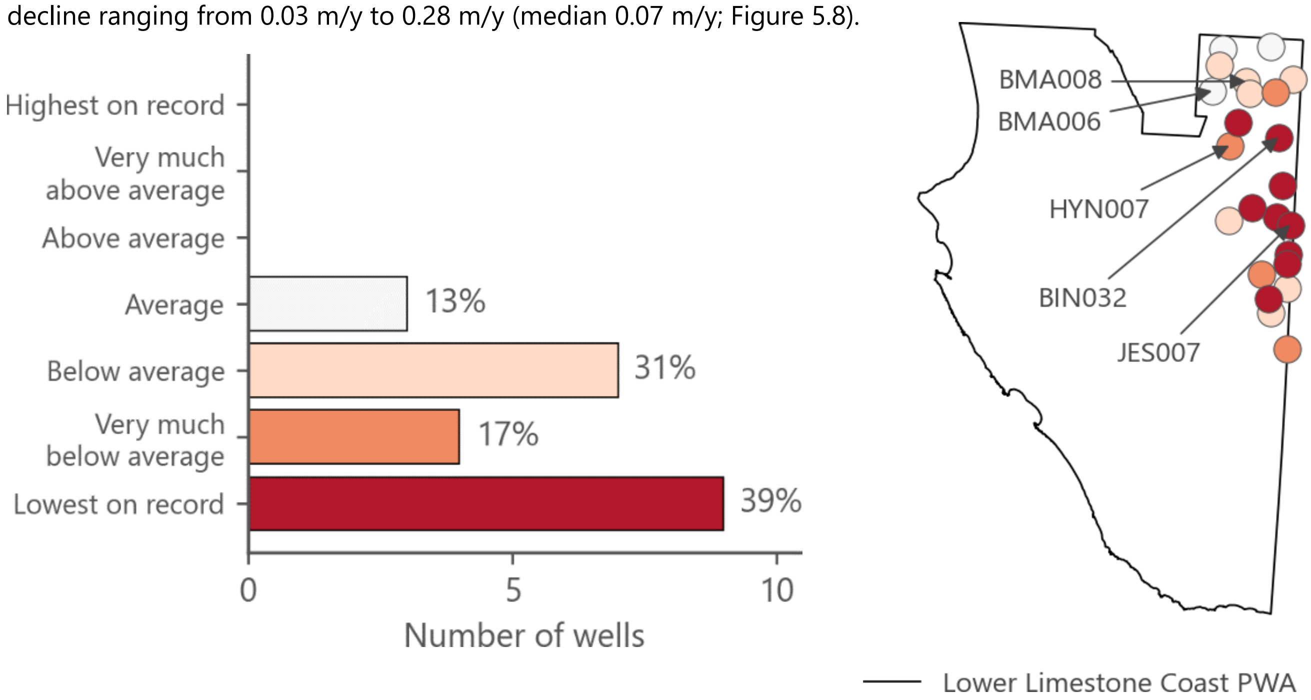

Figure 5.7. **2020 winter-recovered water levels for wells in the unconfined aquifer in the highlands area of the Lower Limestone Coast PWA**

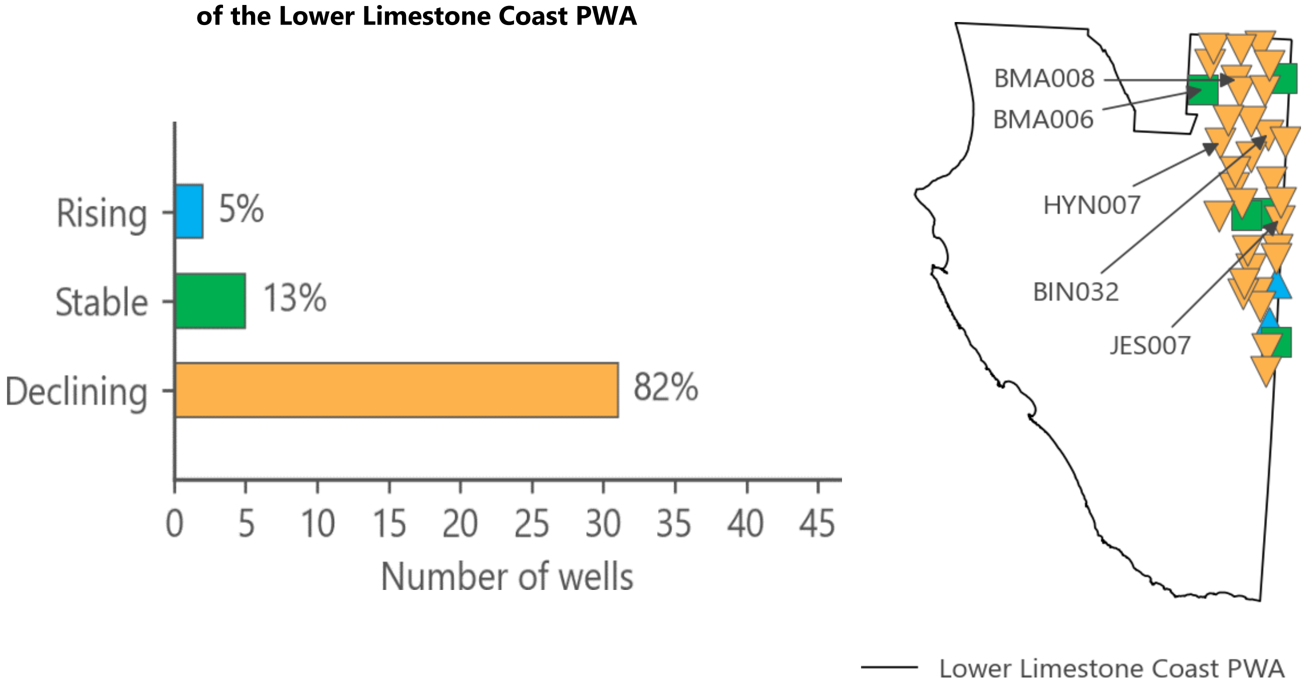

Figure 5.8. **2016–20 trend in winter-recovered water levels for wells in the unconfined aquifer in the highlands area of the Lower Limestone Coast PWA**

In the unconfined aquifer beneath the Highlands area, where the depth to the watertable is generally greater than 10 m, groundwater levels are increasing. This may be in response to widespread clearance of native vegetation, which can result in increased rates of groundwater recharge. Prior to the mid to late-1990s, increasing water levels of up to 0.2 m/y are apparent in several representative wells (e.g. BMA006, BMA008, HYN007, JES007) (Figure 5.7). This rising trend persisted for several years after the commencement of a prolonged period of below-average rainfall around 1997 (Figure 3.3) but subsequently, water levels have typically been declining.

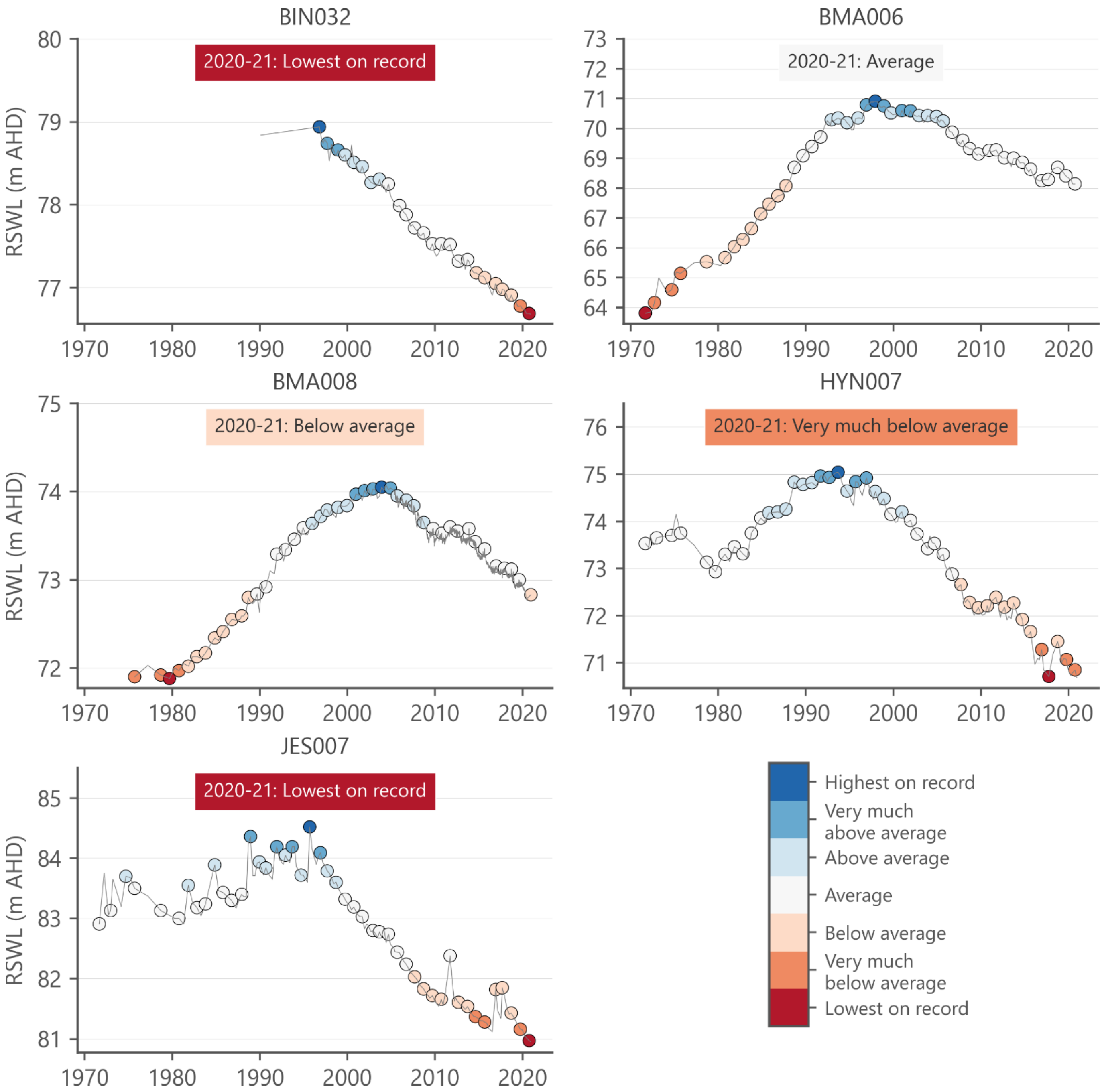

Figure 5.9. Selected hydrographs for wells in the unconfined aquifer in the highlands area of the Lower Limestone Coast PWA

5.2.4 Lower Limestone Coast PWA – Highlands area – salinity

Regular groundwater salinity monitoring in (the former) Naracoorte Ranges PWA began in 1987. The widespread clearance of native vegetation has resulted in increased recharge rates and the flushing of salt down to the watertable, which was previously stored in the root zones of native vegetation (Wohling, 2007). This process is occurring independent of any irrigation activity, although deep drainage beneath irrigated areas is likely to accelerate the process at the local scale.

In 2020, the groundwater salinity ranges from around 414 mg/L to 2035 mg/L. The majority of wells (74%) show salinities between 900–1800 mg/L, with a median of 1295 mg/L (Figure 5.10).

In the 10 years to 2020, the majority of monitoring wells (71%) show an increase in groundwater salinity. Trends in salinity over the past 10 years varies from a decrease of 3.07% per year to an increase of 1.43% per year, with a median rate of 0.14% increase per year (Figure 5.11).

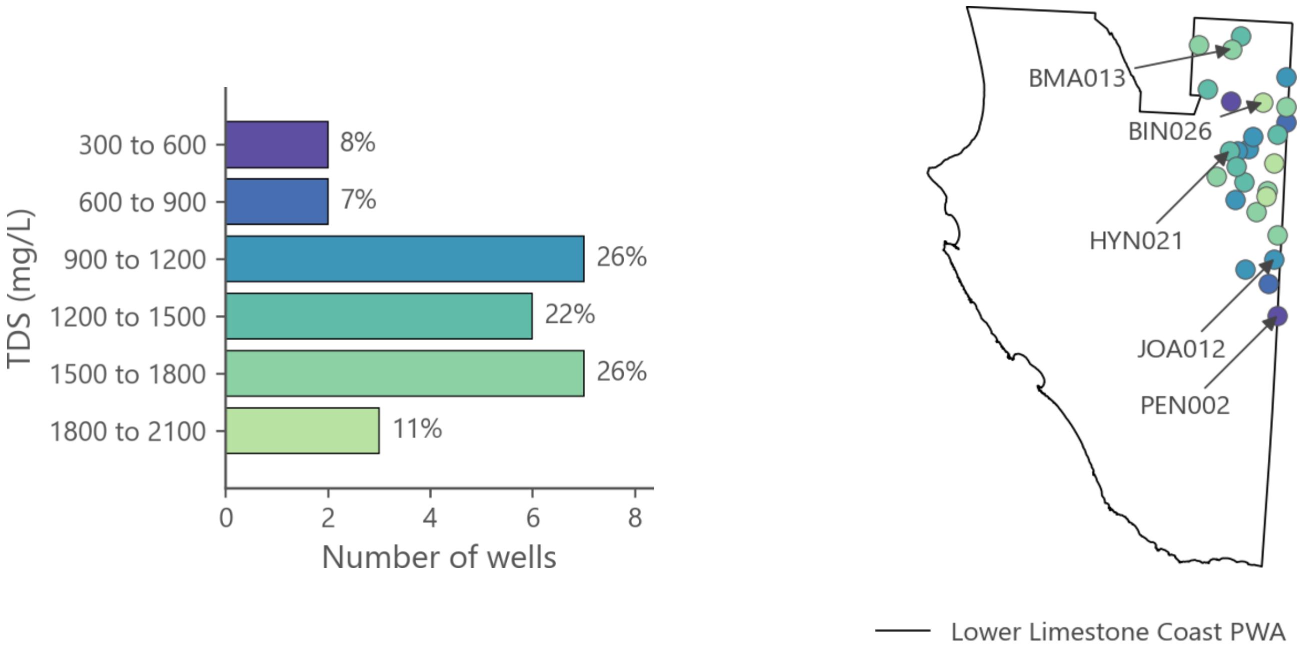

Figure 5.10. 2020 salinity measurements from wells in the unconfined aquifer in the Highlands area of the Lower Limestone Coast PWA

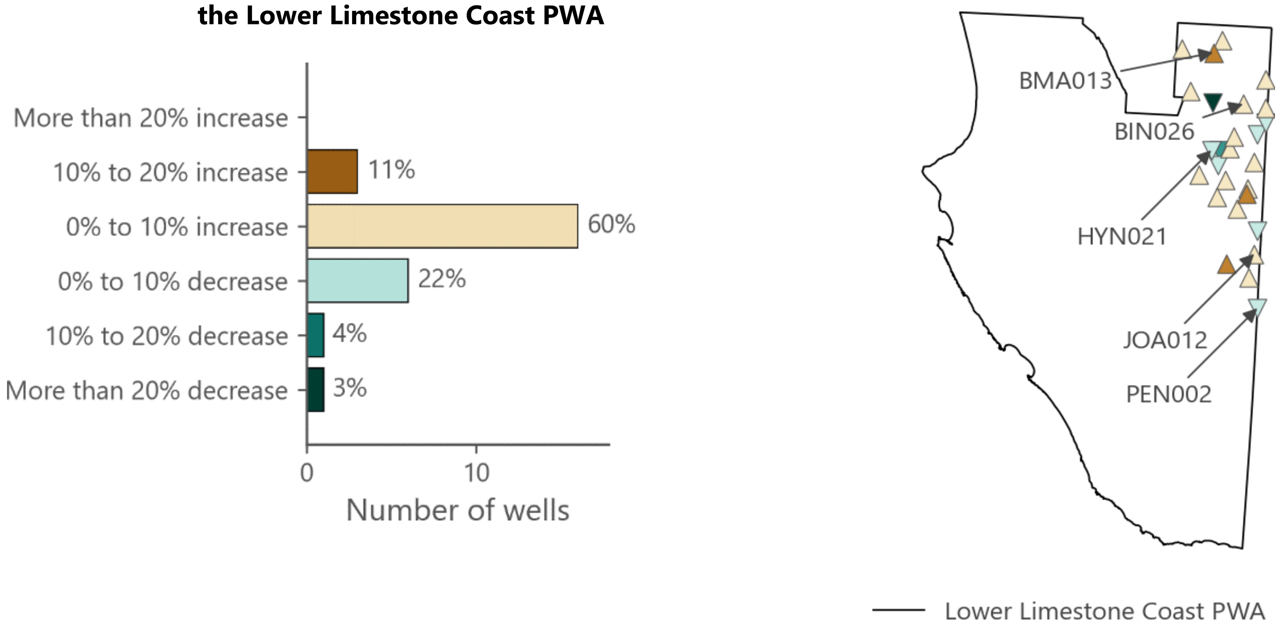

Figure 5.11. Salinity trends in the 10 years to 2020 for wells in the unconfined aquifer in the Highlands area of the Lower Limestone Coast PWA

Figure 5.12). Observation well BMA013 (Figure 5.11) is showing a continuous increasing salinity since monitoring began in 1986. At JOA012, an increase in salinity is apparent prior to 2000, but has remained relatively stable since. Salinities at BIN026 and HYN021 show very small variations in increasing salinity over the past 30 years of around ±100 mg/L.

Observation well PEN002, which is located within a forestry and native vegetation area, shows a small decrease in salinity from early-2000s to 2020 of around 200 mg/L.

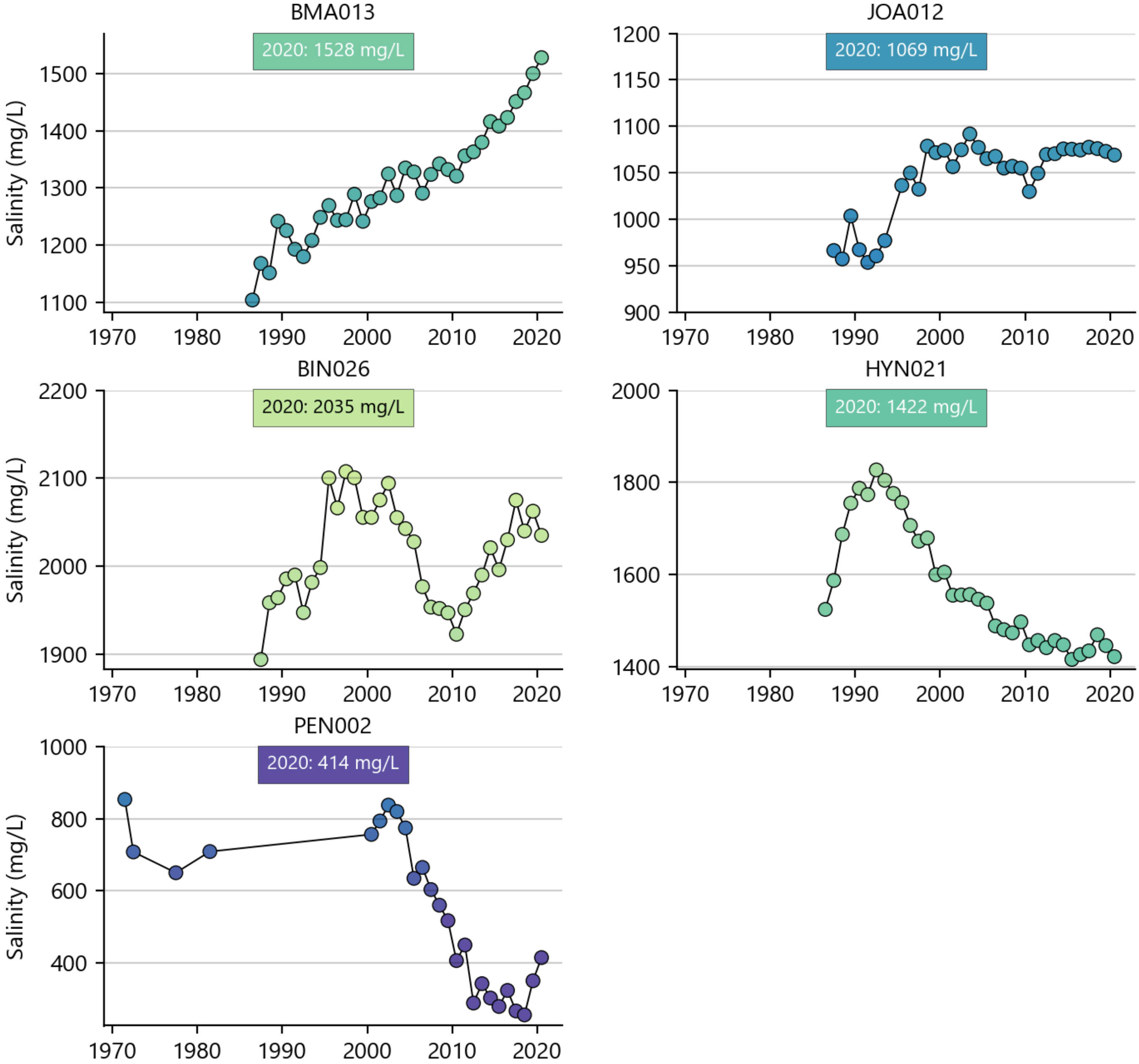

Figure 5.12. Selected salinity graphs for wells in the unconfined aquifer in the Highlands area of the Lower Limestone Coast PWA

5.2.5 Padthaway PWA – Padthaway Flats GMA – water level

Following the 2020–21 irrigation season, most monitoring wells (20 wells; 80%) are classified 'Below average' when compared to their historical record (Section 2.3.1; Figure 5.13). The remaining wells (5 wells; 20%) are classified 'Average' or 'Very much above average'; these are located along a transitional zone between the Padthaway Flats and Padthaway Range management areas.

All monitoring wells show lower water levels in 2020 compared to 30 years ago (Section 2.3.1); the median decline over this period was 1.81 m, with a maximum decline of 2.48 m. However, five-year water level trends (Figure 5.14) show rising levels in the majority of monitoring wells (68%), with rates of rise ranging from 0.03 m/y to 0.20 m/y (median 0.07 m/y).

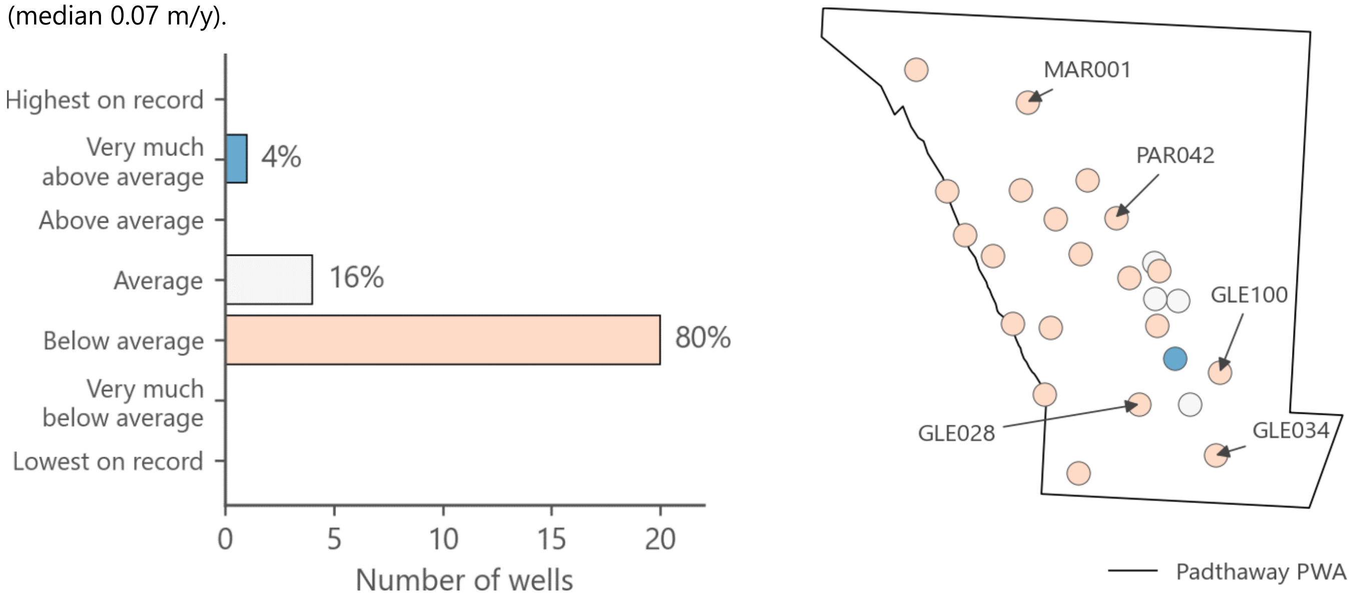

Figure 5.13. 2020 winter-recovered water levels for wells in the unconfined aquifer in the Padthaway Flats management area of the Padthaway PWA

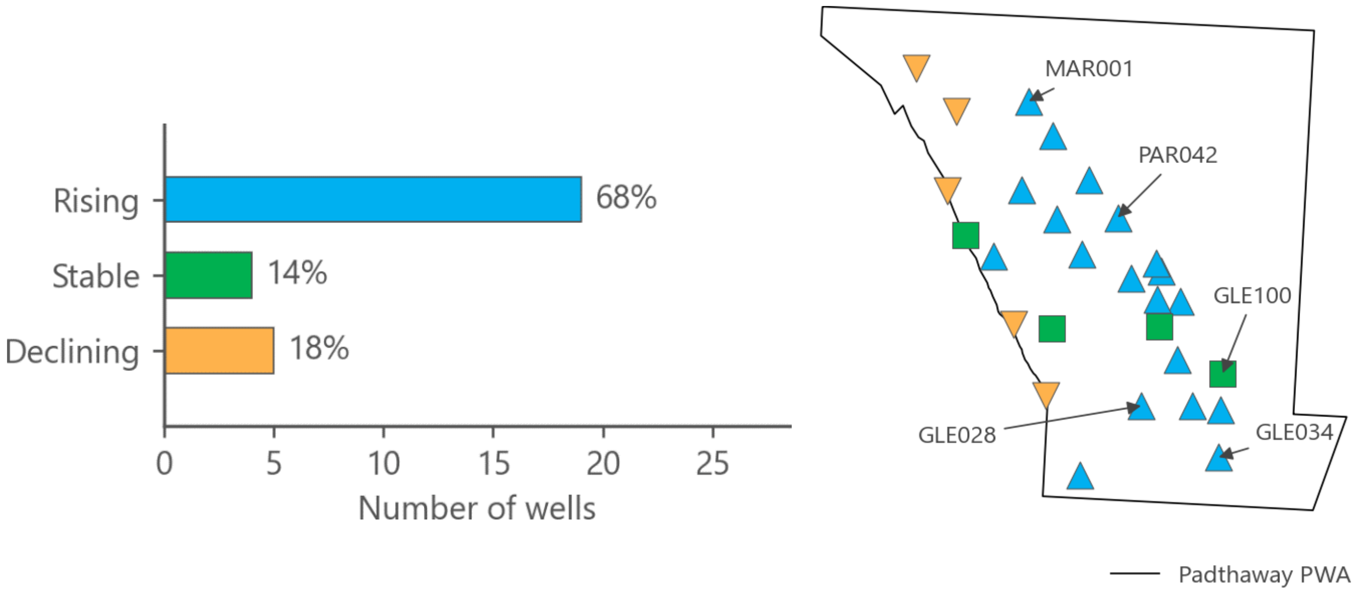

Figure 5.14. 2016–20 trend in winter-recovered water levels for wells in the unconfined aquifer in the Padthaway Flats management area of the Padthaway PWA

The depth to the watertable in much of the Padthaway Flats management area is less than 5 m and consequently, groundwater levels are very responsive to rainfall. Long-term water level data from representative monitoring wells such as MAR001, PAR042, GLE028, GLE100, and GLE034 (Figure 5.15) show a close correlation with rainfall. Below-average rainfall since 1993 (Figure 3.5) aligns with declines in water levels of around 1–2 m. In the periods 2009–11 and 2016–17, above-average annual rainfall aligns with sharp recoveries in water levels.

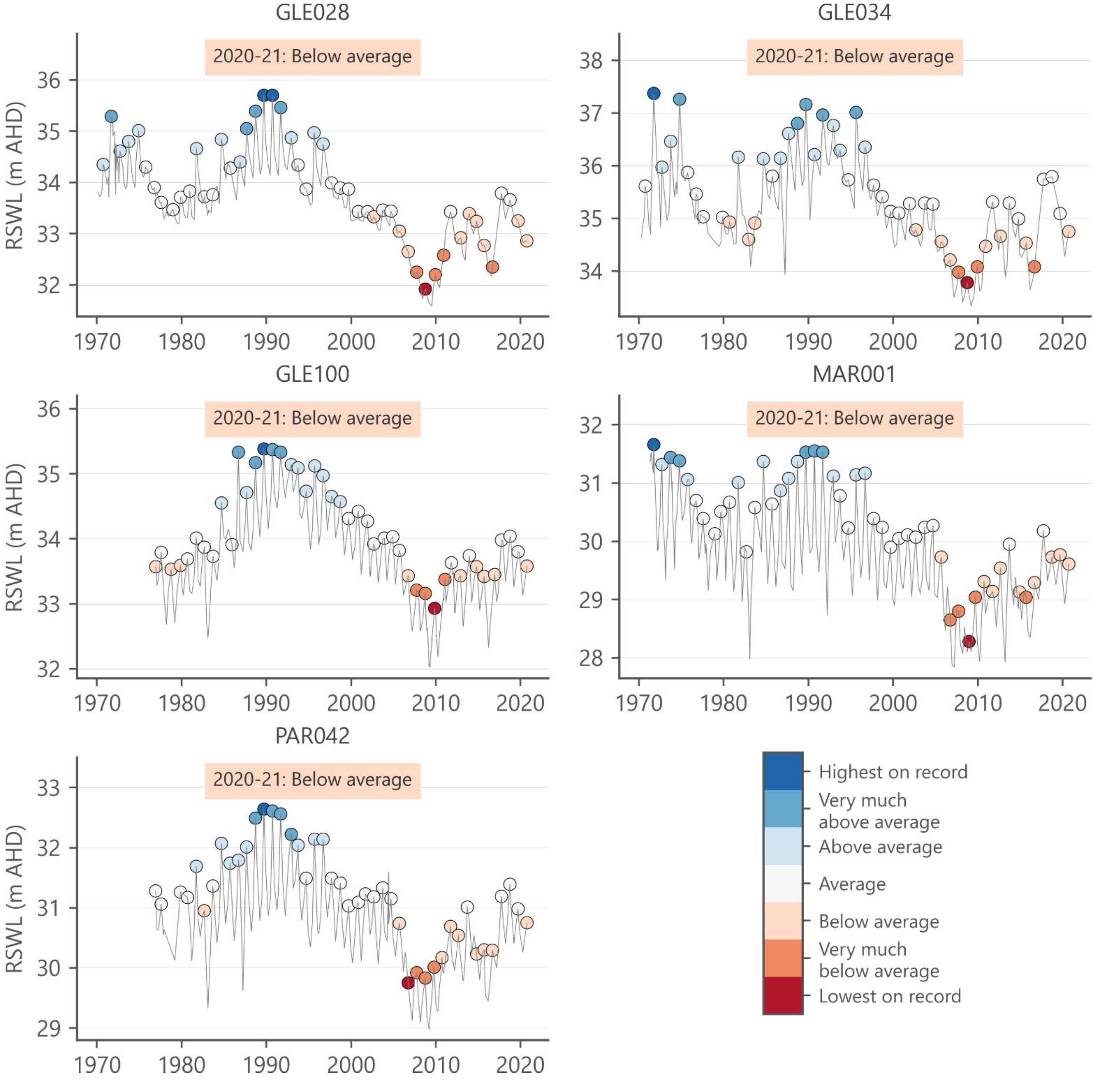

Figure 5.15. Selected hydrographs for wells in the unconfined aquifer in the Padthaway Flats management area of the Padthaway PWA

5.2.6 Padthaway PWA – Padthaway Flats GMA – salinity

In 2020, groundwater salinity in the Padthaway Flats unconfined aquifer ranges from 958 mg/L to 9102 mg/L; 90% of wells show salinities less than 2100 mg/L (Figure 5.16) with a median of 1550 mg/L.

In the 10 years to 2020, the majority of monitoring wells (79%) show trends of increasing groundwater salinity. Trends in salinity vary from a decrease of 2.32% per year to an increase of 2.94% per year, with a median rate of 0.70% increase per year (

Figure 5.17). Wells showing rates of increase greater than 20% over 10 years are generally located on the western edge of the PWA at the coast, towards the end of the groundwater flow path prior to being discharged to the ocean.

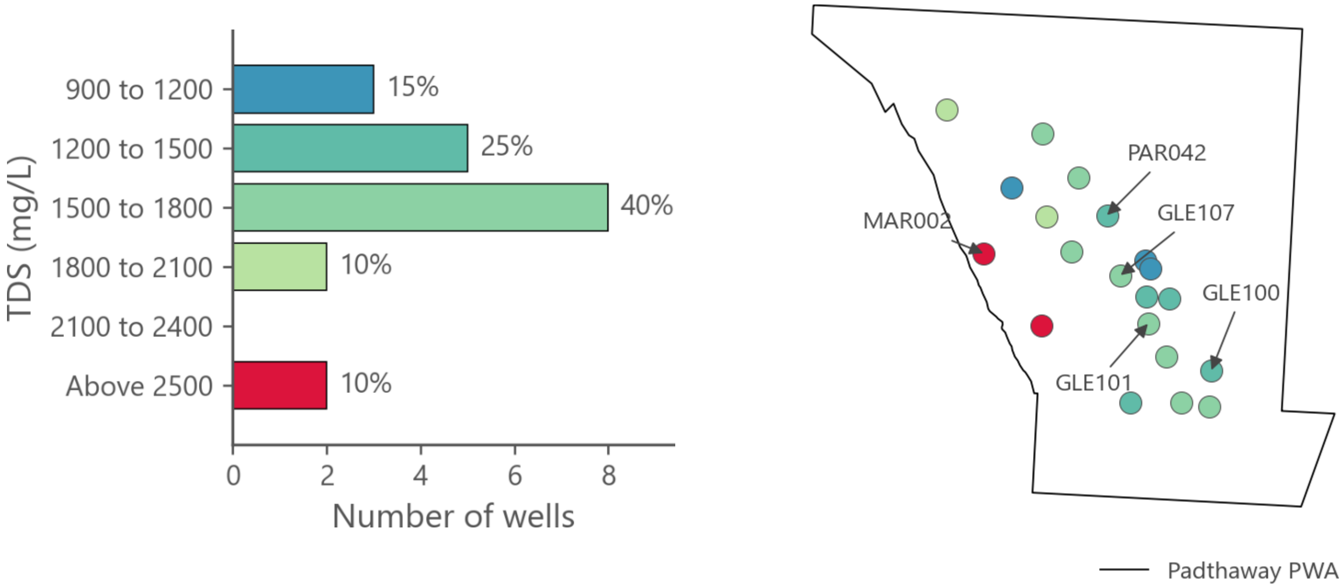

Figure 5.16. 2020 salinity observations from wells in the unconfined aquifer in the Padthaway Flats management area of the Padthaway PWA

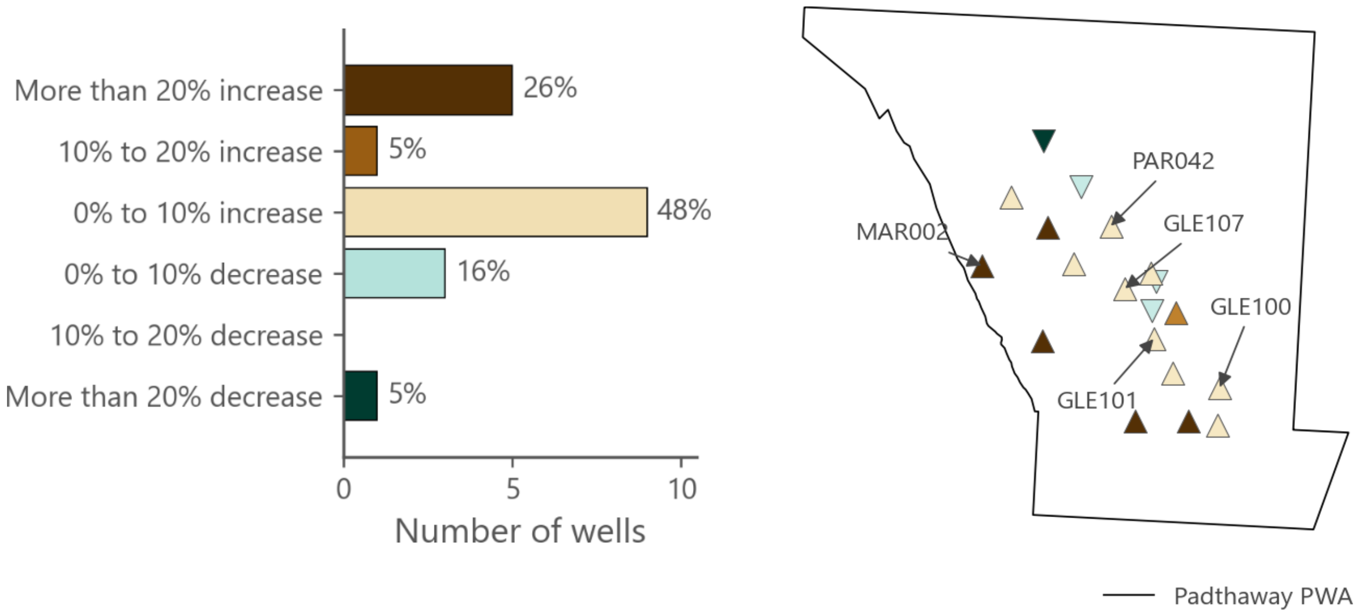

Figure 5.17. Salinity trend in the 10 years to 2020 for wells in the unconfined aquifer in the Padthaway Flats management area of the Padthaway PWA

In the shallow unconfined aquifer, rates of change in groundwater salinity can be variable and may be influenced by rainfall patterns and irrigation practices. PAR042, GLE107 and GLE100 (Figure 5.18) all show a consistent trends of increasing salinity, which corresponds to an extended period of below-average rainfall since around 2004 (Figure 3.5). Variations in salinity in GLE101 show an inverse correlation with rainfall (Figure 3.5).

To the west of the PWA, increases in salinity over the past 10 years are greatest (e.g. MAR002;

Figure 5.17), which may be explained by the recycling of irrigation water in the shallow aquifer.

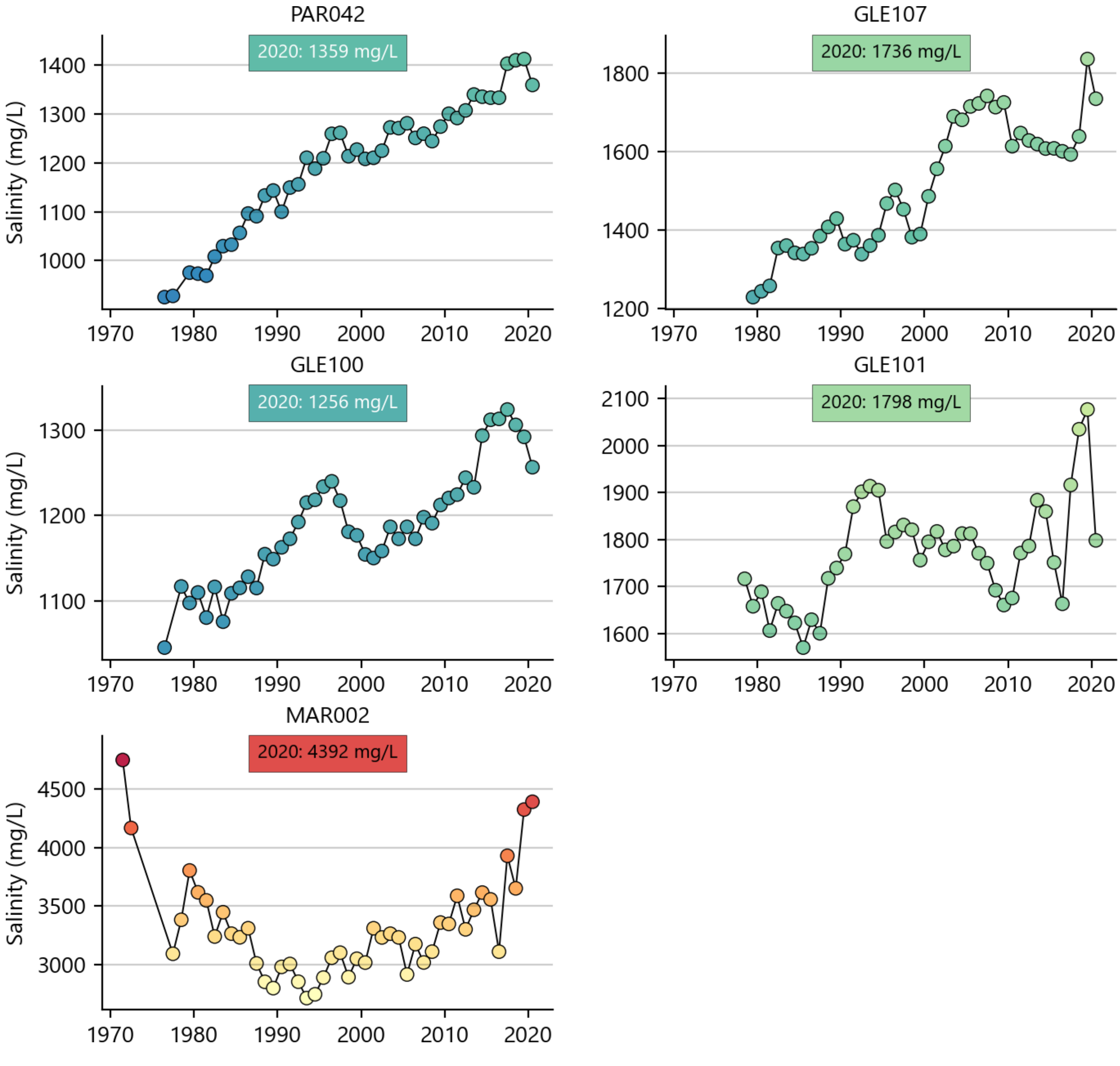

Figure 5.18. Selected salinity graphs for wells in the unconfined aquifer in the Padthaway Flats management area of the Padthaway PWA

5.2.7 Padthaway PWA – Padthaway Range GMA - water level

Following the 2020–21 irrigation season, the majority of monitoring wells (82%) are classified 'Average' or 'Very much above average' (Section 2.3.1; Figure 5.19). Over the past 30 years, changes in water levels range from a decline of 1.91 m to a rise of 1.27 m; the median change is a rise of 0.46 m.

Five-year trends in water levels show most wells are either stable (27%) or rising (46%) (Figure 5.20), with rates of rise ranging from 0.03 to 0.07 m/y.

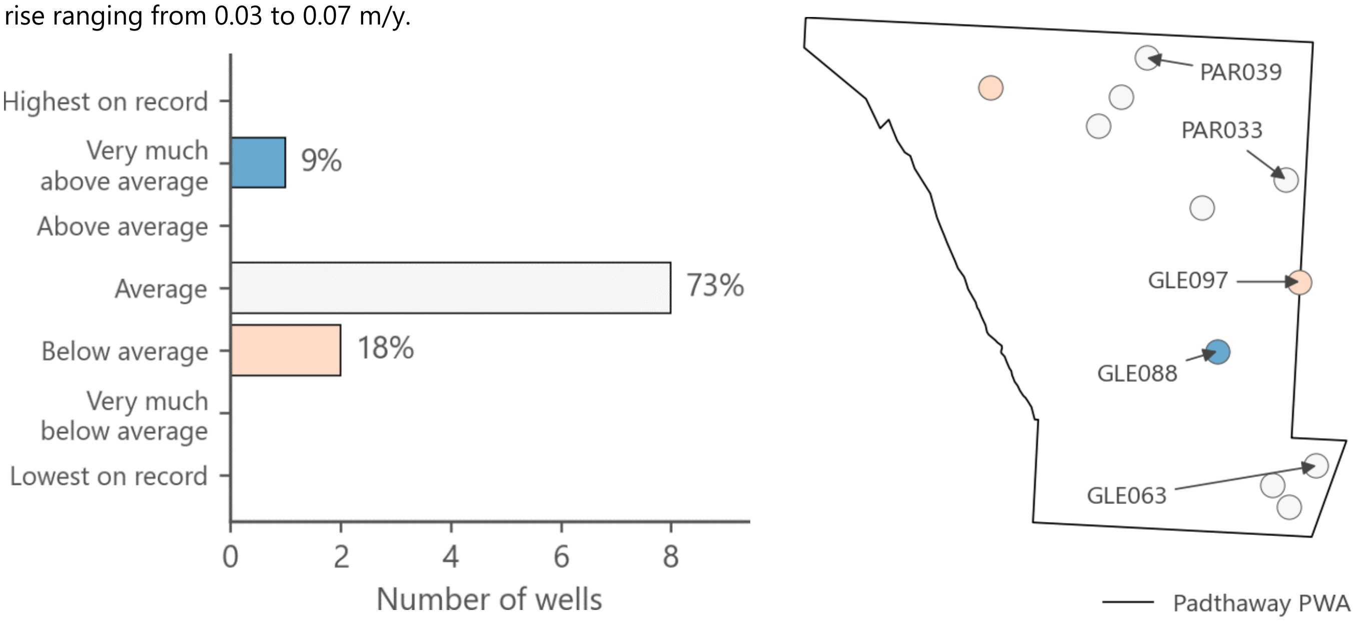

Figure 5.19. 2020 recovered water levels for wells in the unconfined aquifer in the Padthaway Range management area of the Padthaway PWA

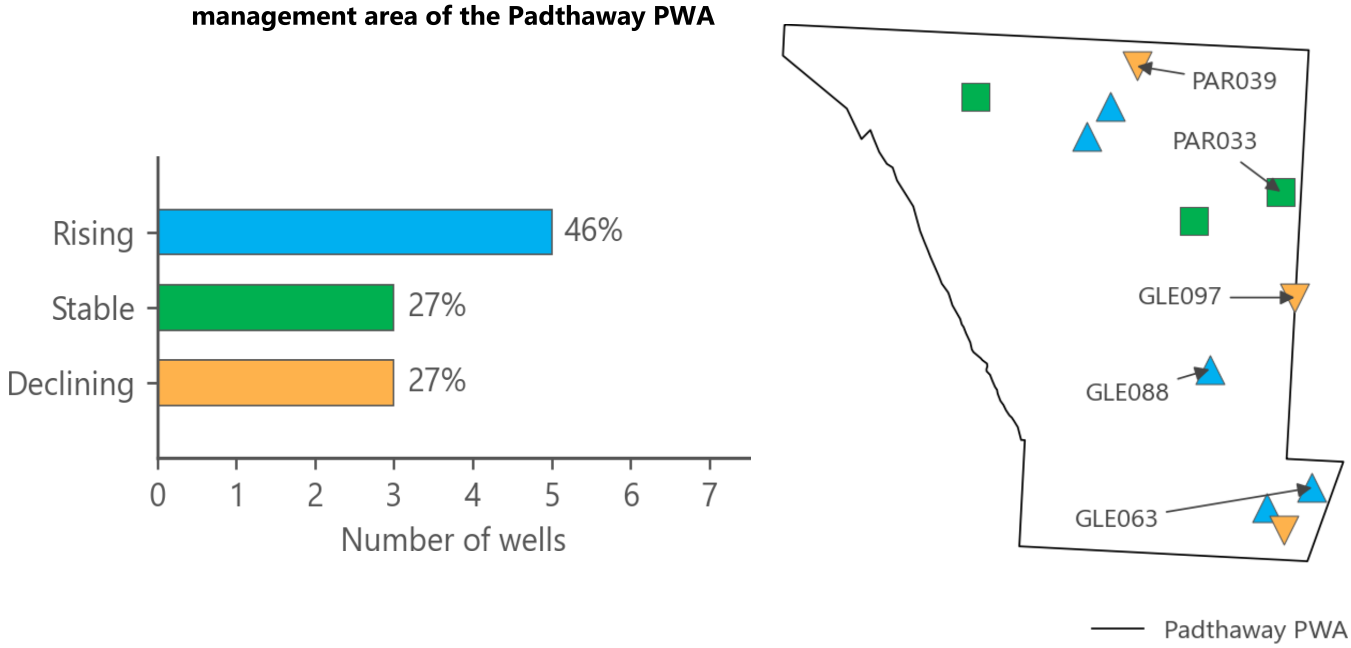

Figure 5.20. 2016–20 trend in recovered water levels for wells in the unconfined aquifer in the Padthaway Range management area of the Padthaway PWA

In Padthaway Range GMA, where the depth to the watertable is generally greater than 10 m, unconfined aquifer water levels are responding to changes in land use. The widespread clearance of native vegetation has resulted in increased recharge rates and rising groundwater levels (Wohling, 2007). Several representative monitoring wells (PAR039, PAR033, GLE097, GLE088, GLE063) illustrate rising water levels from the 1980s to the mid-2000s (Figure 5.21).

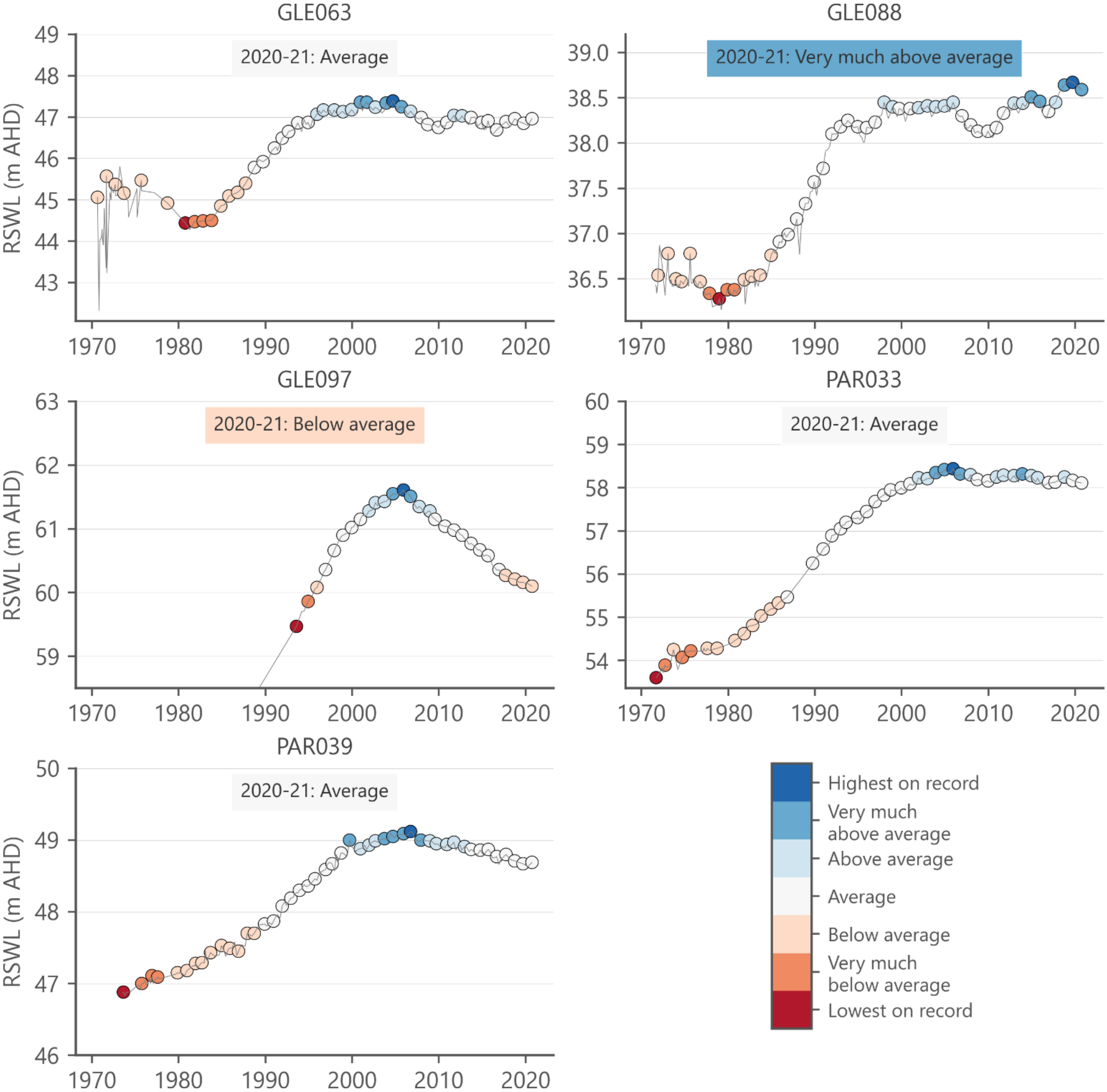

Figure 5.21. Selected hydrographs for wells in the unconfined aquifer in the Padthaway Range management area of the Padthaway PWA

5.2.8 Padthaway PWA – Padthaway Range GMA – salinity

In 2020, all monitoring wells show groundwater salinity less than 2000 mg/L, ranging from 985 mg/L to 1914 mg/L (median 1271 mg/L; Figure 5.22).

In the 10 years to 2020, the majority of monitoring wells (67%) show an increase in groundwater salinity. Trends in salinity over this period vary from a decrease of 0.63% per year to an increase of 1.46% per year, with a median rate of 0.24% increase per year (Figure 5.23).

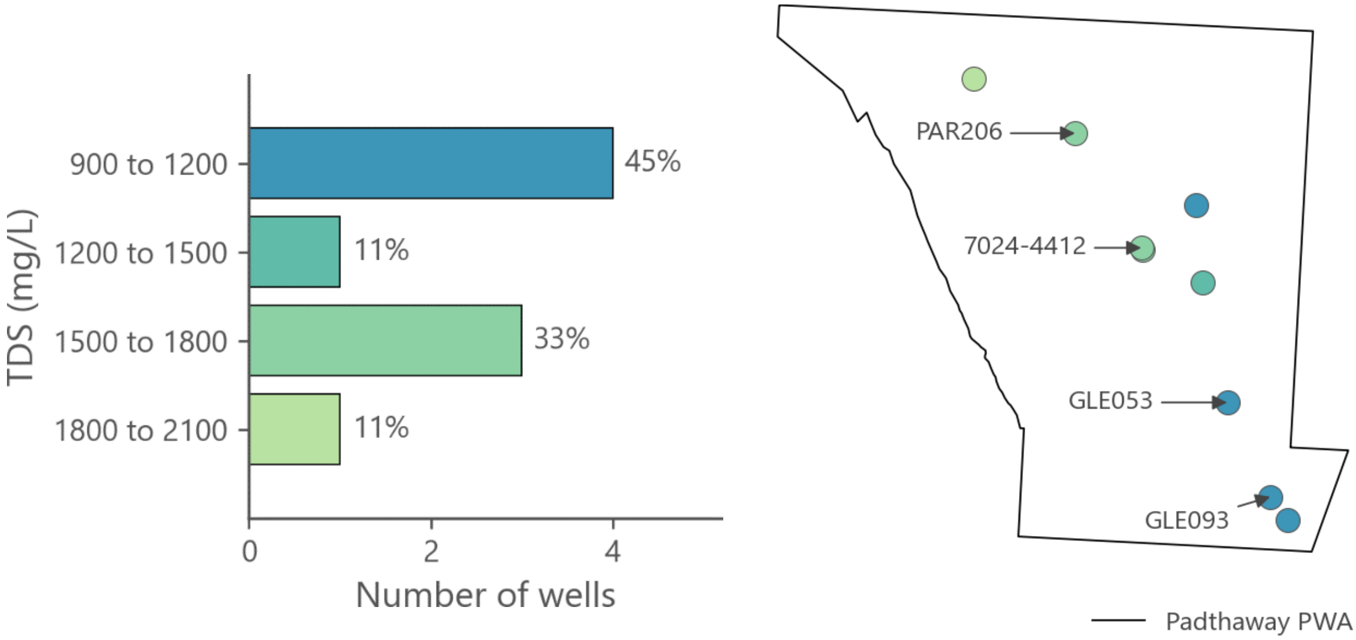

Figure 5.22. 2020 salinity observations from wells in the unconfined aquifer in the Padthaway Range management area of the Padthaway PWA

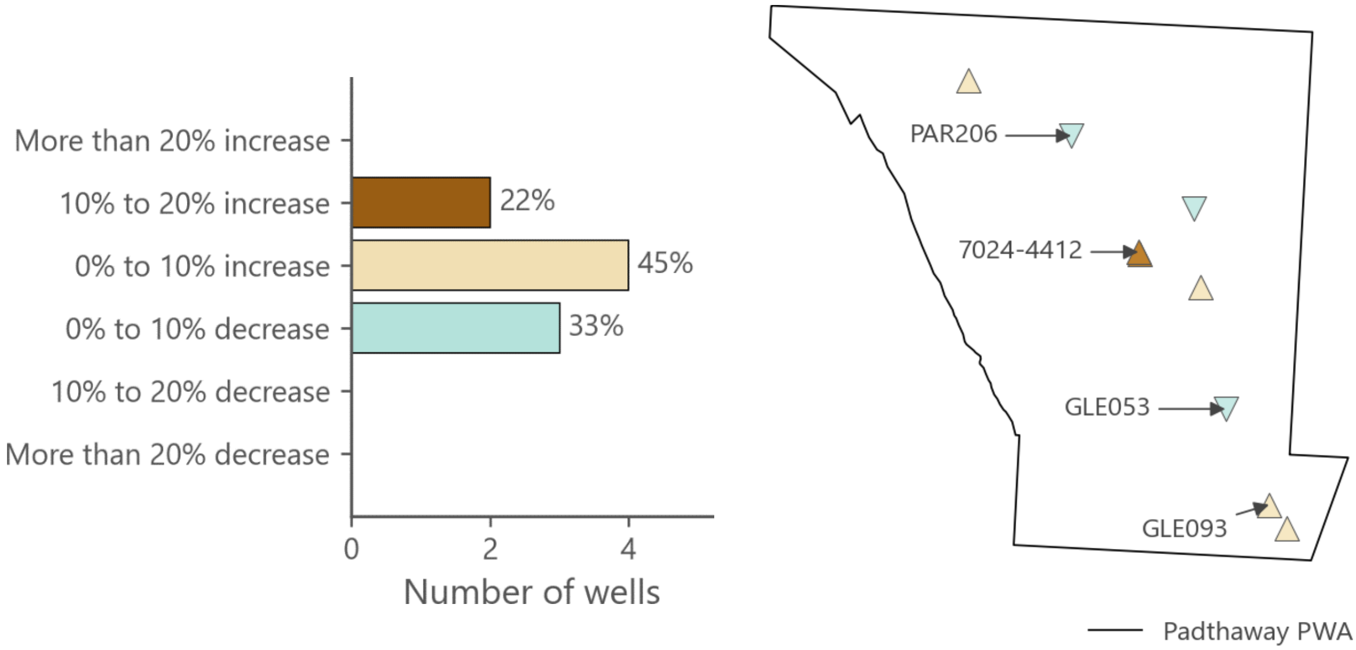

Figure 5.23. Salinity trend in the 10 years to 2020 for wells in the unconfined aquifer in the Padthaway Range management area of the Padthaway PWA

In the Padthaway Ranges, the widespread clearance of native vegetation has resulted in increased recharge rates and the flushing of salt, which was previously stored in the root zone of native vegetation, down to the watertable (Wohling, 2007). This process is occurring independent of any irrigation activity, although drainage from irrigated areas is likely to accelerate this process at the local scale. Observation wells GLE093 and 7024-4412 are displaying steady increases in salinity since monitoring began in 1970 and 2000, respectively (Figure 5.24).

PAR206 shows a decreasing salinity over the past 10 years, which may be due to the unsaturated-zone having been completely flushed and lower salinity water is now recharging the aquifer, or possibly throughflow of fresher groundwater flowing from the adjacent ranges.

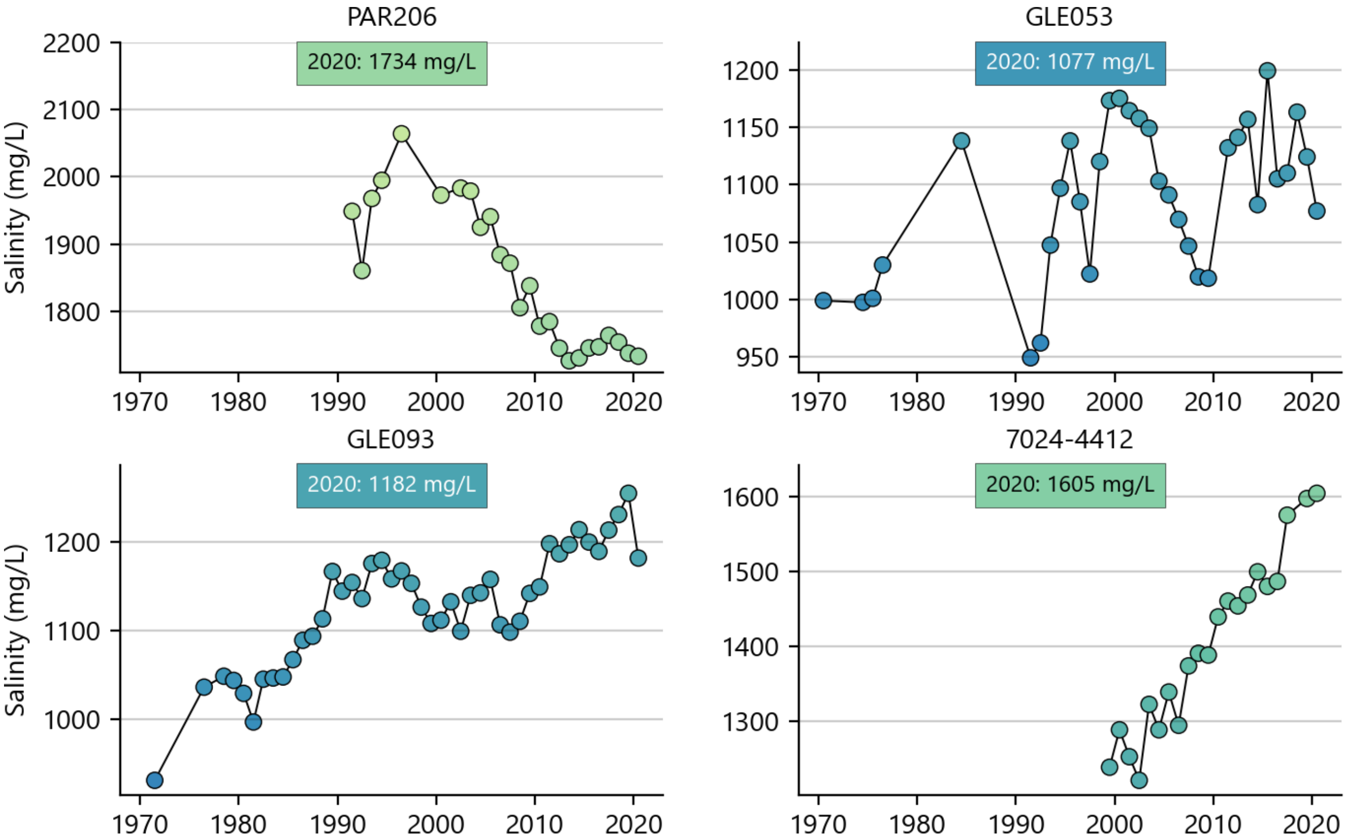

Figure 5.24. Selected salinity graphs for wells in the unconfined aquifer in the Padthaway Range management area of the Padthaway PWA

5.2.9 Tatiara PWA – Plains area – water level

Following the 2020–21 irrigation season, water levels in 41 monitoring wells (95%) are classified 'Below average' or lower (Section 2.3.1). Nearly half of all monitoring wells show their lowest winter-recovered water level on record (Figure 5.25); these wells are mainly located in the transitional zone between the plains and Mallee highlands (Figure 1.1). Over the past 30 years, water levels have declined in 41 of 43 wells (95%), with declines ranging from 0.45 to 11.81 m; the median decline is 3.84 m.

Five-year trends show declining water levels for 42 wells (81%), with rates of decline ranging from 0.02 m/y to 2.81 m/y (median 0.08 m/y; Figure 5.26).

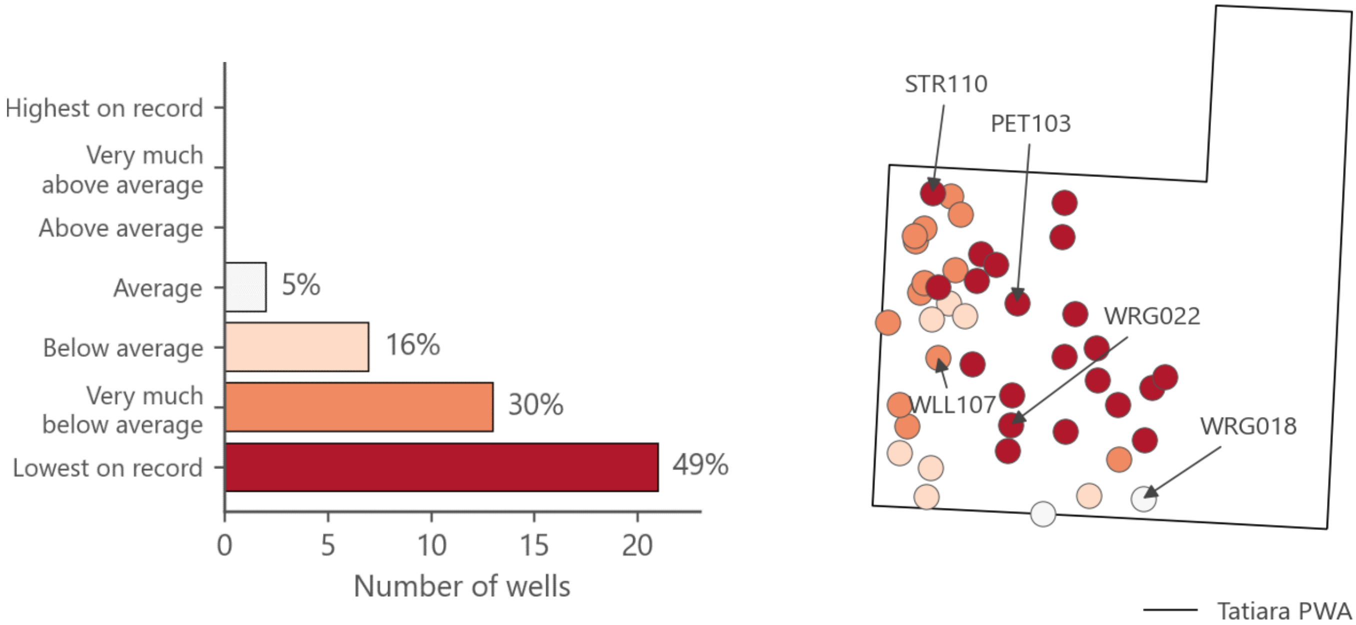

Figure 5.25. **2020 winter-recovered water levels for wells in the unconfined aquifer in the Plains area of the Tatiara PWA**

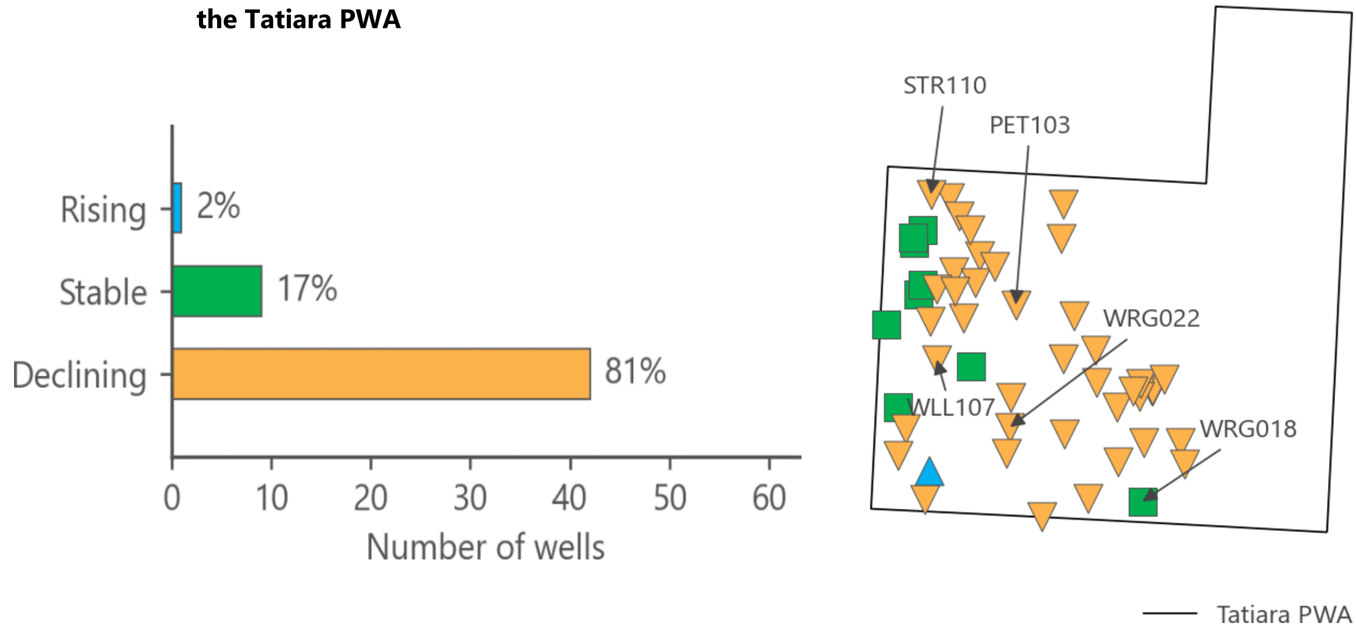

Figure 5.26. **2016–20 trend in winter-recovered water levels for wells in the unconfined aquifer in the Plains area of the Tatiara PWA**

The shallow depth to the watertable of 5 to 10 m in the unconfined aquifer on the low-lying plains results in groundwater levels being responsive to rainfall. Representative wells from across the Tatiara PWA plains area (Figure 5.27) include two wells from an area of intensive irrigation near Keith (WLL107 and STR110). These wells show seasonal drawdown and winter recovery due to pumping for irrigation in summer. A steady and consistent declining trend in water levels of around 0.2 m/y is apparent, which corresponds with a prolonged period of below-average rainfall since 1996 (Figure 3.7).

Further east and to the south, most wells show water levels continuing to decline in recent years, especially those located in the transitional zone between the plains and highlands (e.g. PET103 and WRG022; Figure 5.27).

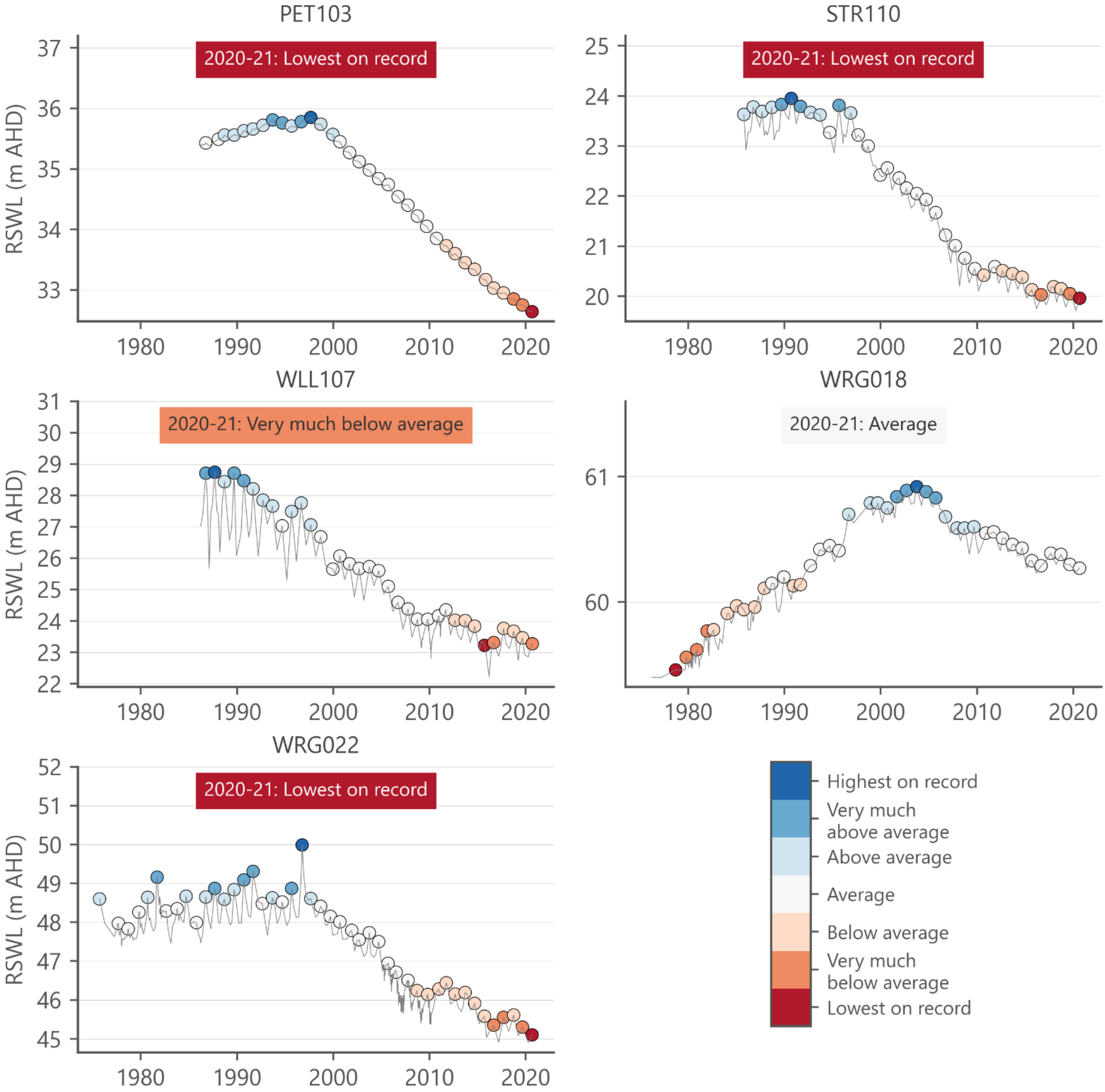

Figure 5.27. Selected hydrographs for wells in the unconfined aquifer in the Plains area of the Tatiara PWA

5.2.10 Tatiara PWA – Plains area – salinity

In 2020, groundwater salinity ranges from 393 mg/L to 8753 mg/L (median 2602 mg/L; Figure 5.28). Salinities greater than 4500 mg/L is generally measured in the north-western part of the Tatiara PWA, where intensive flood irrigation is often practised.

In the 10 years to 2020, the majority of monitoring wells (59%) show a decrease in groundwater salinity. Trends in salinity over this period vary from a decrease of 9.99% per year to an increase of 2.50% per year, with a median rate of 0.16% decrease per year (Figure 5.29).

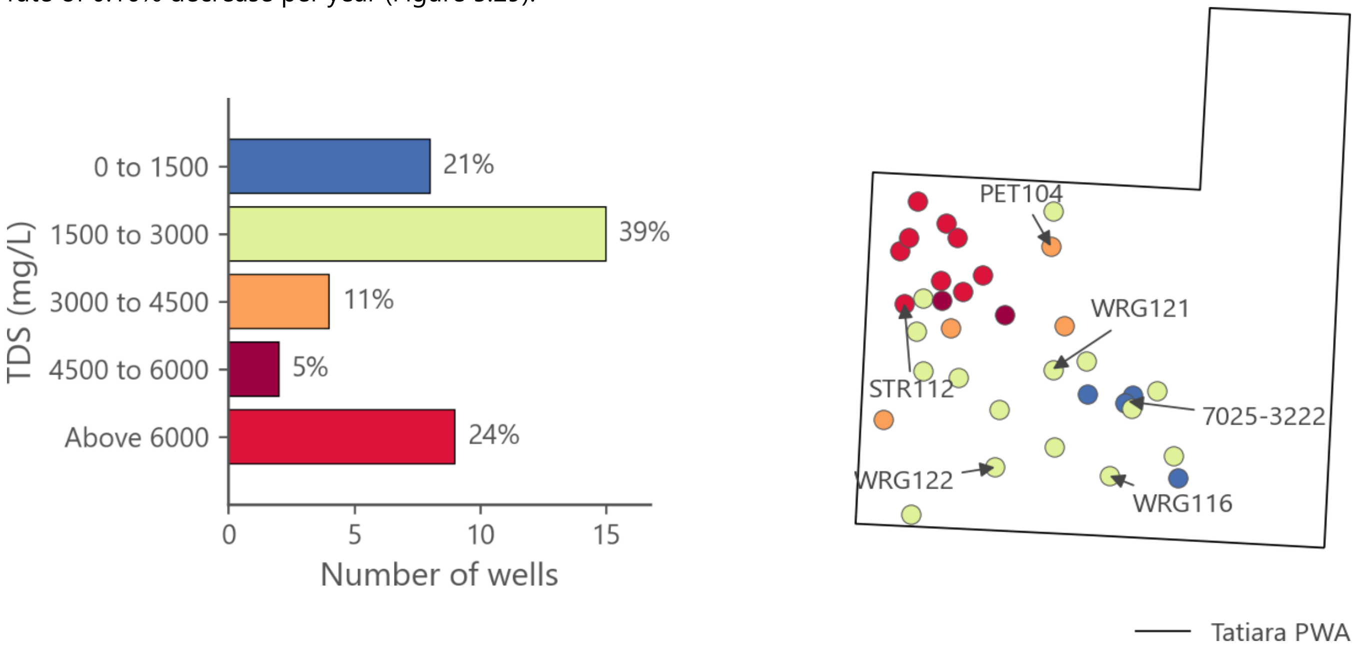

Figure 5.28. 2020 salinity observations from wells in the unconfined aquifer in the Plains area of the Tatiara PWA

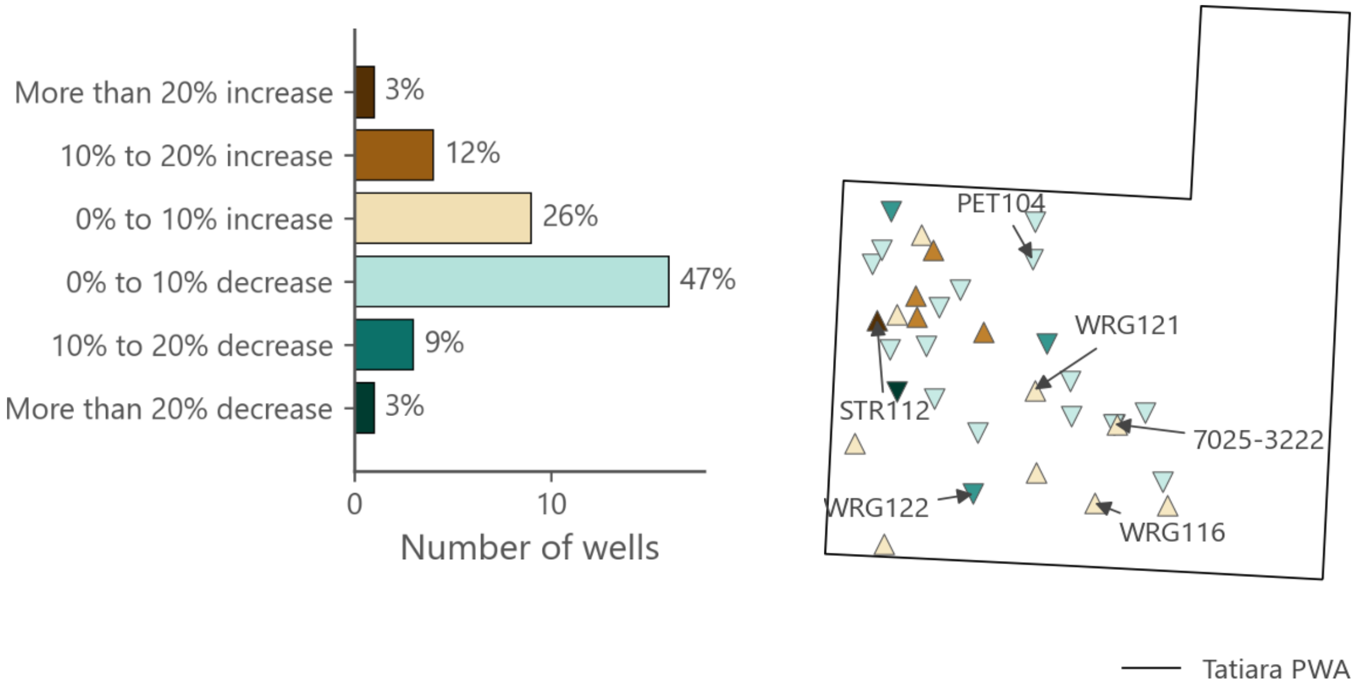

Figure 5.29. Salinity trends in the 10 years to 2020 for wells in the unconfined aquifer in the Plains area of the Tatiara PWA

Many irrigation wells in the unconfined aquifer of the Tatiara plains are showing increasing salinity (Figure 5.30) due to the recycling of irrigation drainage water in the shallow aquifer (STR112, WRG121 and WRG116) (Wohling, 2007).

Decreasing salinities have been recorded in a number of observation wells since the late 1990s (e.g. WRG122 and PET104) although the processes leading to aquifer freshening are uncertain.

One of the Bordertown water supply wells (7025-3222) shows relatively stable salinity with some decreases in the early-2000s when monitoring began.

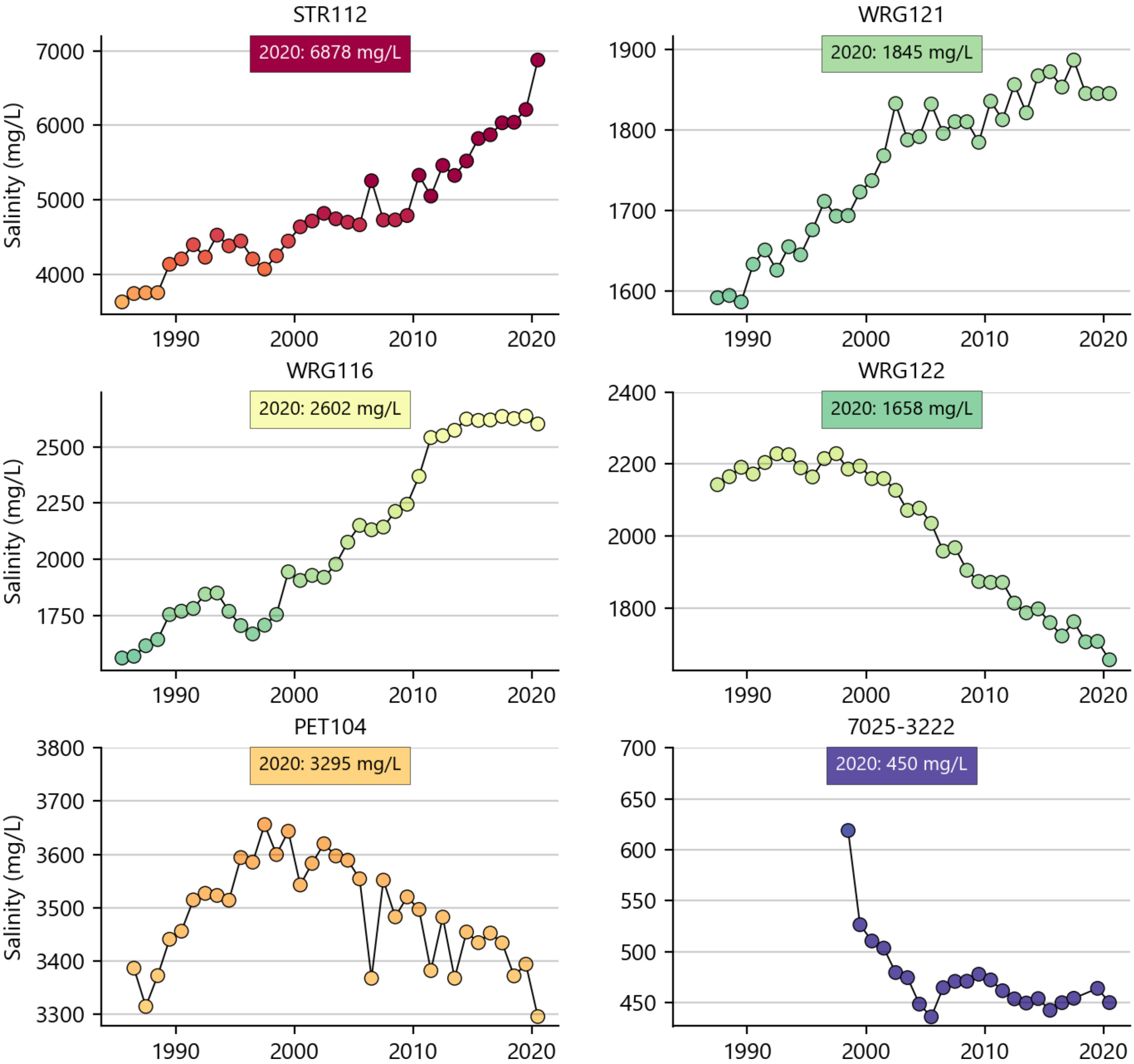

Figure 5.30. Selected salinity graphs for wells in the unconfined aquifer in the Plains area of the Tatiara PWA

5.2.11 Tatiara PWA – Highlands area – water level

Following the 2020–21 irrigation season, 22 monitoring wells (92%) show winter-recovered water levels below their respective historical average, including six wells (25%) that show their lowest level on record (Section 2.3.1; Figure 5.31). Over the past 30 years, 23 of 24 wells (96%) show declines in water level. Changes in water levels range from a rise of 0.05 m to a decline of 2.12 m (median change is a decline of 0.25 m).

Five-year trends show declining water levels for 21 out of 23 wells (91%) wells, with rates of decline ranging from 0.02 to 0.07 m/y (median 0.05 m/y; Figure 5.32).

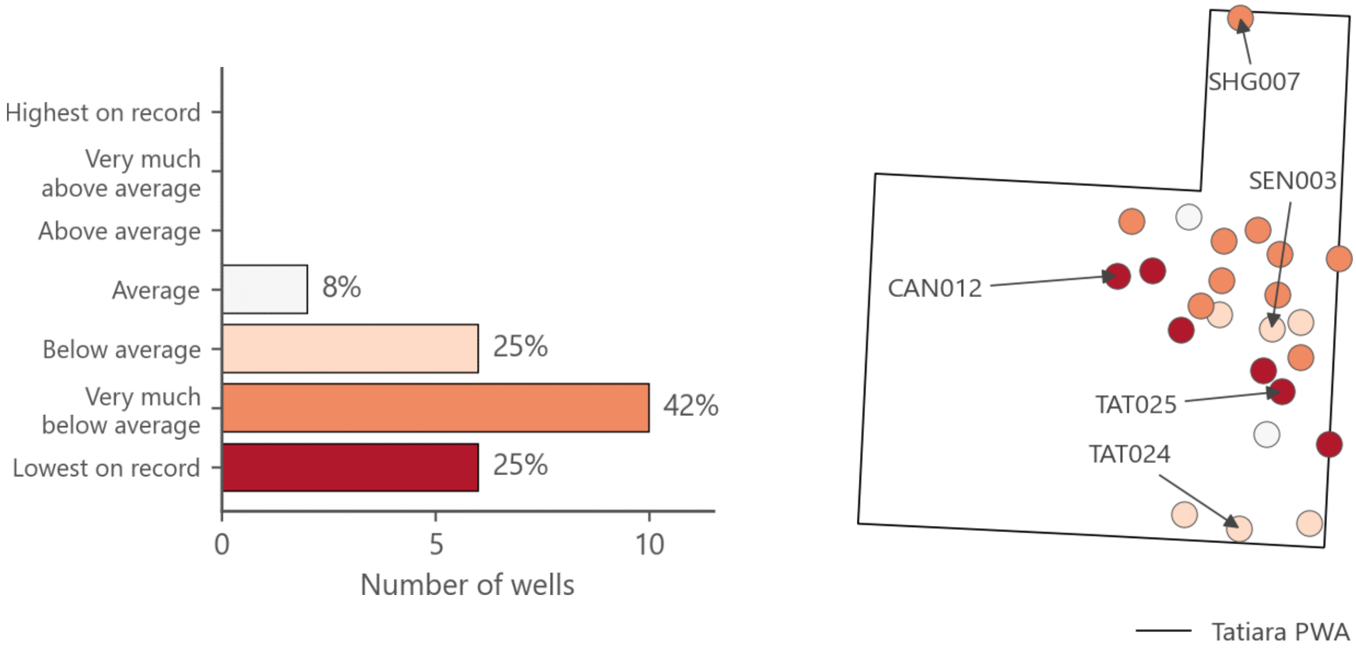

Figure 5.31. **2020 winter-recovered water levels for wells in the unconfined aquifer in the Highlands area of the Tatiara PWA**

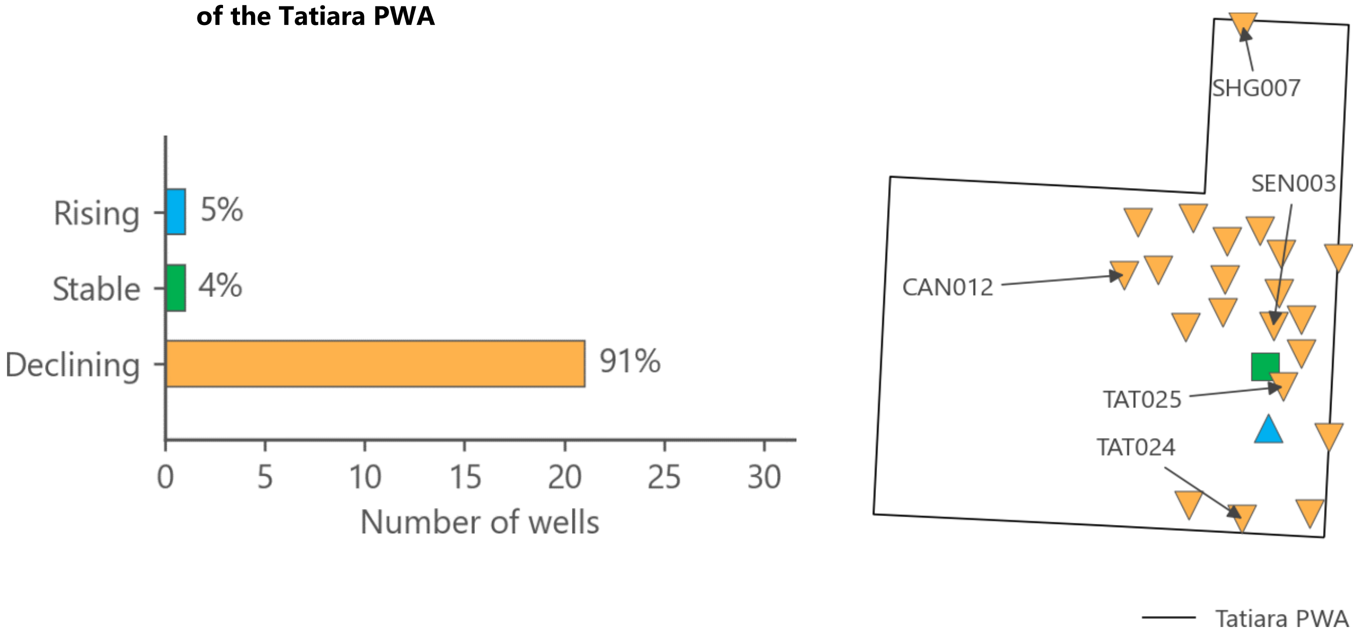

Figure 5.32. **2016–20 trend in winter-recovered water levels for wells in the unconfined aquifer in Highlands area of the Tatiara PWA**

In the Tatiara PWA Highlands area, where the depth to the watertable is generally greater than 10 m and the saturated thickness of the unconfined aquifer is generally high, groundwater levels have fluctuated mostly less than 2 m in the longer term. Subtle rises in water levels occurred throughout the 1980s and 1990s (e.g. SEN003, SHG007, and TAT024) or were generally stable (CAN012 and TAT025) (Figure 5.33); subsequently, water levels have shown generally subtle declining trends.

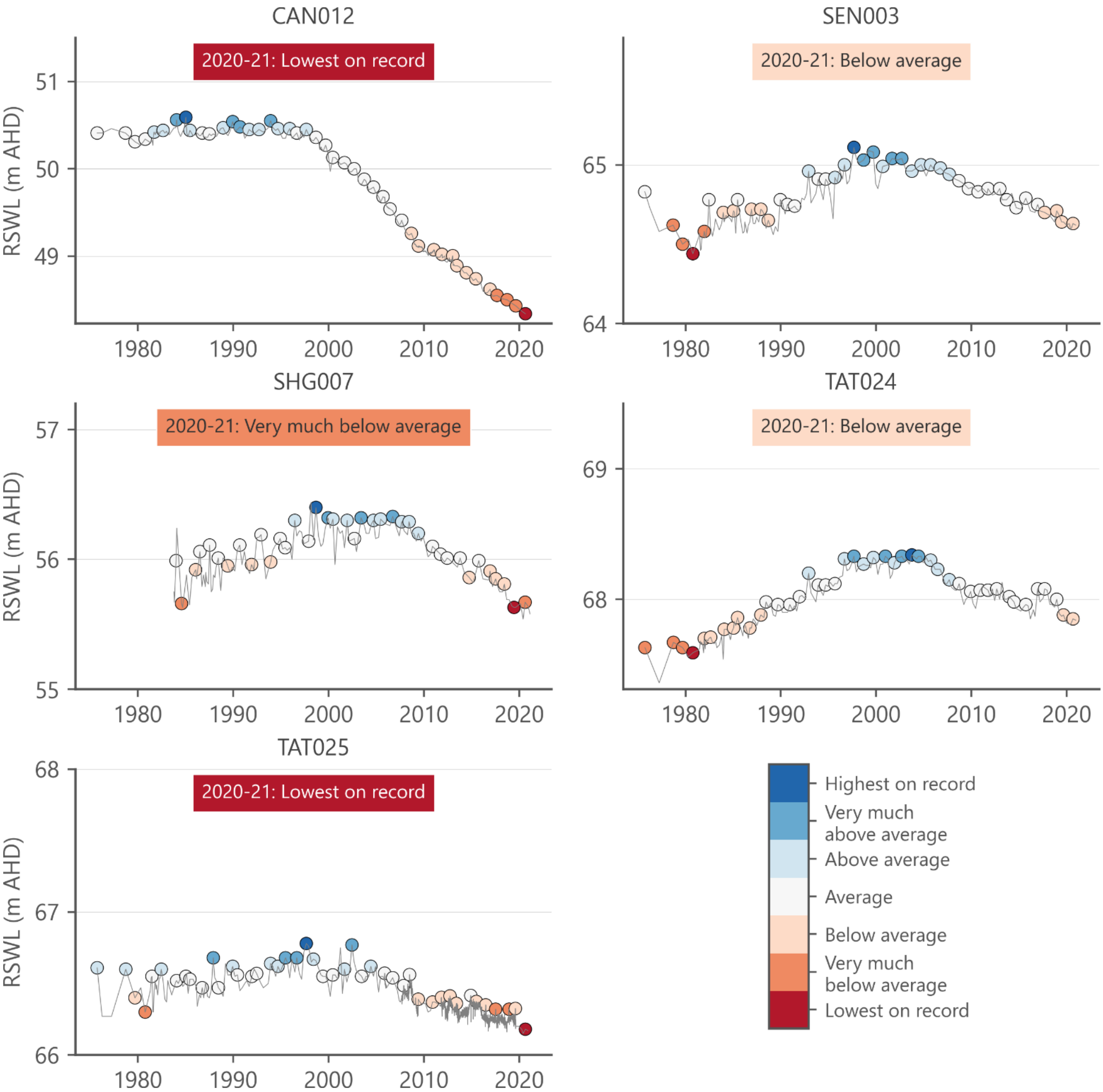

Figure 5.33. Selected hydrographs for wells in the unconfined aquifer in the Highlands area of the Tatiara PWA

5.2.12 Tatiara PWA – Highlands area – salinity

In 2020, groundwater salinity ranges from 1017 mg/L to 2322 mg/L (median 1443 mg/L; Figure 5.34).

In the 10 years to 2020, greater than half of monitoring wells (56%) show a decrease in groundwater salinity. Trends in salinity over this period vary from a decrease of 0.31% per year to an increase of 0.49% per year, with a median rate of 0.05% decrease per year (Figure 5.35).

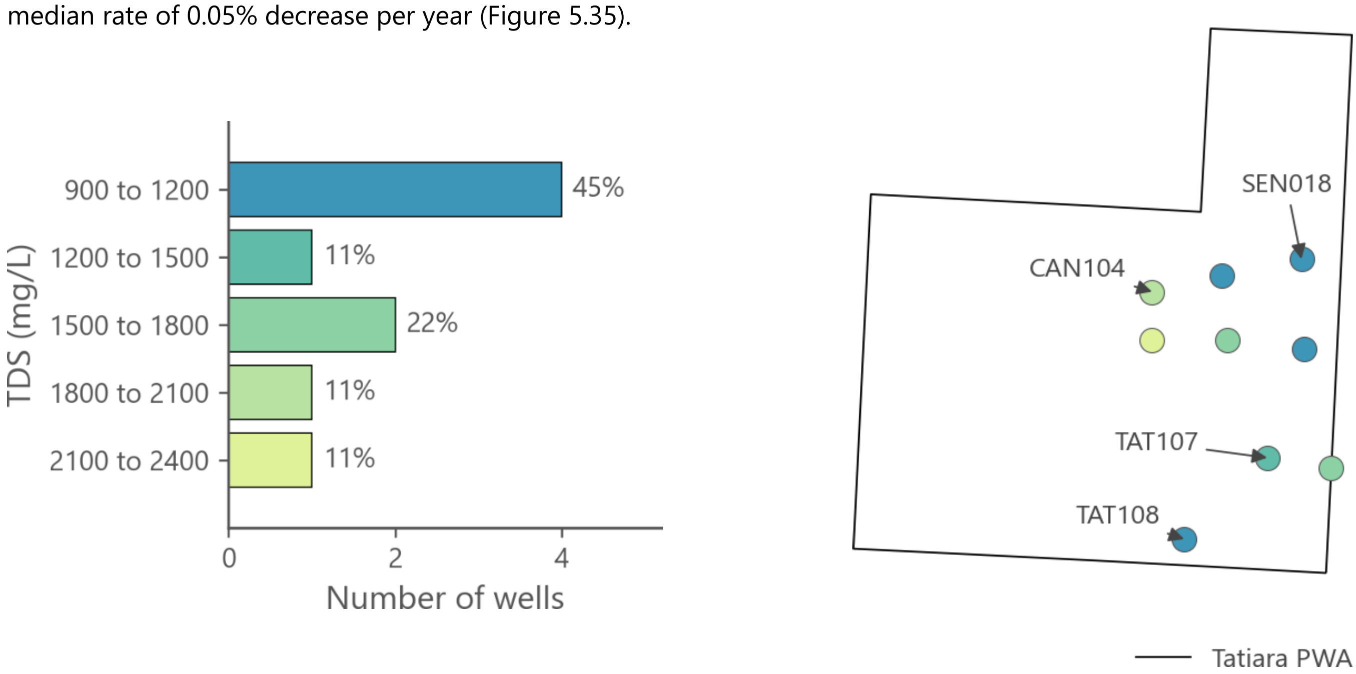

Figure 5.34. 2020 salinity observations from wells in the unconfined aquifer in Highlands area of the Tatiara PWA

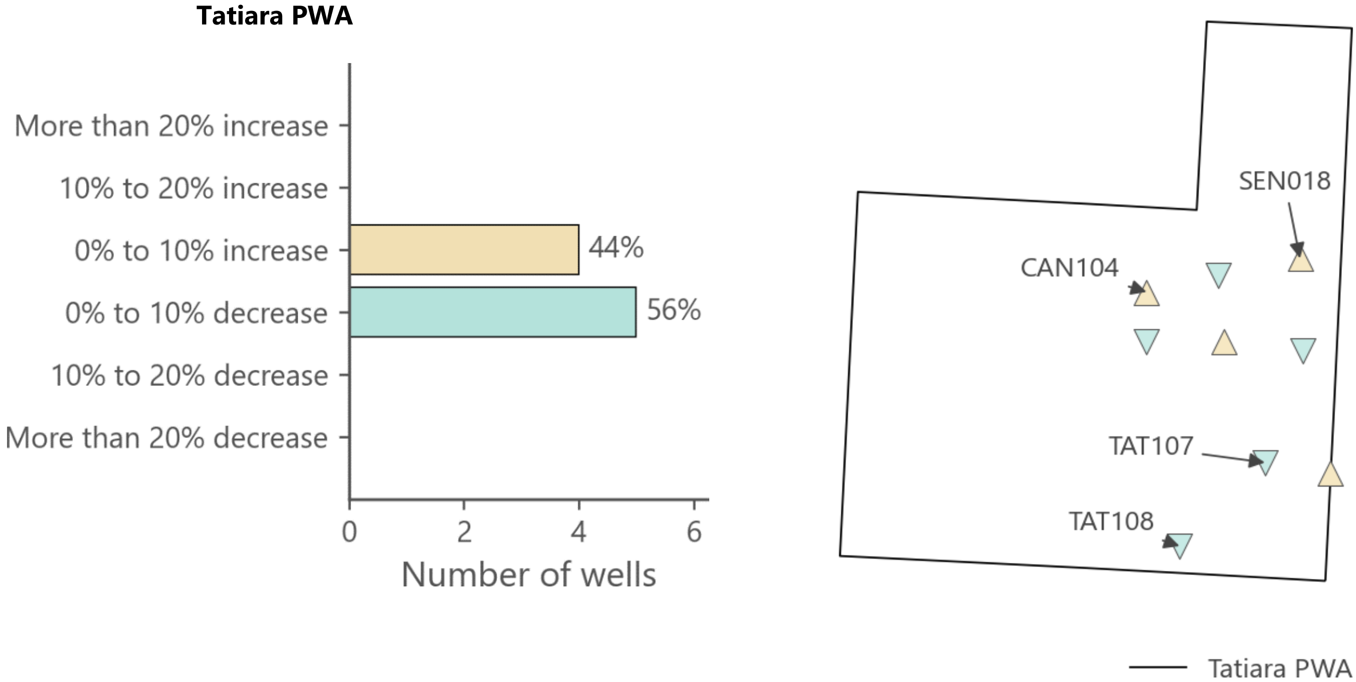

Figure 5.35. Salinity trend in the 10 years to 2020 for wells in the unconfined aquifer in the Highlands area of the Tatiara PWA

The widespread clearance of native vegetation in the Padthaway Ranges has resulted in increased recharge rates and the flushing of salt, which was previously stored in the root zone of the native vegetation, down to the watertable (Wohling, 2007) – this process may also be occurring in the Tatiara PWA Highlands area (Figure 5.36). Increases in groundwater salinity is observed at CAN104 since monitoring began in the 1980s, but appears to have stabilised over the past few years. TAT108 shows a gradual increase up until 2000 but has since stabilised.

TAT107 and SEN018 are located in the eastern part of the PWA where the depth to the watertable is over 30 m and consequently, any salt that may have been mobilised from the shallow root zone has not yet impacted the aquifer and salinity is stable.

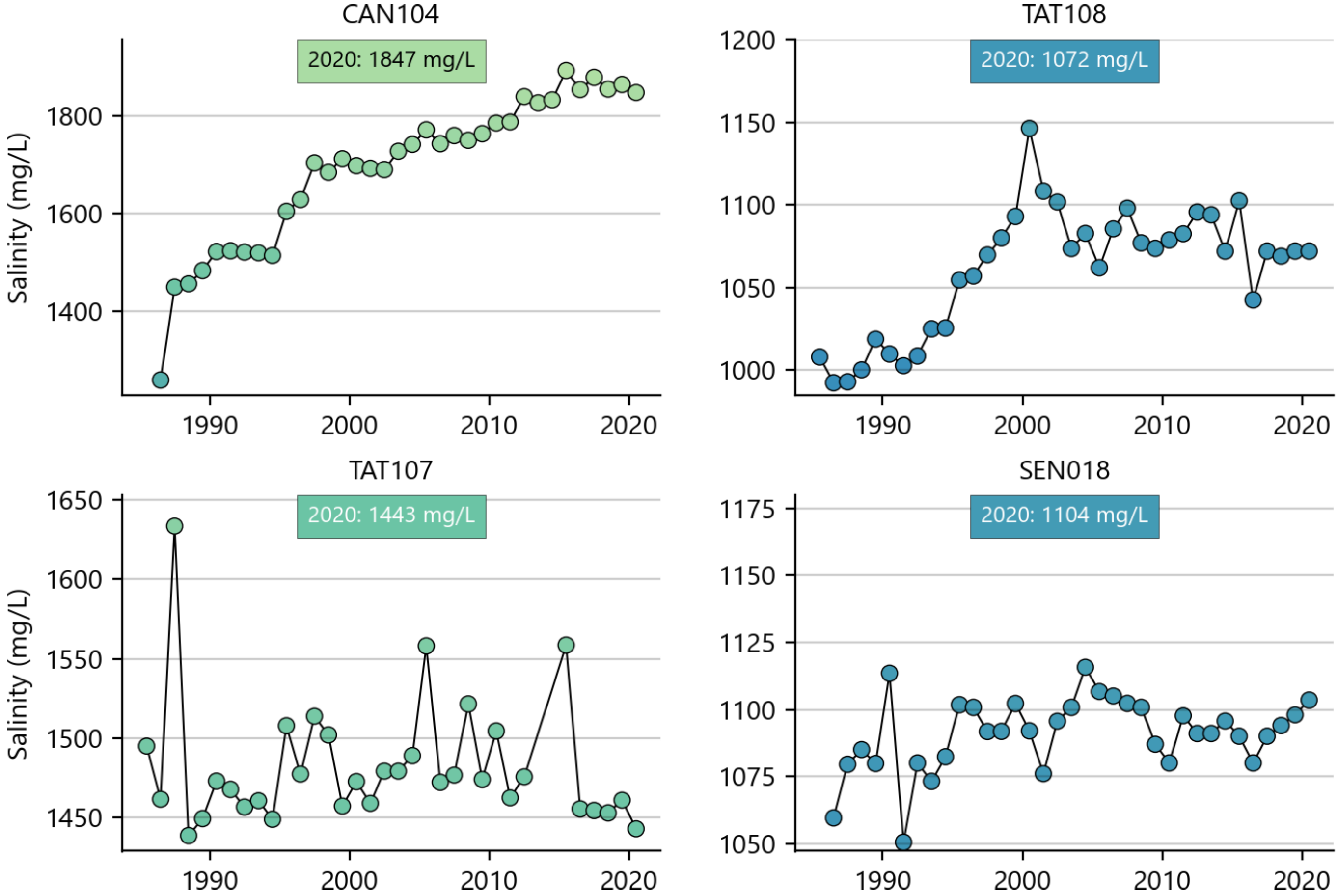

Figure 5.36. Selected salinity graphs for wells in the unconfined aquifer in the Highlands area of the Tatiara PWA

5.2.13 Tintinara-Coonalpyn PWA – Plains area – water level

Following the 2020–21 irrigation season, the majority of monitoring wells are classified 'Below average' compared to their respective historical record (12 wells; 50%) while six wells (25%) show their lowest level on record (Section 2.3.1; Figure 5.37). These wells are located in the central part of the Tintinara-Coonalpyn PWA, near an area of intensive groundwater extraction. Over the past 20 years, water levels in the majority of wells (nine out of 12 wells; 75%) have declined, with changes in water levels ranging from a rise of 0.58 m to a decline of 2.86 m (the median change is a decline of 1.04 m).

Five-year trends show declining water levels for 21 out of 23 wells (91%); rates of decline range from 0.05 to 0.21 m/y (median 0.13 m/y; Figure 5.38).

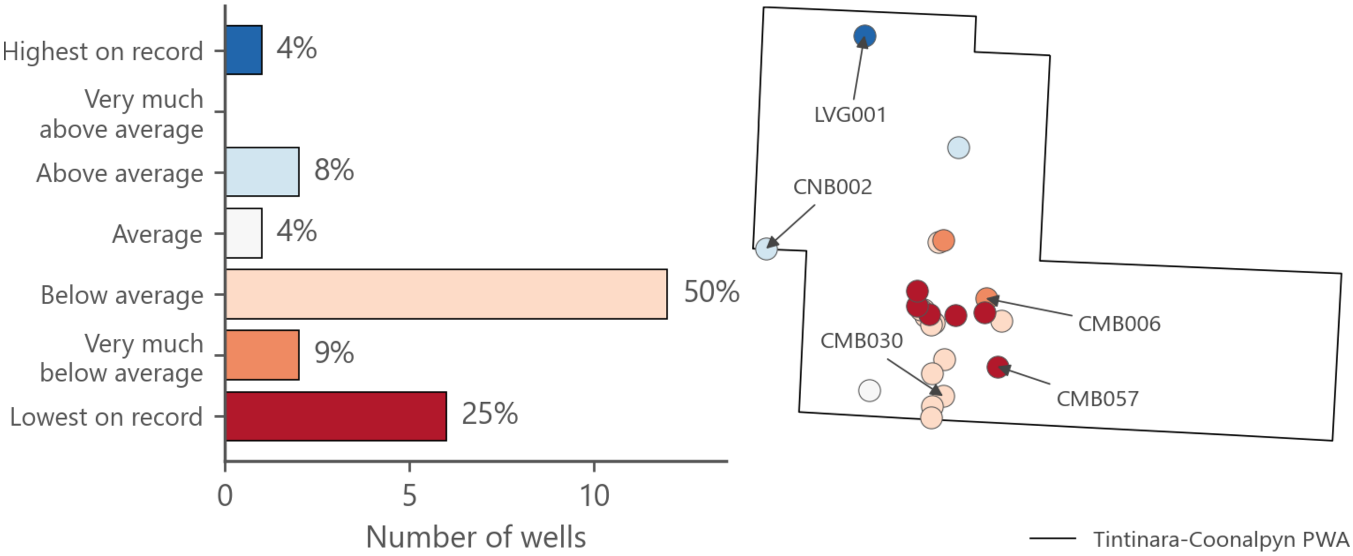

Figure 5.37. 2020 winter-recovered water levels for wells in the unconfined aquifer in the Plains area of the Tintinara-Coonalpyn PWA

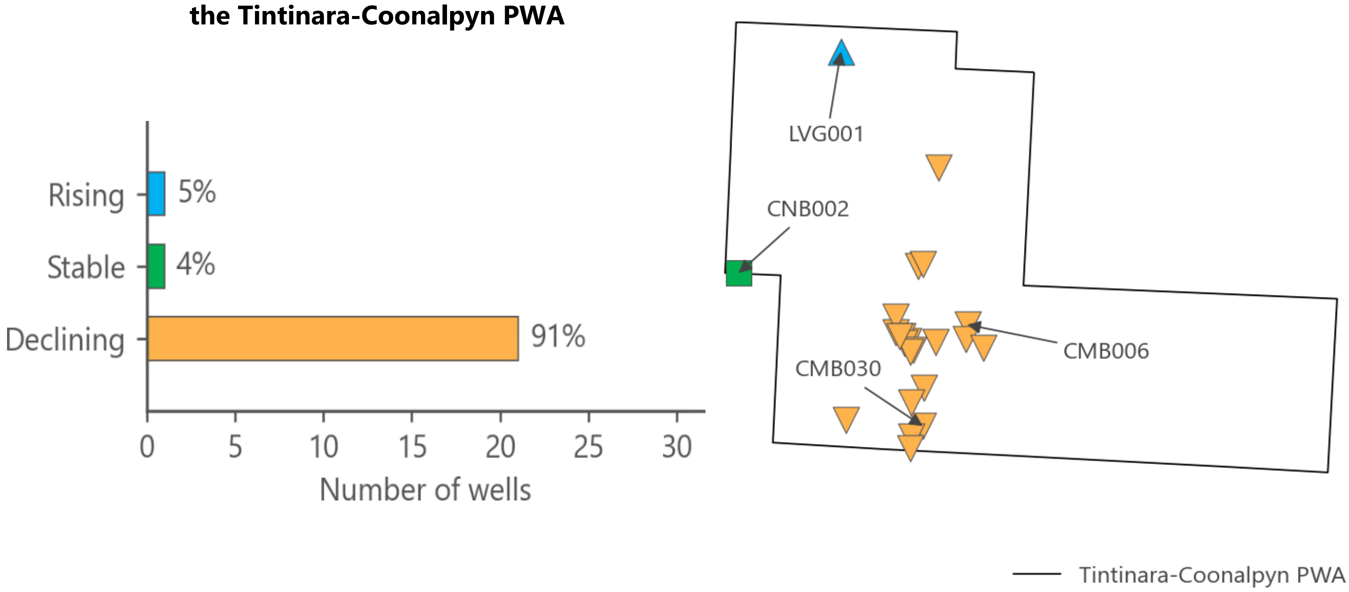

Figure 5.38. 2016–20 trend in winter-recovered water levels for wells in the unconfined aquifer in the Plains area of the Tintinara-Coonalpyn PWA

The shallow depth to the watertable of 5 to 10 m in the unconfined aquifer on the low-lying plains results in the groundwater level trends being very responsive to rainfall. Representative monitoring wells CMB006 and CMB057 show a declining trend in water levels since 1996 (Figure 5.39) that corresponds with an increase in extraction and a prolonged period of below-average rainfall, particularly since 2004-05. Monitoring well CMB030, where the depth to water in the well is less than 2 m, shows large seasonal fluctuations of around 1 m.

The water level in LVG001, which is located towards the northern boundary of the Tintinara-Coonalpyn PWA Plains area, shows a gradual rise since the late-1980s (Figure 5.39), despite very low rainfall over the period 200516 (Figure 3.9).

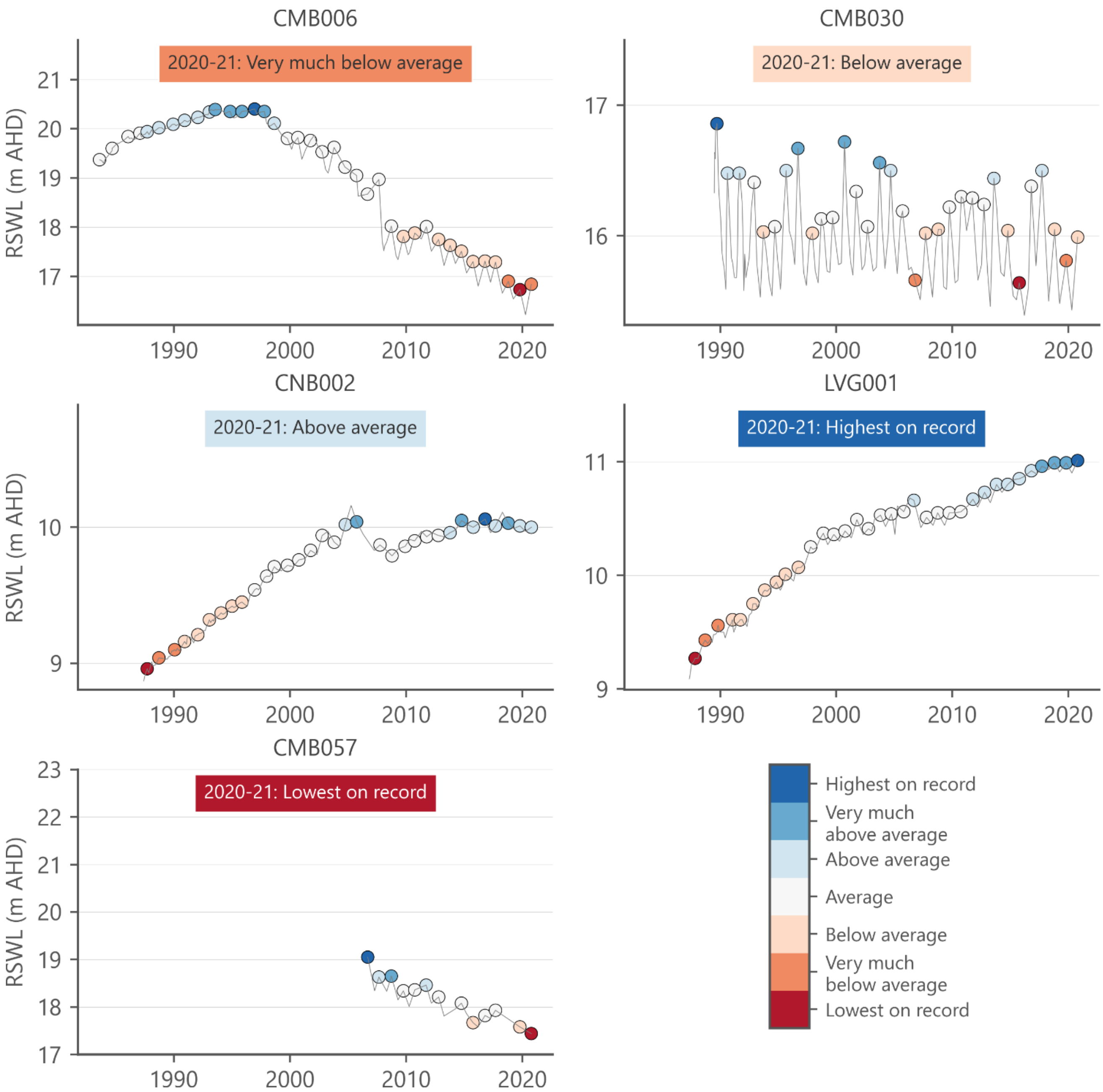

Figure 5.39. Selected hydrographs for wells in the unconfined aquifer in the Plains area of the Tintinara-Coonalpyn PWA

5.2.14 Tintinara-Coonalpyn PWA – Mallee highlands area – water level

During 2019–20, water levels in all monitoring wells are classified 'Below average' or lower (Section 2.3.1; Figure 5.40). Three (38%) wells show their lowest level on record – these are located towards the eastern extent of the Tintinara-Coonalpyn PWA. Water levels in all wells have declined over the past 20 years, with declines ranging from 0.53 m to 2.14 m (median 1.10 m).

Five-year trends are showing declining water levels for 7 out of 8 wells (87%), with rates of decline ranging from 0.04 to 0.21 m/y (median 0.11 m/y; Figure 5.41).

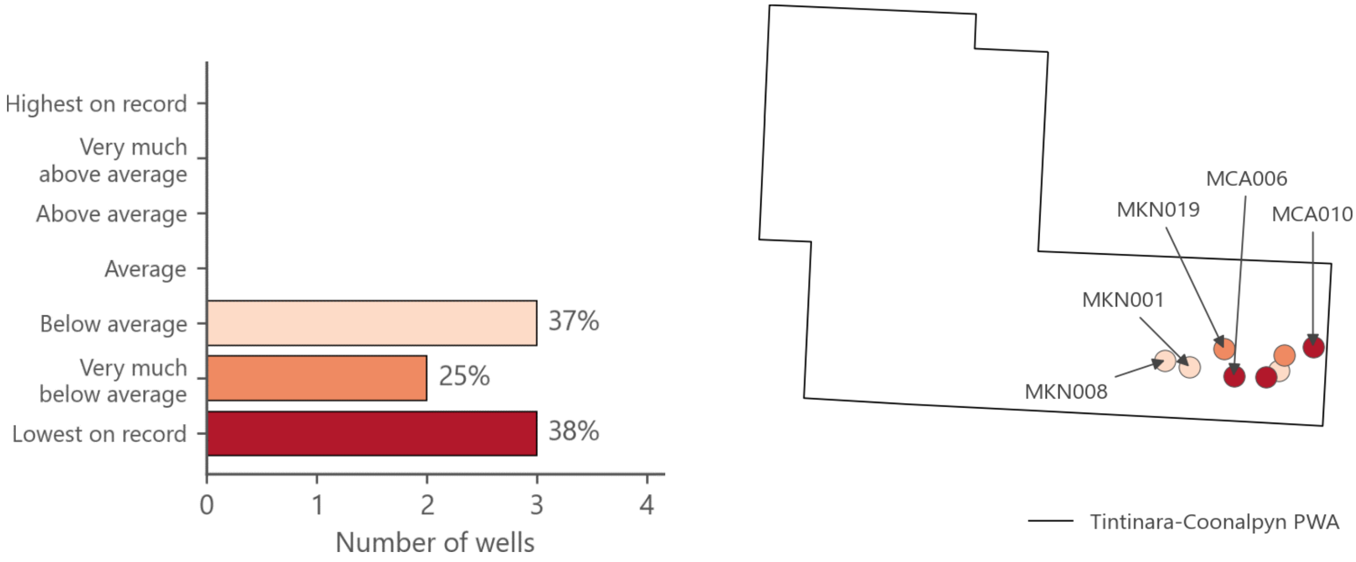

Figure 5.40. 2020 winter-recovered water levels for wells in the unconfined aquifer in the Mallee highlands area of the Tintinara-Coonalpyn PWA

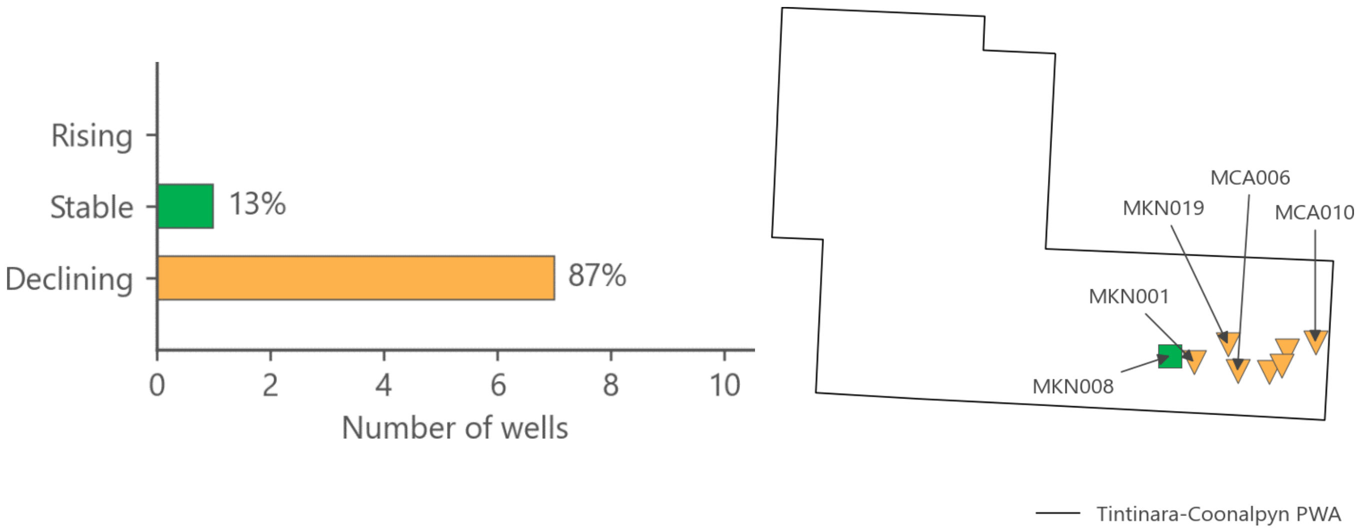

Figure 5.41. 2016–20 trend in winter-recovered water levels for wells in the unconfined aquifer in the Mallee highlands area of the Tintinara-Coonalpyn PWA

Historical changes in water levels in the Mallee highlands area of the Tintinara-Coonalpyn PWA (Figure 5.42) follow a similar pattern to wells in the neighbouring Tatiara PWA highlands area (Figure 5.33), with generally rising water levels from the early 1980s to the late 1990s, followed by gradual declines of 12 m (e.g. MKN019 and MKN008). However, the saturated thickness of the unconfined aquifer is generally high.

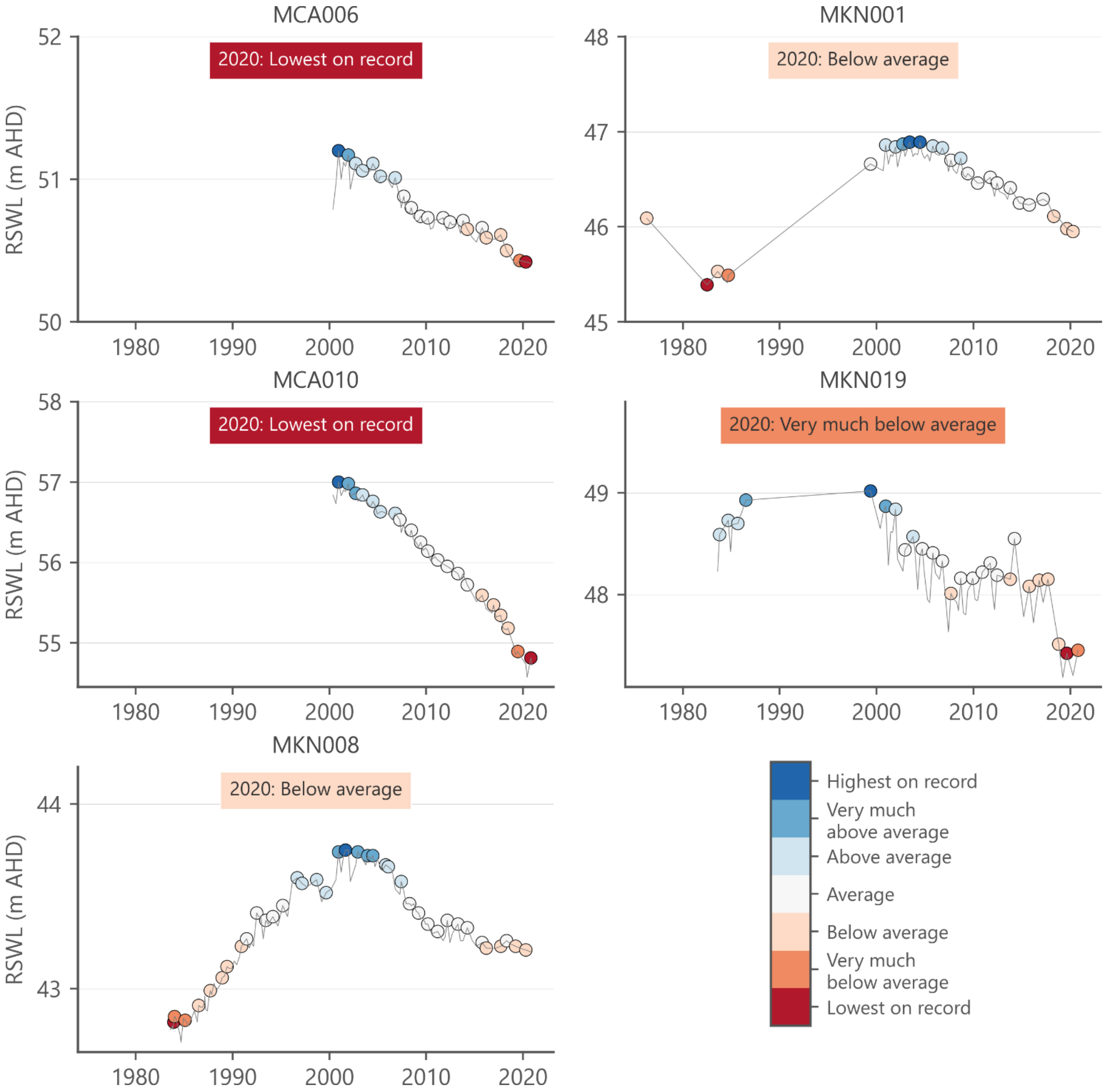

Figure 5.42. Selected hydrographs for wells in the unconfined aquifer in the Mallee highlands area of the Tintinara-Coonalpyn PWA

5.2.15 Tintinara-Coonalpyn PWA – salinity

In 2020, groundwater salinity ranges from 1290 mg/L to 2321 mg/L (median 2027 mg/L; Figure 5.43).

Trends in salinity over the past ten years (Section 2.3.2) from three wells show salinity is increasing at LEW005 at a rate of 0.08% per year, and salinity is decreasing at LEW012 and CMB015 at respective rates of 4.94% and 0.45% per year (Figure 5.44).

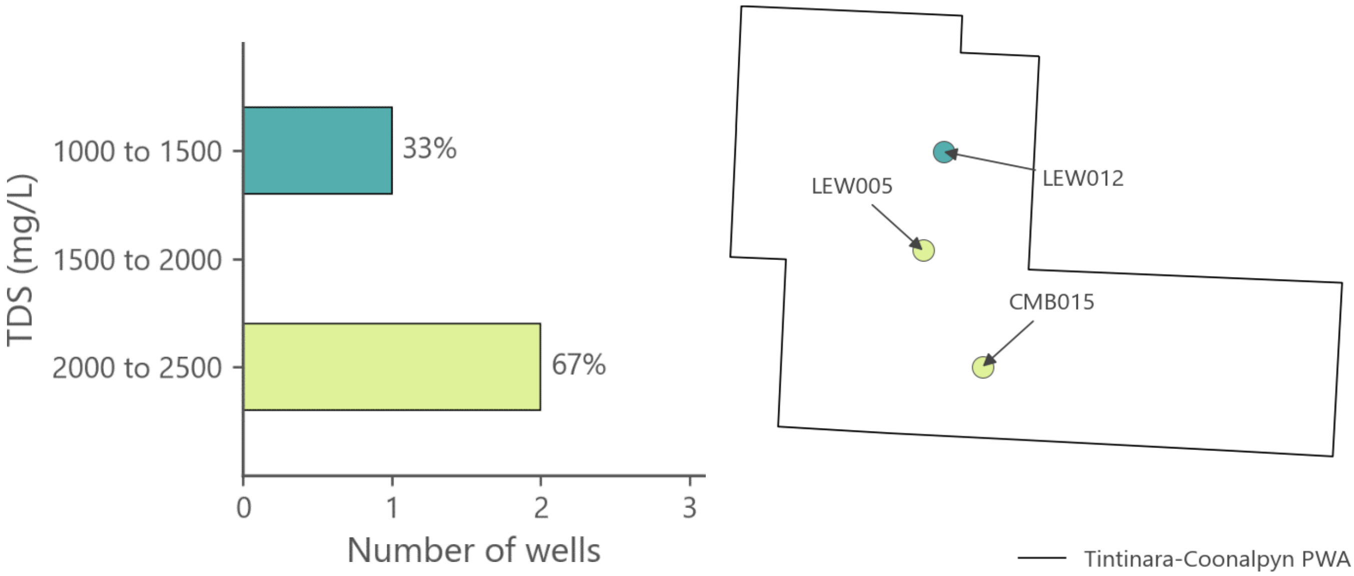

Figure 5.43. 2020 salinity observations from wells in the unconfined aquifer in the Tintinara-Coonalpyn PWA

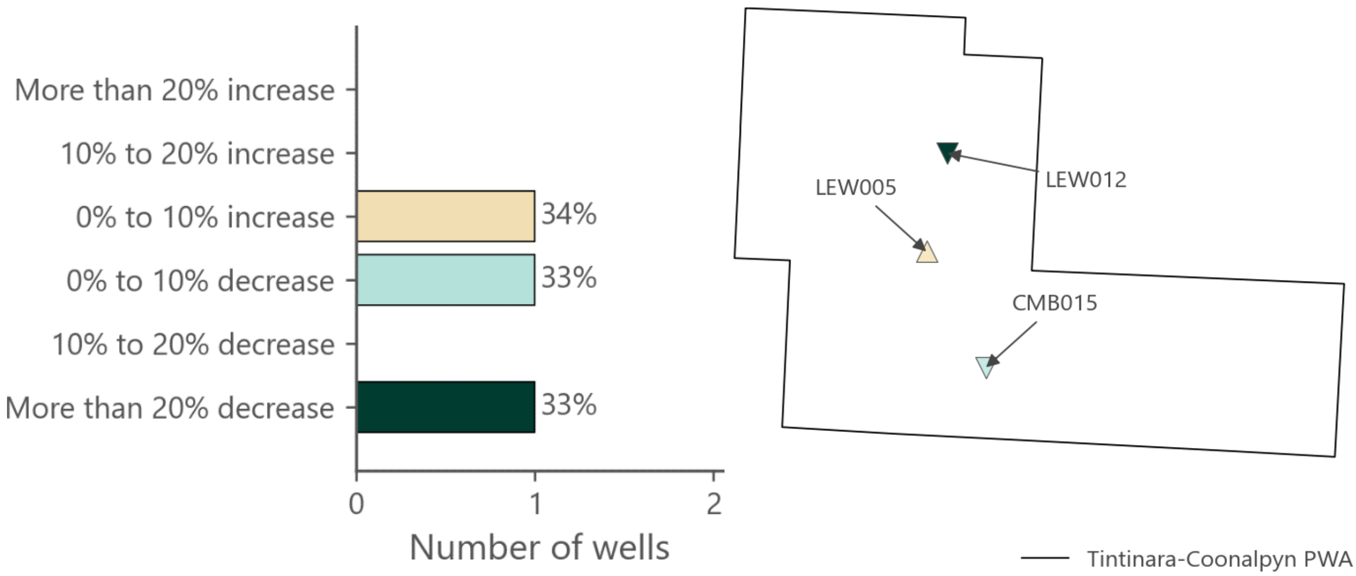

Figure 5.44. Salinity trend in the 10 years to 2020 for wells in the unconfined aquifer in the Tintinara-Coonalpyn PWA

5.3 Confined aquifer

5.3.1 Lower Limestone Coast PWA – confined aquifer – water level

Following the 2020–21 irrigation season, 29 monitoring wells (34%) show winter-recovered water levels that are classified 'Average' when compared their respective historical level (Section. 2.3.1), while levels in 32% of wells are classified 'Above-average' or higher (Figure 5.45). In general, most wells with levels that are classified greater than 'Average' are in the north-western part of the PWA around Kingston SE and Robe (Figure 1.1), where the confined aquifer is artesian and more water is taken from the aquifer for irrigation. Wells with winter-recovered water levels that are classified 'Below average' and 'Lowest on record' are located mostly towards the eastern and northern margins of the PWA, where rates of water use from the confined aquifer are generally lower.

Over the past 30 years, 60% of wells show declining levels (median change in water levels for all wells was a decline of 0.39 m). Five-year trends show water levels in 47 wells (51%) are declining at rates ranging from 0.02 to 0.46 m/y (median decline of 0.06 m/y), and rising for 30 wells (33%) at rates ranging from 0.02 to 0.64 m/y (median rise of 0.04 m/y; Figure 5.46).

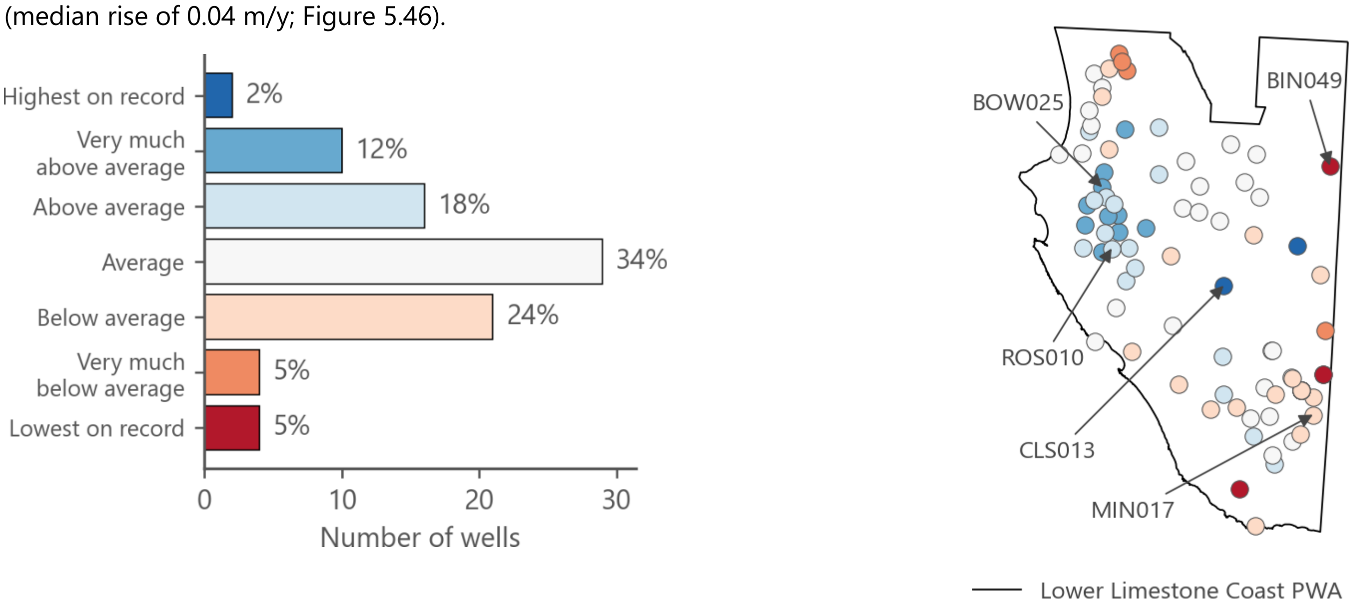

Figure 5.45. 2020 winter-recovered water levels for wells in the confined aquifer in the Lower Limestone Coast PWA

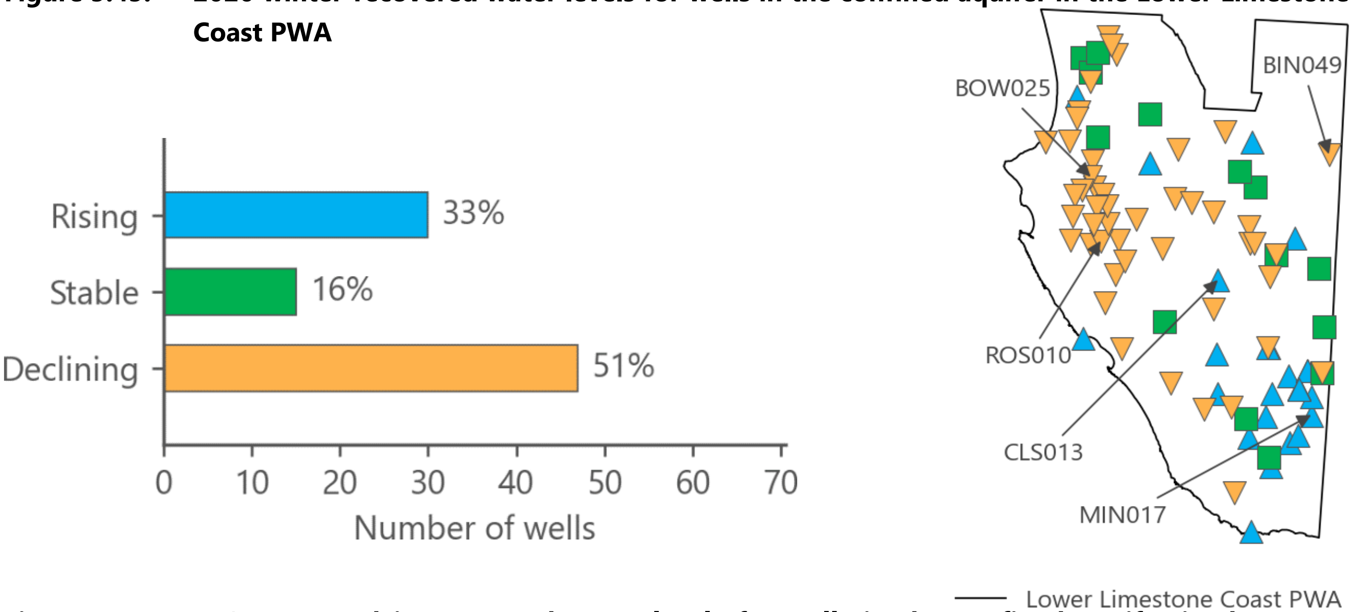

Figure 5.46. 2016–20 trend in recovered water levels for wells in the confined aquifer in the Lower Limestone Coast PWA

The main area of extraction from the confined aquifer in the Lower Limestone Coast PWA is in the central artesian area, inland between Kingston SE and Beachport (e.g. BOW025 and ROS010; Figure 5.47). Beyond this area, extraction is generally limited, except for town water supplies and some irrigation south of Mount Gambier. Monitoring wells located near areas of extraction show pumping signals in water levels, such as BOW025, ROS010, and CLS013 (Figure 5.47). In these wells, winter-recovered water levels show subtle increases since 2010.

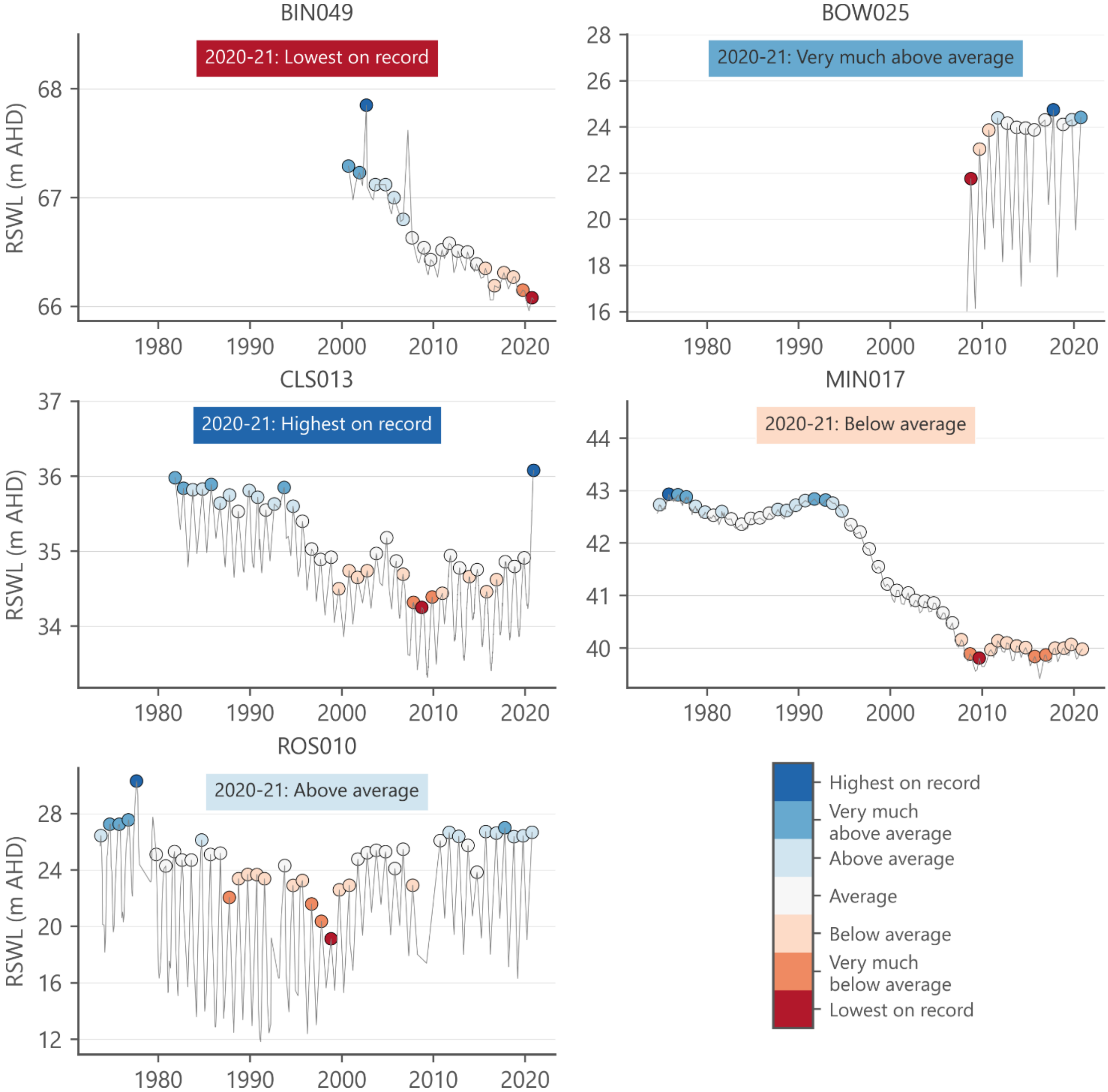

Figure 5.47. Selected hydrographs for wells in the confined aquifer in the Lower Limestone Coast PWA

5.3.2 Lower Limestone Coast PWA – confined aquifer – salinity

In 2020, groundwater salinity ranges from 543 mg/L to 1300 mg/L (median 703 mg/L; Figure 5.48). The majority of wells (67%) show salinity of less than 800 mg/L. These wells are located primarily around the area of intensive irrigation, i.e. inland from Beachport and Kingston SE (Figure 1.1).

In the 10 years to 2020, the majority of monitoring wells (95%) show subtle increases in groundwater salinity. Trends in salinity over this period vary from a decrease of 0.32% per year to an increase of 0.99% per year, with a median rate of 0.40% increase per year (Figure 5.49).

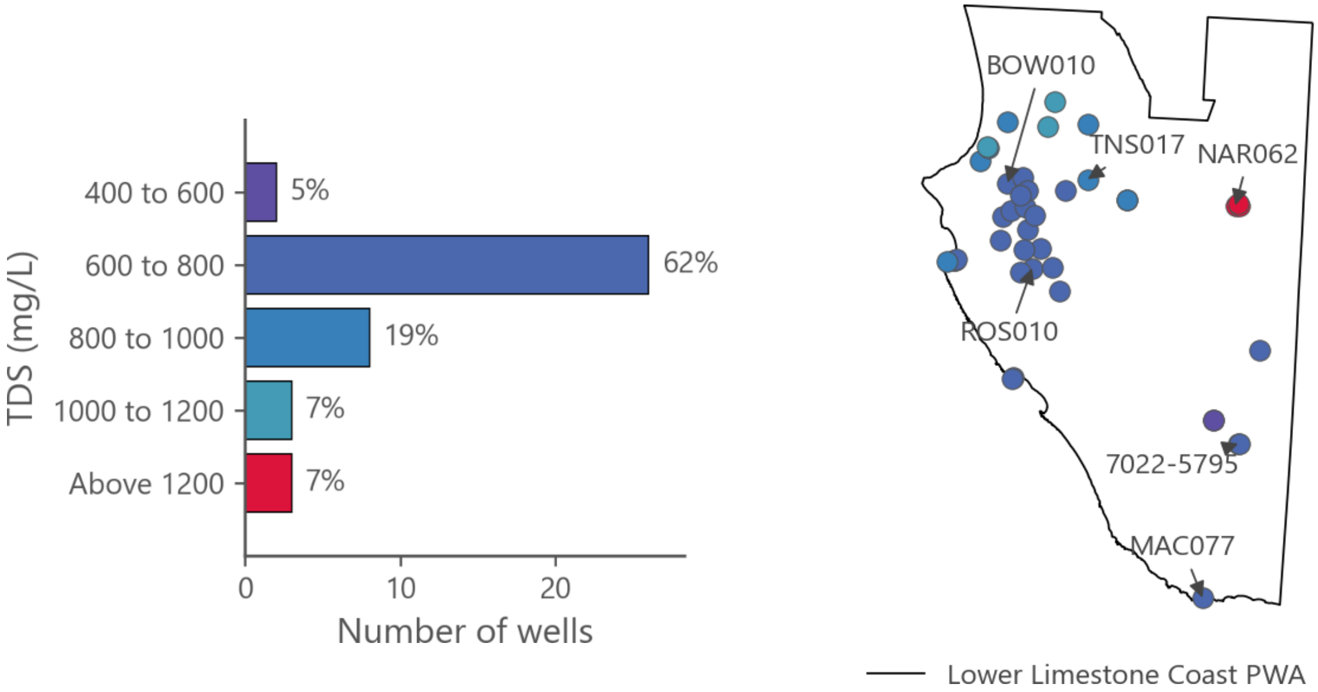

Figure 5.48. 2020 salinity observations from wells in the confined aquifer in the Lower Limestone Coast and Padthaway PWAs

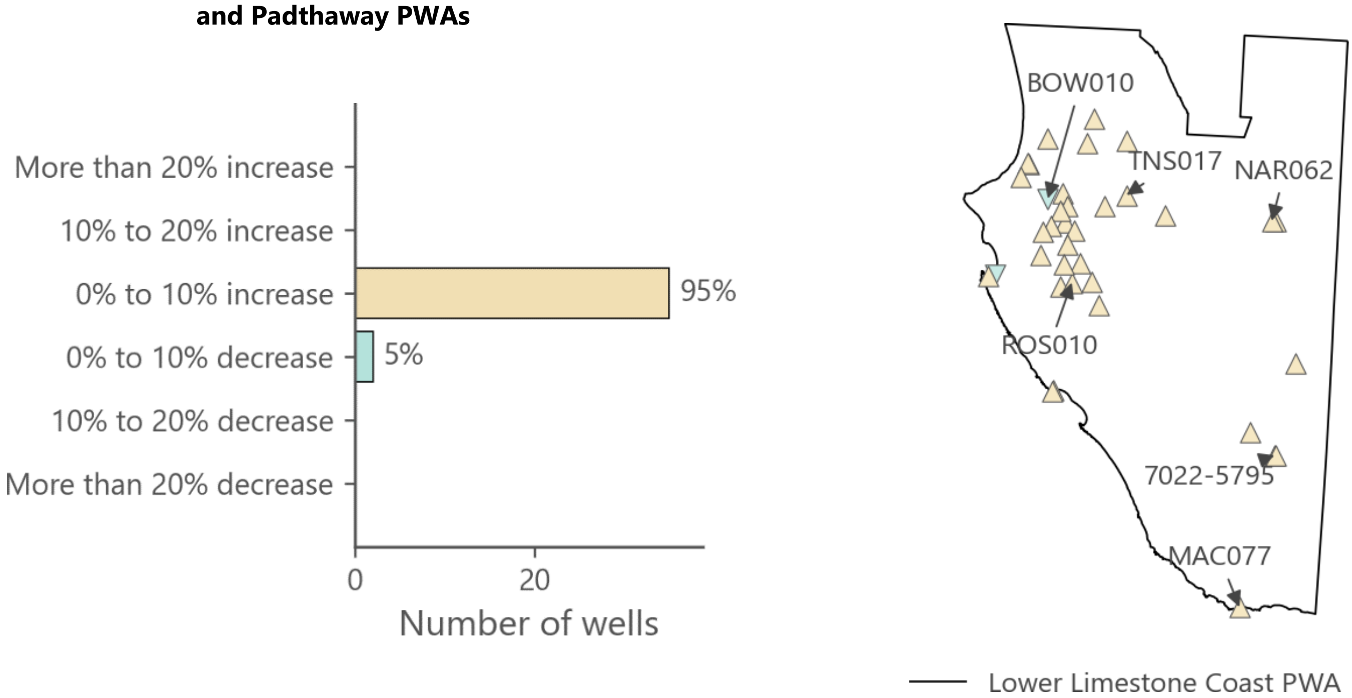

Figure 5.49. Salinity trend in the 10 years to 2020 for wells in the confined aquifer in the Lower Limestone Coast and Padthaway PWAs

Salinity from a selection of confined aquifer monitoring wells in the Lower Limestone Coast PWA illustrate common or important trends (Figure 5.50). Most of the town water supplies in the Lower Limestone Coast PWA are obtained from the confined aquifer.

Observation wells TNS017, LAC023 and ROS010 are located in the artesian part of the aquifer (inland of Kingston to Beachport) and this is where most groundwater extraction occurs. Groundwater salinity in most wells is relatively stable since monitoring began in 1970.

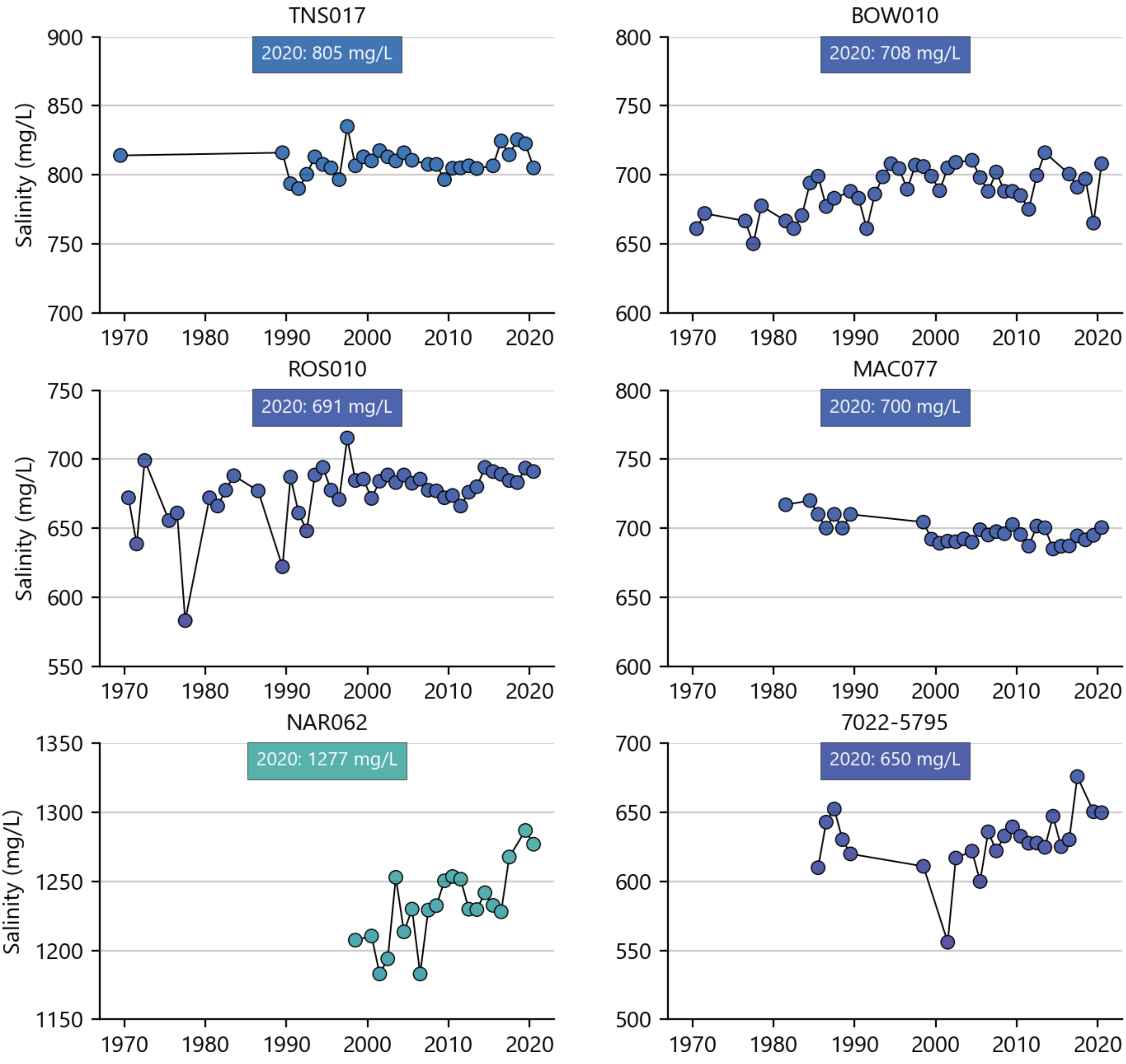

Figure 5.50. Selected salinity graphs for wells in the confined aquifer in the Lower Limestone Coast PWA

5.3.3 Tatiara PWA – confined aquifer – water level

In 2020, winter-recovered water levels in all five monitoring wells in the confined aquifer are below their historical average, with four wells (80%) at their lowest winter-recovered water level on record (Section 2.3.1; Figure 5.51). Water levels in all wells have declined over the past 20 years, with declines ranging from of 0.67 to 2.48 m (median decline of 2.31 m).

Five-year trends show declining water levels for 4 out of 5 wells (80%), with rates of decline ranging from 0.03 to 0.06 m/y (median 0.5 m/y; Figure 5.52).

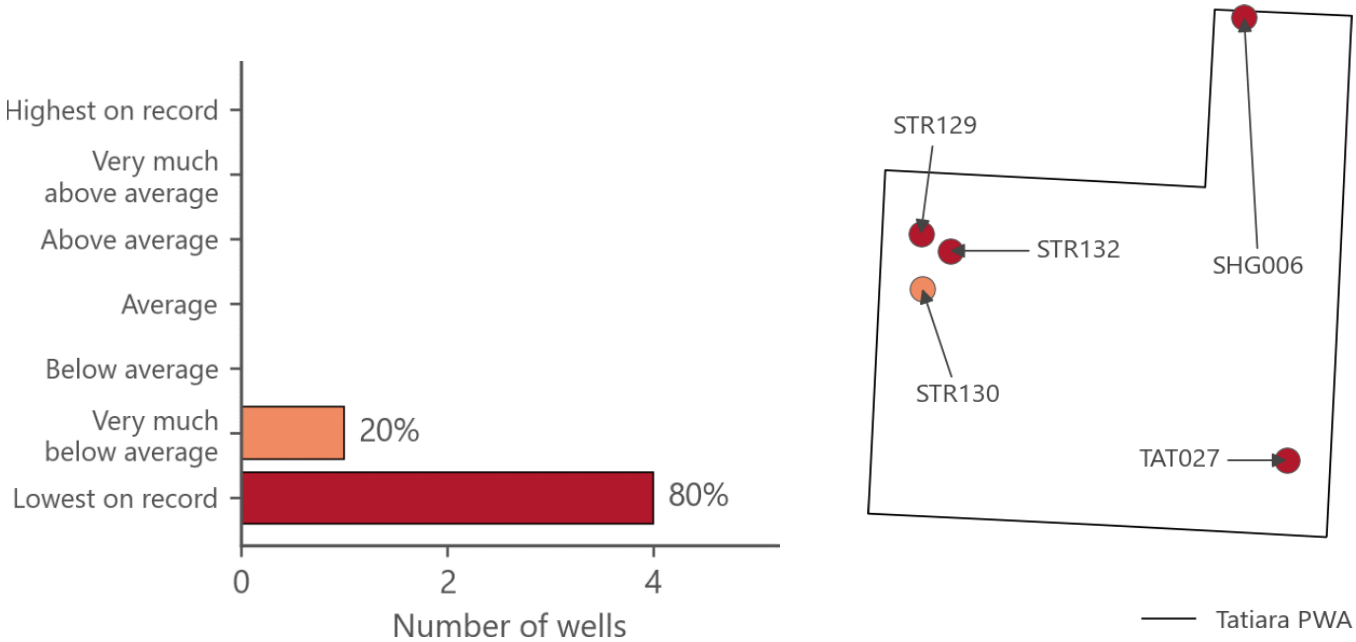

Figure 5.51. 2020 winter-recovered water levels for wells in the confined aquifer in the Tatiara PWA

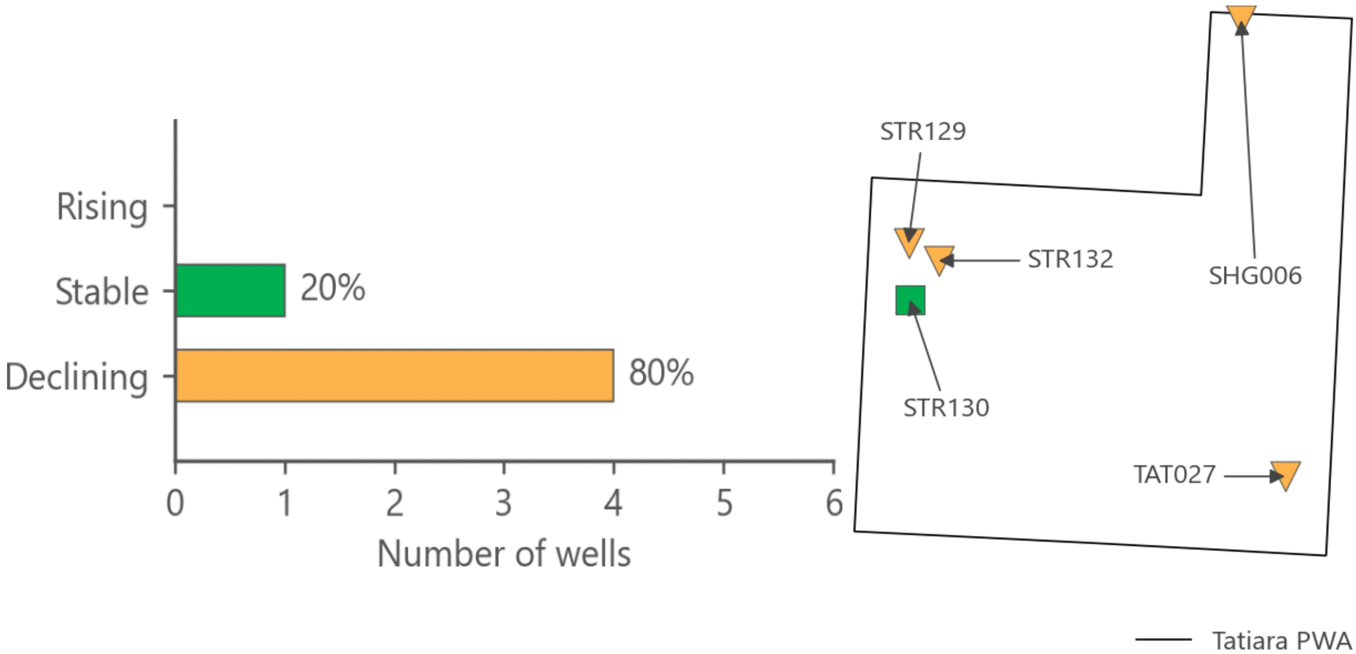

Figure 5.52. 2016–20 trend in winter-recovered water levels for wells in the confined aquifer in the Tatiara PWA

The groundwater level trends observed in the confined aquifer (Figure 5.53) are very similar to those observed in the overlying unconfined aquifer in both the plains (STR129, STR130, and STR132; Figure 5.27) and highlands areas (SHG006 and TAT027; Figure 5.33).

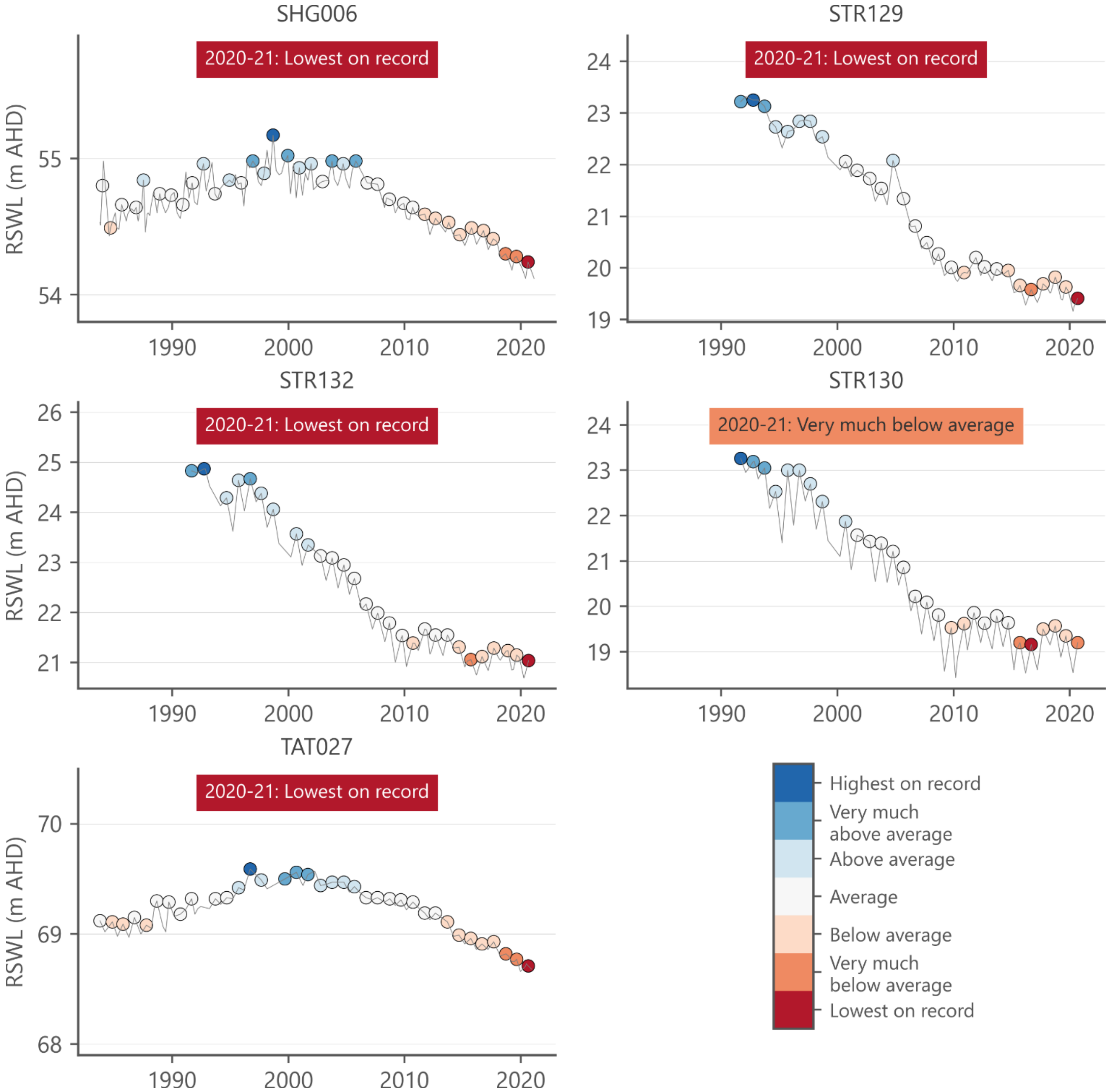

Figure 5.53. Selected hydrographs for wells in the confined aquifer in the Tatiara PWA

5.3.4 Tintinara-Coonalpyn PWA – confined aquifer – water level

Following the 2020–21 irrigation season, water levels in 17 monitoring wells (65%) are classified 'Average' when compared to their respective historical levels, while 8 wells (31%) are classified 'Below average' (Section 2.3.1; Figure 5.54). Over the past 20 years, water levels in all wells have declined, with declines ranging from of 0.21 m to 10.06 m (median decline of 3.34 m).

Five-year trends show declining water levels in 22 out of 27 wells (81%), with rates of decline ranging from 0.03 m/y to 1.08 m/y (median 0.29 m/y; Figure 5.55).

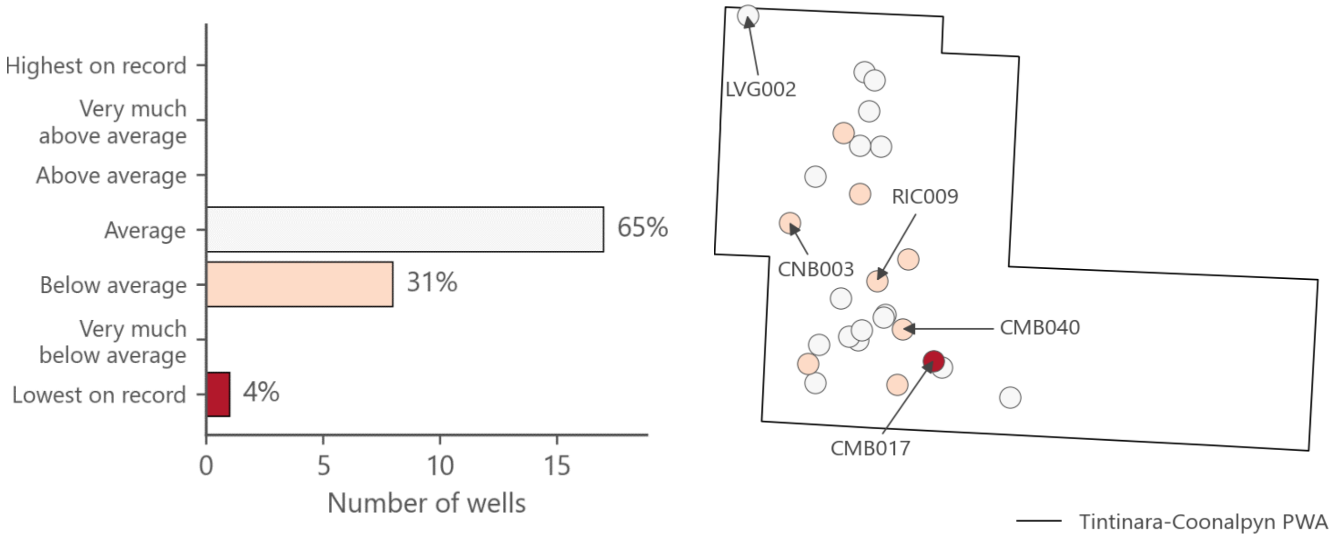

Figure 5.54. 2020 winter-recovered water levels for wells in the confined aquifer in the Tintinara-Coonalpyn PWA

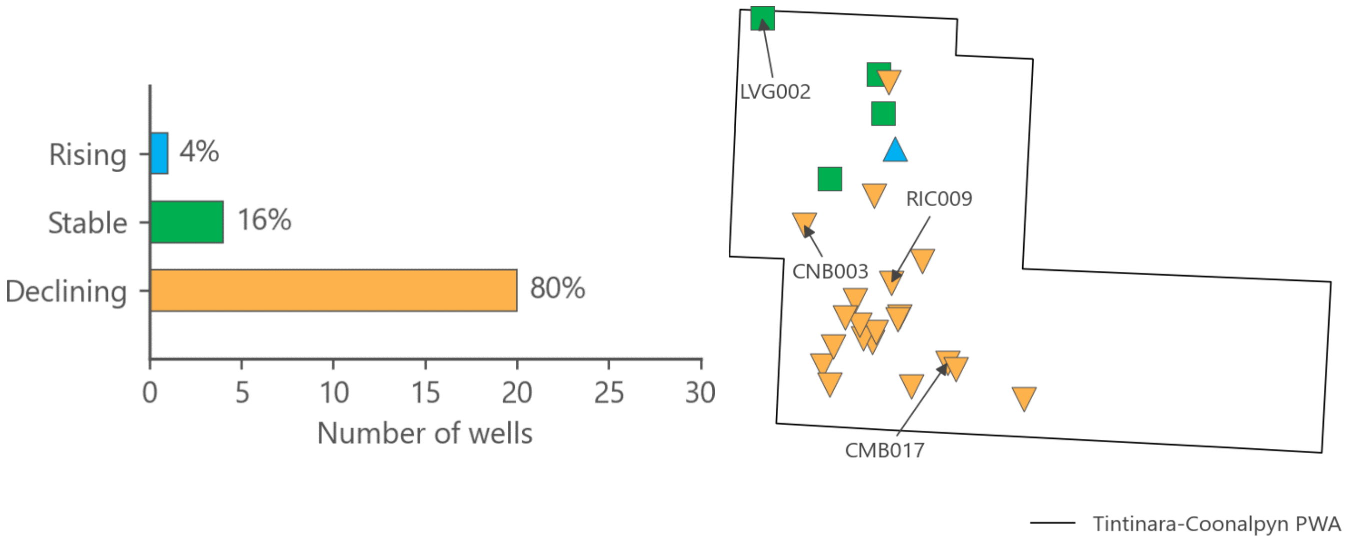

Figure 5.55. 2016–20 trend in winter-recovered water levels for wells in the confined aquifer in the Tintinara-Coonalpyn PWA

The majority of representative monitoring wells in the confined aquifer in the Tintinara-Coonalpyn PWA (Figure 5.56) show trends of declining water levels, occurring around the time of the Millennium Drought (late-1990s through 2010), after which a recovery in levels is mostly evident. For example, monitoring well LVG002 is located near the northern boundary of the PWA (Figure 5.55) and has seen a recovery in since 2010; the water level is currently classified 'Average' (Figure 5.56).

The effects of groundwater pumping on water levels are seen as seasonal fluctuations in water level, and are most pronounced in wells near Tintinara (Figure 1.1) (e.g. RIC009, Figure 5.56).

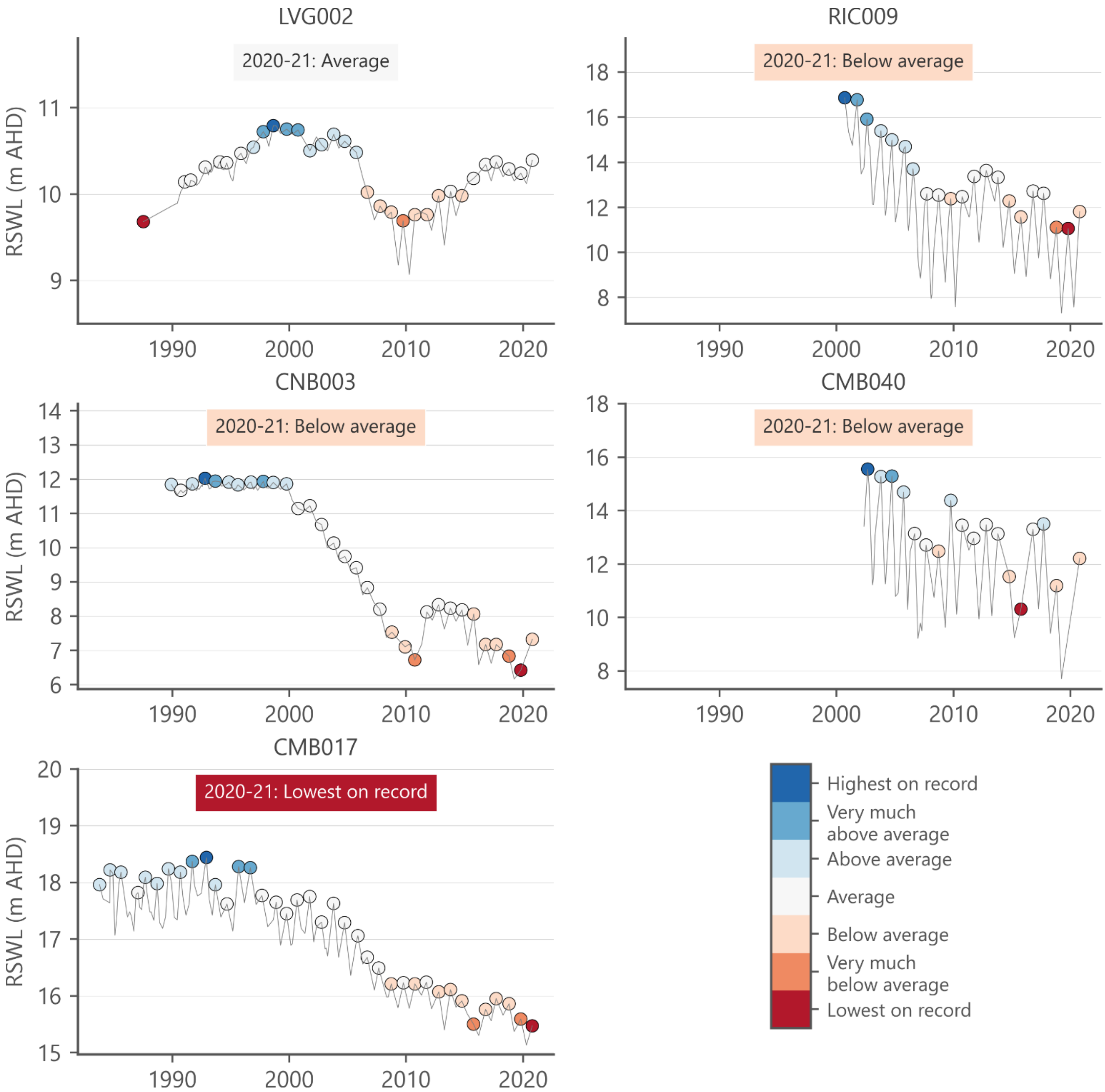

Figure 5.56. Selected hydrographs for wells in the confined aquifer in the Tintinara-Coonalpyn PWA

5.3.5 Tintinara-Coonalpyn and Tatiara PWAs – confined aquifer salinity

In 2020, confined aquifer salinity in the Tintinara-Coonalpyn and Tatiara PWAs ranges from 972 mg/L to 4082 mg/L (median 1521 mg/L; Figure 5.57). In general, the highest salinities occur toward the south-west of the PWA.

In the 10 years to 2020, the majority of monitoring wells (73%) show a decrease in groundwater salinity. Trends in salinity over this period vary from a decrease of 0.71% per year to an increase of 0.55% per year, with a median rate of 0.10% decrease per year (Figure 5.58).

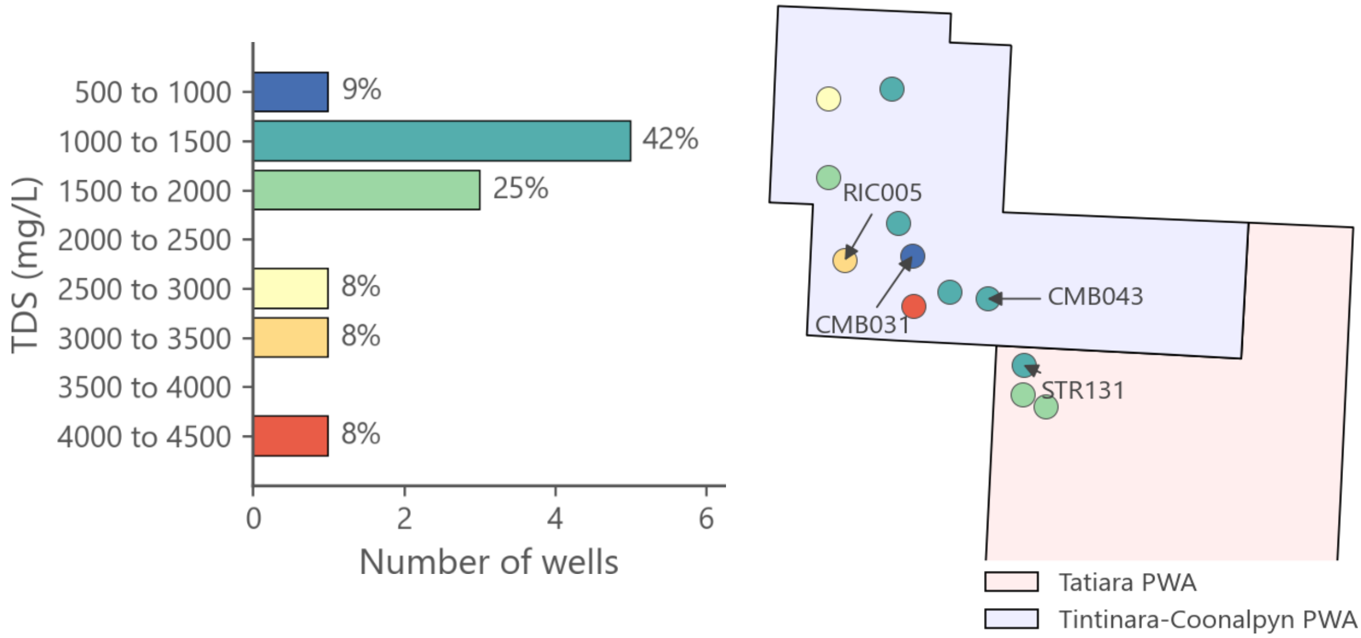

Figure 5.57. 2020 salinity observations from wells in the confined aquifer in the Tintinara-Coonalpyn and Tatiara PWAs

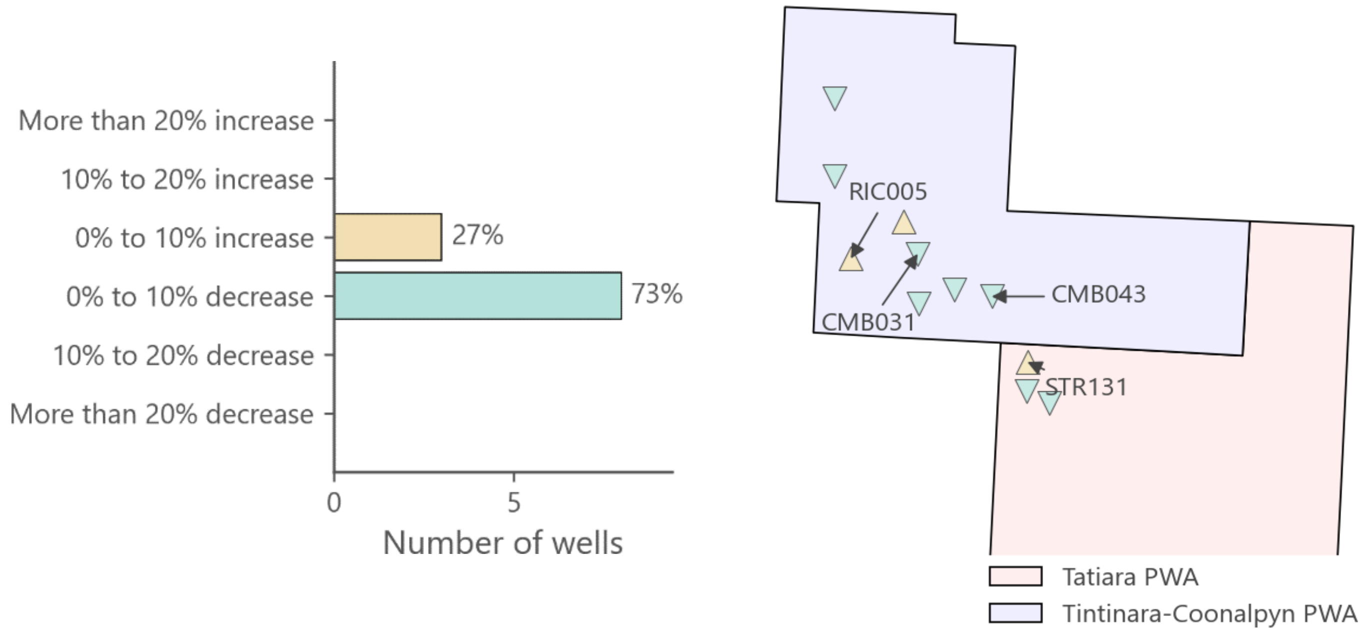

Figure 5.58. Salinity trend in the 10 years to 2020 for wells in the confined aquifer in the Tintinara-Coonalpyn and Tatiara PWAs

Salinity from a selection of confined aquifer monitoring wells in the Tintinara Coonalpyn and Tatiara PWAs illustrate common or important trends (Figure 5.59). Salinity is stable across both PWAs with variations of generally less than 200 mg/L over the past 20 to 30 years.

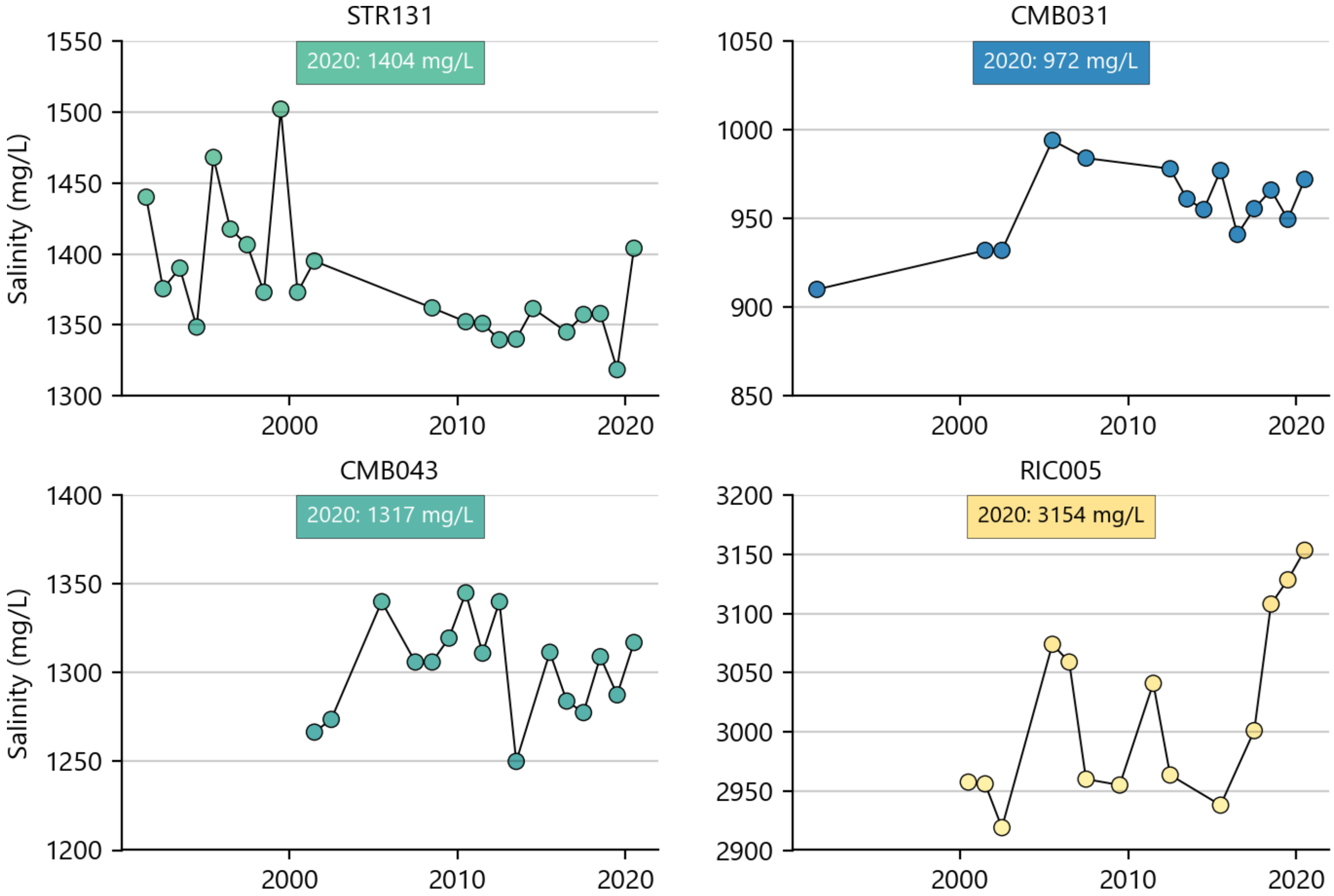

Figure 5.59. Selected salinity graphs for wells in the confined aquifer in the Tintinara Coonalpyn and Tatiara PWAs

6 Water use

Given the lack of reliable surface water flows, there is a large reliance on groundwater resources for town water supply, irrigation, and stock, domestic and industrial uses. Across the Limestone Coast Landscape region, greater than 90% of total groundwater extraction is sourced from unconfined aquifers (Figure 6.1). Extraction from the confined aquifer contributes between 5% and 10% of total licensed water use and a comparatively small volume of surface water is also used in the Morambro Creek area. The majority of water extracted is from the Lower Limestone Coast PWA (Figure 6.2), which is also the largest region by area (Figure 1.1).

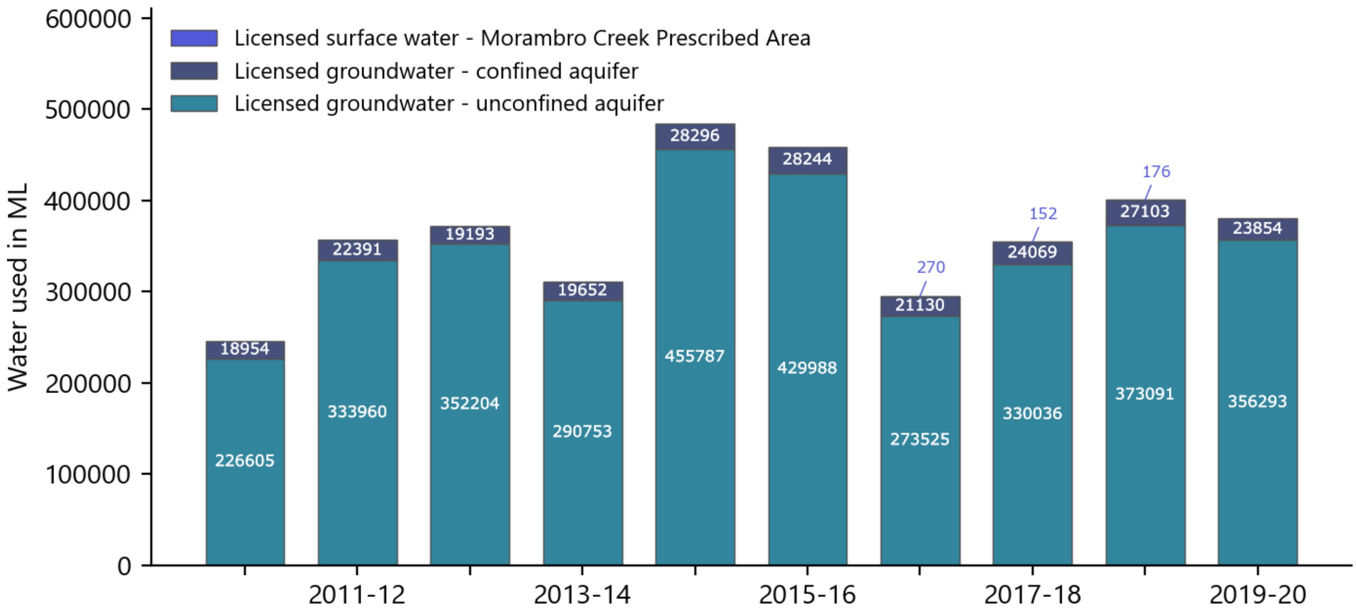

Figure 6.1. Licensed water extraction from 2010–11 to 2019–20 by water resource type

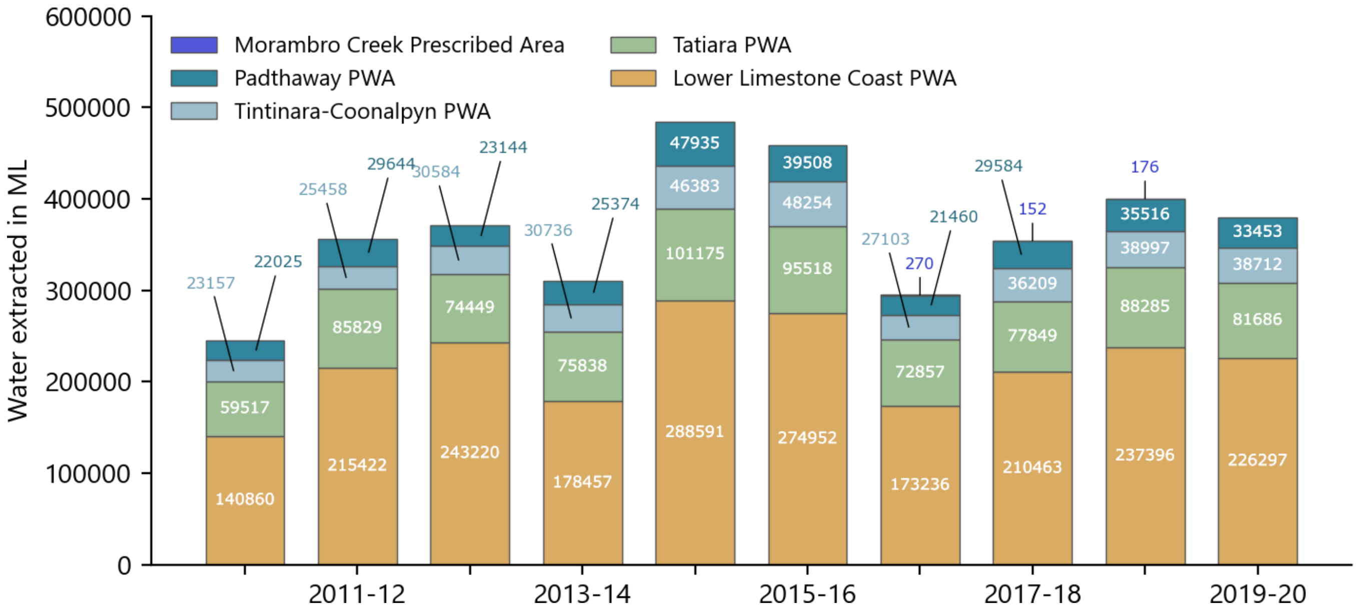

Figure 6.2. Licensed water extraction from 2010–11 to 2019–20 by prescribed area

The total amount of water used in 2019–20 was 380 148 ML (Figure 6.1). This includes only licensed groundwater extraction as no licensed surface water extraction was possible. Imported water from the River Murray via the Tailem Bend to Keith pipeline is excluded from total water use that is cited in this assessment.

6.1 Surface water use

The Morambro Creek and Nyroca Channel PWC and Morambro Creek PSWA were prescribed in response to an increase in demand for water for aquifer recharge schemes to address the increasing salinity of the adjacent groundwater resource in the Padthaway PWA. The majority of existing users divert water from the Morambro Creek or the Nyroca Channel. Others divert water via dams or drainage wells. The diverted water is used for aquifer recharge, stock, domestic, irrigation and recreation purposes. There is no commercial, industrial or town take of water in the PWC or PSWA.

Low reliability of streamflow in Morambro Creek has meant there has been no systematic development of the surface water resource. Licensees are limited to a rate of take once specific flow thresholds are reached. Currently there are four licences to take or divert water within the prescribed area.

There was no streamflow recorded in 2019–20 and as a result of this, surface water extraction from the creek was not possible.

6.2 Groundwater use

Most groundwater extraction is from the unconfined aquifers of the Lower Limestone Coast and Tatiara PWAs (Figure 6.3), although the Padthaway PWA has high rates of extraction over a relatively small area (Figure 1.1). The primary use from the unconfined aquifer is irrigation. Extraction from the confined aquifer occurs mainly across the Lower Limestone Coast and Tintinara-Coonalpyn PWAs (Figure 6.4).

In general, volumes of extraction from unconfined aquifers show an inverse correlation with annual rainfall – relatively low volumes are extracted in years of above-average rainfall. A similar, albeit weaker, inverse correlation generally exists for extractions from the confined aquifers.

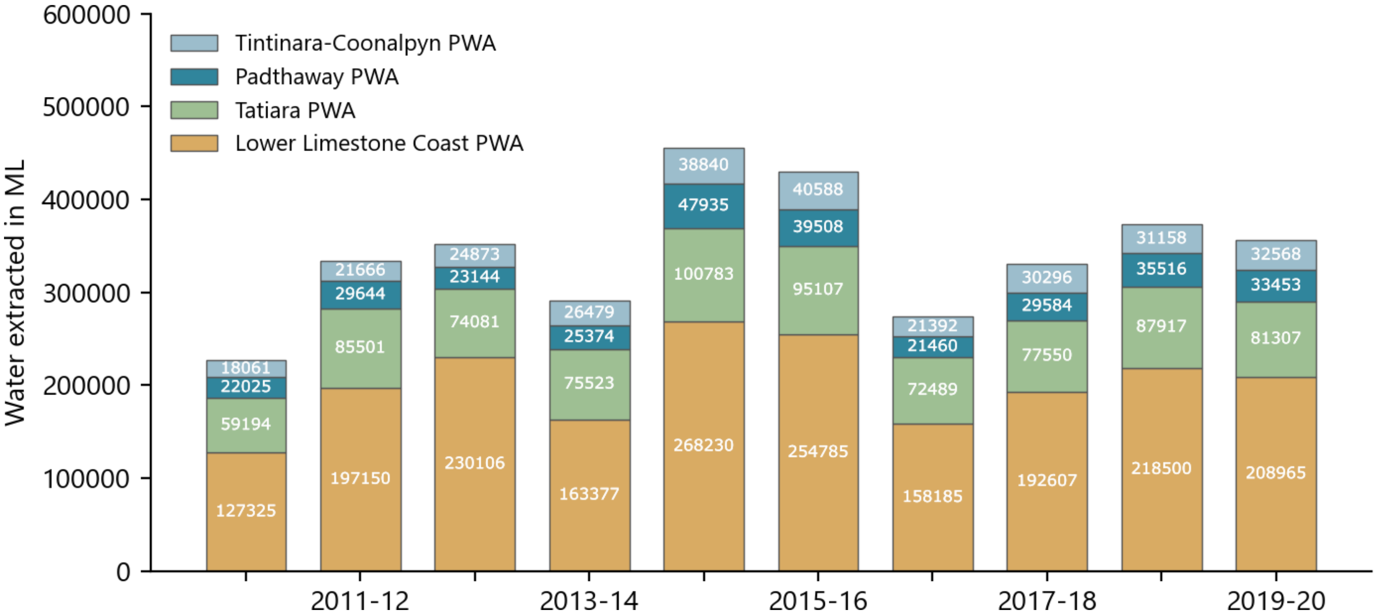

Figure 6.3. Licensed water extraction from the unconfined aquifer between 2010–11 and 2019–20

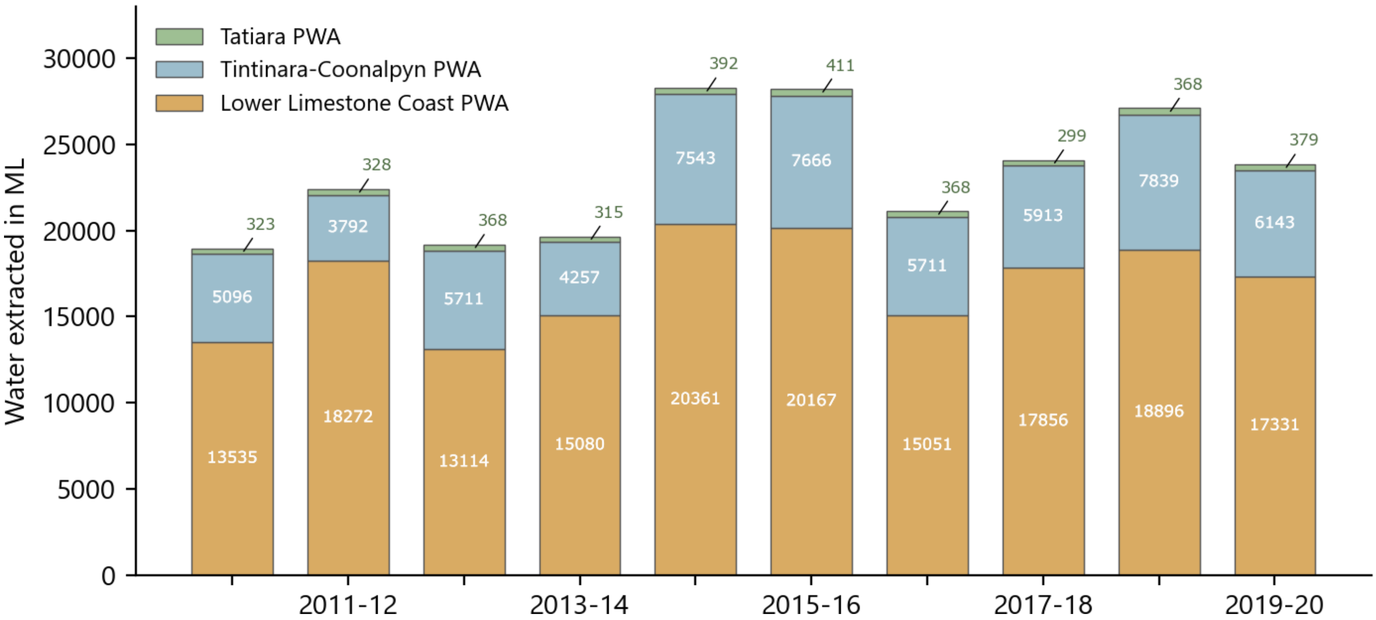

Figure 6.4. Licensed water extraction from the confined aquifer between 2010–11 and 2019–20

6.2.1 Lower Limestone Coast PWA

In 2019–20, licensed groundwater extractions from the unconfined aquifer are 208 965 ML. This is a decrease of 4% compared to 2018–19. Relatively low volumes were extracted in 2016–17, 2013–14, and 2010–11, which were all years of above-average rainfall at the Mount Gambier rainfall station (BoM station 26021; Figure 3.1).

Licensed extractions from the confined aquifer totalled 17 331 ML in 2019–20, an 8% decrease from 2018–19.

6.2.2 Padthaway PWA

In 2019–20, licensed groundwater extractions from the unconfined aquifer are 33 453 ML; this is a decrease of 6% from 2018–19 that occurred despite a 5% reduction in annual rainfall over the same period (Marcollat BoM station 26017; Figure 3.5). The lowest volumes were extracted in 2016–17 and 2010–11, which were both years with markedly above-average rainfall (Figure 3.5).

There were no licensed extractions from the confined aquifer in 2019–20 in the Padthaway PWA.

6.2.3 Tatiara PWA

In 2019–20, licensed groundwater extractions from the unconfined aquifer are 81 307 ML, which is a decrease of 8% from 2018–19, which corresponds to an increase in rainfall of 12% over the same period (Keith BoM station 25507; **Error! Reference source not found.**). The lowest volumes extracted over the past nine years have been in 2016–17, 2013–14, and 2010–11, which were all years of above-average rainfall (**Error! Reference source not found.**).

There was a very small increase in extraction from the confined aquifer of 3% in 2019–20 (379 ML compared to 368 ML in the previous year).

6.2.4 Tintinara-Coonalpyn PWA

In 2019–20, licensed groundwater extractions from the unconfined aquifer are 32 568 ML, which is an increase of 5% compared to 2018–19. This is despite a large increase in rainfall of 20% over the same period (Tintinara BoM station 25514; Figure 3.9).

In 2019–20, licensed extractions from the confined aquifer are 6143 ML, which is a decrease of 22% from 2018–19.

6.3 Farm dams

Farm dam development in the PSWA has the potential to significantly reduce the low flow component of streamflow of the Morambro Creek and Nyroca Channel prescribed watercourses and the Marcollat watercourse downstream. There are approximately 290 farm dams in the PSWA, and some of these divert water from the PWC and PSWA for stock and domestic purposes. Any recreational use is primarily for amenity dams. Total farm dam storage is estimated from an aerial survey in 2013 to be 250 ML. Across the Morambro PSWA, smaller dams (capacity less than 5 ML) account for the majority of the number of dams (99%), and represent 62% of the total storage capacity of dams. Larger dams (5 ML or greater capacity) make up 1% of the total dam count but contribute 38% of the total storage capacity (Figure 6.5).

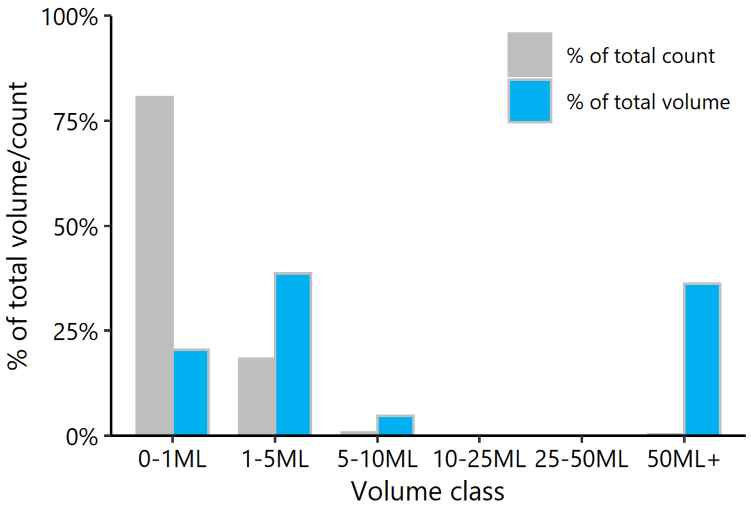

Figure 6.5. Count and volume of farm dam classes in the Morambro PSWA

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