

Adelaide Plains Prescribed Wells Areas 2019–20 water resources assessment

Department for Environment and Water
December, 2021

DEW Technical Note 2021/14



**Government
of South Australia**

Department for
Environment and Water

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Government of South Australia
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81-95 Waymouth St, ADELAIDE SA 5000
Telephone +61 (8) 8463 6946
ABN 36702093234

www.environment.sa.gov.au

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1 Summary

Central Adelaide PWA	T1 aquifer	
Kangaroo Flat region	T2 aquifer	
Northern Adelaide	T1 aquifer	
Plains PWA	T2 aquifer	

LEGEND

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

Rainfall

- Representative rainfall stations are located in Gawler, Smithfield and North Adelaide (SILO Patched Point Datasets).
- Total annual rainfall in 2019–20 ranges between 363–443 mm, which is below the long-term average (1979–2020) for all three stations.
- All months except February and April 2020 were below the long-term monthly average (1979–2020).

Groundwater

- In 2020, most groundwater levels in wells in the T1 aquifer are classified 'Above average' or greater (64% of wells in the Central Adelaide PWA and 63% in the NAP PWA), while nearly half of the wells in the T2 aquifer are classified 'Below average' or lower (47% of wells in the NAP PWA and all four wells in the Kangaroo Flat region).
- Five-year trends show that groundwater levels in the T1 and T2 aquifers of the NAP PWA are declining in most wells. Five-year trends show rising water levels in 50% of wells, while 38% of wells are declining in the T1 aquifer of the Central Adelaide PWA.
- Ten-year trends show that groundwater salinity in the T1 aquifer of the Central Adelaide PWA is decreasing in the majority of monitoring wells (64%), with a median rate of decline of 0.07% per year.
- Ten-year trends show that groundwater salinity for the majority of wells (82% of T1 wells and 78% of T2 wells) in the NAP PWA vary within the range $\pm 10\%$, with a median rate of 1.41% decrease per year for the T1 aquifer while the median salinity for the T2 aquifer is stable.
- Ten-year trends show that groundwater salinity in three of the four wells in the T2 aquifer of the Kangaroo Flat region is increasing, with a median rate of 0.22% increase per year.

Water use

- Groundwater that is extracted from the T1 and T2 aquifers of the Kangaroo Flat region and NAP PWA is predominantly used for horticulture; total annual extraction was lower in 2019–20 relative to the previous water-use year. The decrease in groundwater extraction in 2019–20 coincides with higher rainfall compared to 2018–19.
- In 2019–20, managed aquifer recharge schemes injected a total of 1122 ML into the T1 aquifer and 3887 ML into the T2 aquifer, with most of the total volume (70%) injected in the NAP PWA.

1.1 Purpose

The Department for Environment and Water (DEW) has a key responsibility to monitor and report annually on the status of South Australia's groundwater and surface water resources. To fulfil this responsibility, 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 detailed information for each resource
- **Fact sheets:** provide summary information for each resource
- **State-wide summary:** covers the main water resources in a quick-reference format.

This document is the Technical Note for the Central Adelaide, Northern Adelaide Plains and Dry Creek PWAs (2019–20) (collectively 'the Adelaide Plains') and collates rainfall and water data collected between July 2019 and September 2020, and groundwater level and salinity data collected between July and December 2019.

1.2 Regional context

Groundwater is a prescribed resource in the Central Adelaide, Northern Adelaide Plains and Dry Creek PWAs under South Australia's *Landscape SA Act 2019* (the Act). A water allocation plan for the NAP PWA was adopted in 2000 and provides rules for the management of its groundwater resources. The public consultation phase of developing a draft Water Allocation Plan for the Adelaide Plains (i.e. Central Adelaide, Northern Adelaide Plains and Dry Creek PWAs) is complete. The water allocation plan will replace the existing Northern Adelaide Plains Water Allocation Plan when it becomes operational on 1 July 2022 and it will be the first water allocation plan for the Central Adelaide and Dry Creek PWAs.

The Central Adelaide PWA mostly lies within the Green Adelaide management area, and partly in the (1) Hills and Fleurieu and (2) Northern and Yorke Landscape regions (Figure 1.1). It encompasses most of the Adelaide metropolitan area, extending from Outer Harbor and Evanston South in the north to Noarlunga in the south.

The NAP PWA is located immediately north of the Central Adelaide PWA, in the Green Adelaide and Northern and Yorke Landscape regions. The Kangaroo Flat region is located in the north-east area of the NAP PWA, encompassing an area of around 80 km².

Groundwater use in the Kangaroo Flat region was restricted in 2000 under the Act, and the region was prescribed in 2004. Since 2017, allocations in the Kangaroo Flat region have been subject to staged reductions to mitigate the risk of increasing groundwater salinity as a result of inter-aquifer leakage between the T2 and overlying Quaternary aquifers in the short term, and lateral inflow of higher-salinity groundwater from the northeast in the longer term (Barnett 2013).

Groundwater occurs in multiple aquifers across the Adelaide Plains; however, most groundwater is extracted from the T1 and T2 aquifers. For this reason, areas with the greatest rates of extraction are reported here *viz.*, the T1 aquifer of the Central Adelaide PWA, the T1 and T2 aquifers of the Northern Adelaide Plains PWA and the T2 aquifer of the Kangaroo Flat region.

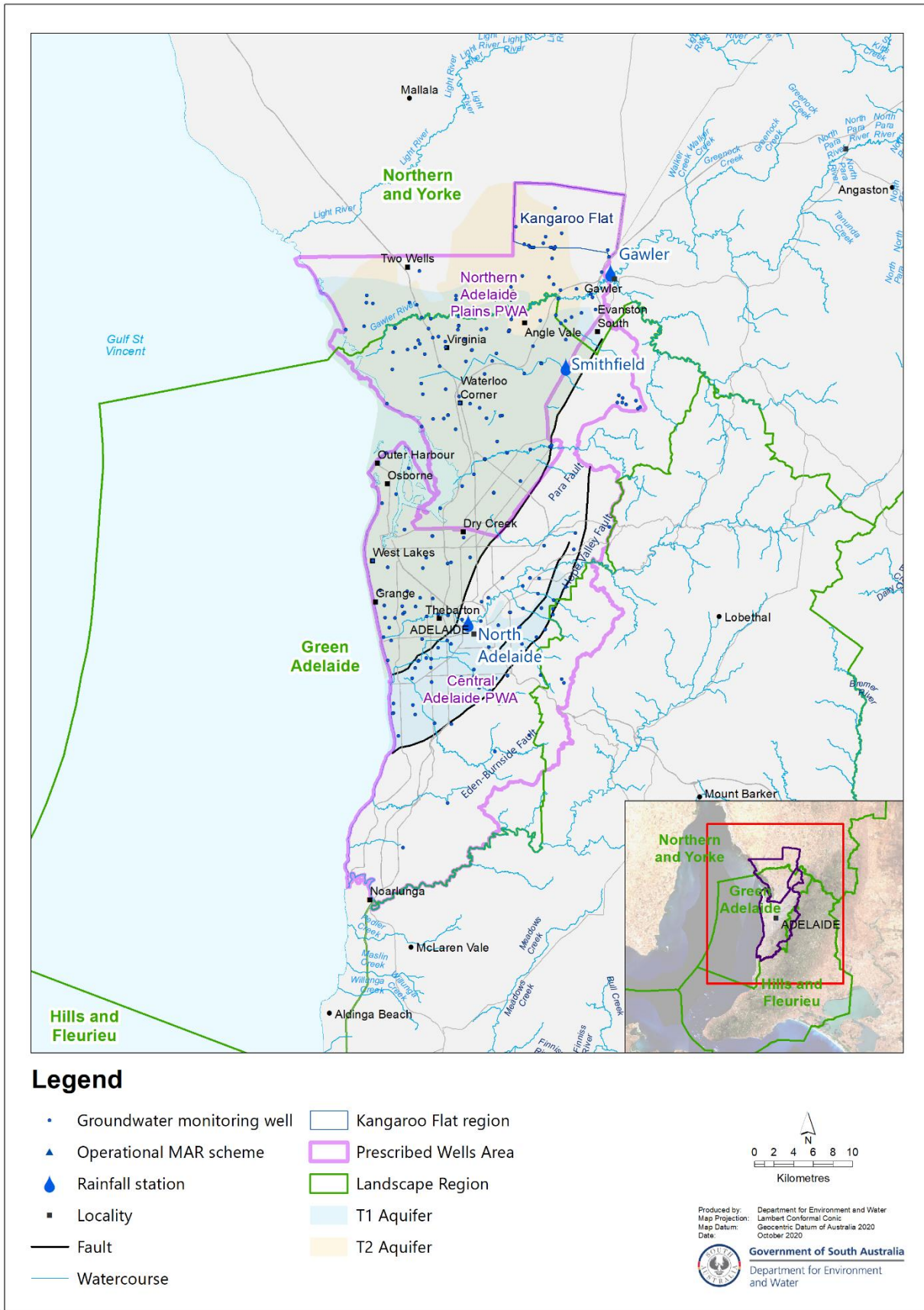


Figure 1.1 Location of the Central Adelaide and Northern Adelaide Plains PWAs

2 Methods and data

This section describes the source of rainfall, surface water, groundwater and extraction data presented in this assessment, and describes the methods used to analyse and present these data.

2.1 Rainfall

Daily rainfall observations have been used from selected Bureau of Meteorology (BoM) stations in order to calculate monthly and annual totals. The data have been obtained from the [SILO Patched Point Dataset](#) service provided by the Queensland Government, which provides interpolated values to fill gaps in observations (see Section 3).

Rainfall maps were compiled using gridded datasets obtained from the BoM (Figure 3.1). The long-term average annual rainfall map was obtained from [Climate Data Online](#). The 2019–20 map of total rainfall was compiled from monthly rainfall grids obtained for the months between July 2019 and June 2020 from the [Australian Landscape Water Balance](#) website.

2.2 Groundwater

2.2.1 Water level

Water level data¹ 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. In general, the aquifers in the Central Adelaide and Northern Adelaide Plains PWAs return to a recovered maximum level between July and November of the same year.

For those wells with suitable long-term records, the annual recovered water levels were then ranked from lowest to highest and given a description according to their decile range² (Table 2.1). The definition of a suitable long-term record varies depending on the history of monitoring activities in different areas; for the Central Adelaide PWA, any well with 20 years or more of recovered water levels is included, while for the Northern Adelaide Plains PWA any well with 10 years or more is included and for the Kangaroo Flat region any well with 3 years or more is included.

The number of wells in each description class for the most recent year is then summarised for each aquifer (e.g. Figure 4.1) and hydrographs are shown for a selection of wells to illustrate common or important trends (e.g. Figure 4.3). Five-year trends are calculated using annual recovered water levels for those wells that 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

¹ "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).



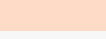
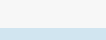


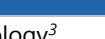
² Decile: a division of a ranked set of data into ten groups with an equal number of values. In this case e.g. the first decile contains those values below the 10th percentile.

below, above, or within a given tolerance threshold. This threshold and the status of 'stable' is intended to allow for the demarcation of wells where water levels are changing at very low rates and would normally be considered stable, and also to accommodate very small human or instrument measurement errors. The number of rising, declining and stable wells are then summarised for each aquifer (e.g. Figure 4.2).

Regional-scale confined and unconfined sedimentary aquifers such as the T1 and T2 aquifers are given tolerance thresholds of 2 cm/y.

Twenty-year changes in water level were calculated as the difference between the average water level in a three-year period twenty years ago (i.e. 1999–2001) and the average water level in 2019.

Table 2.1. Percentile/decile descriptions*

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

* Deciles and descriptions as defined by the Bureau of Meteorology³

2.2.2 Salinity

Where more than one salinity sample has been collected in the course of a year, the annual mean salinity is used for analysis. Salinity is measured as total dissolved solids (TDS). The results are shown in Figure 4.4.

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 4.5).

Salinity graphs are shown for a selection of wells to illustrate common or important trends (e.g. Figure 4.6)

2.3 Groundwater extraction

Meter readings are used to estimate licensed extraction volumes for groundwater sources. Where meter readings are not available, licensed or allocated volumes are used (Figure 5.1 and Figure 5.2).

³ Bureau of Meteorology [Annual climate statement](#)

2.4 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](#). For additional information related to groundwater monitoring well nomenclature, please refer to the Well Details page on [WaterConnect](#).

Other important sources of information on water resources of the Northern Adelaide Plains and Central Adelaide PWAs and Kangaroo Flat region, are:

- Summary reports on the groundwater resources of the Northern Adelaide Plains and Central Adelaide PWAs and Kangaroo Flat region (DEWNR, 2011), and annual groundwater level and salinity status reports (DEW, 2019a-d).
- The Water Allocation Plan for the Northern Adelaide Plains Prescribed Wells Area (NABCWMB, 2000).
- Gerges (2006) provides an overview of the hydrogeology of the Adelaide metropolitan area.

3 Rainfall

The climate of the Adelaide Plains is described as temperate, typically comprising cold, wet winters and hot, dry summers (BoM, 2021). Long-term data (1986–2015) indicate a high rainfall gradient across the Adelaide Plains, increasing from around 400 mm/y at the coast to around 650 mm/y at the foot of the Mount Lofty Ranges, which is a distance of around 20 km (Figure 3.1). Annual rainfall is greatest in the south-east towards the peak of the ranges at greater than 900 mm/y.

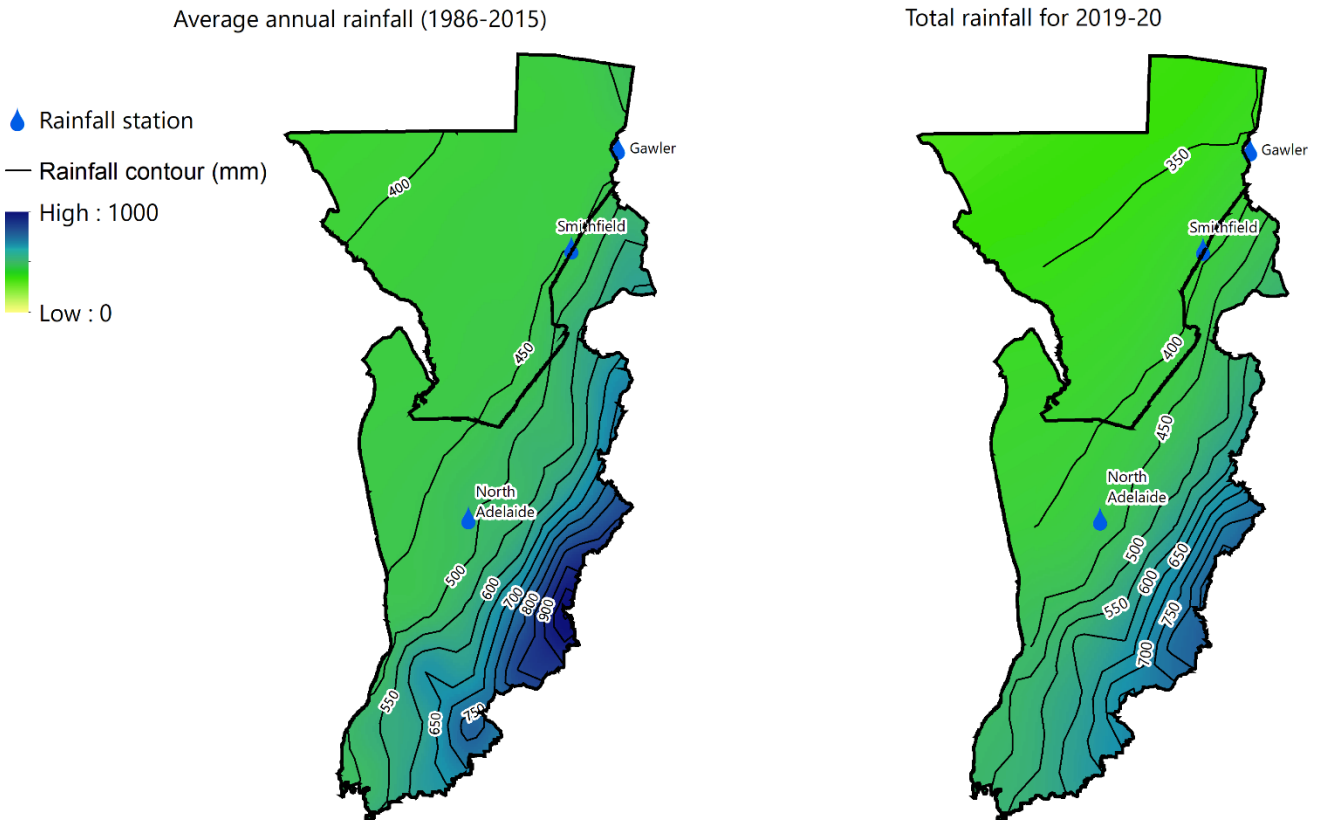


Figure 3.1 Rainfall in the Central Adelaide and Northern Adelaide Plains PWAs compared to the long-term average annual rainfall (1986–2015)

Three rainfall stations have been selected as representative of the following areas⁴:

- Gawler (Kangaroo Flat region).
- Smithfield (Northern Adelaide Plains PWA).
- North Adelaide (Central Adelaide PWA).

Annual rainfall for 2019–20 ranges between 363–443 mm/y and is below the long-term average at each of the three representative rainfall stations.

⁴ 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).

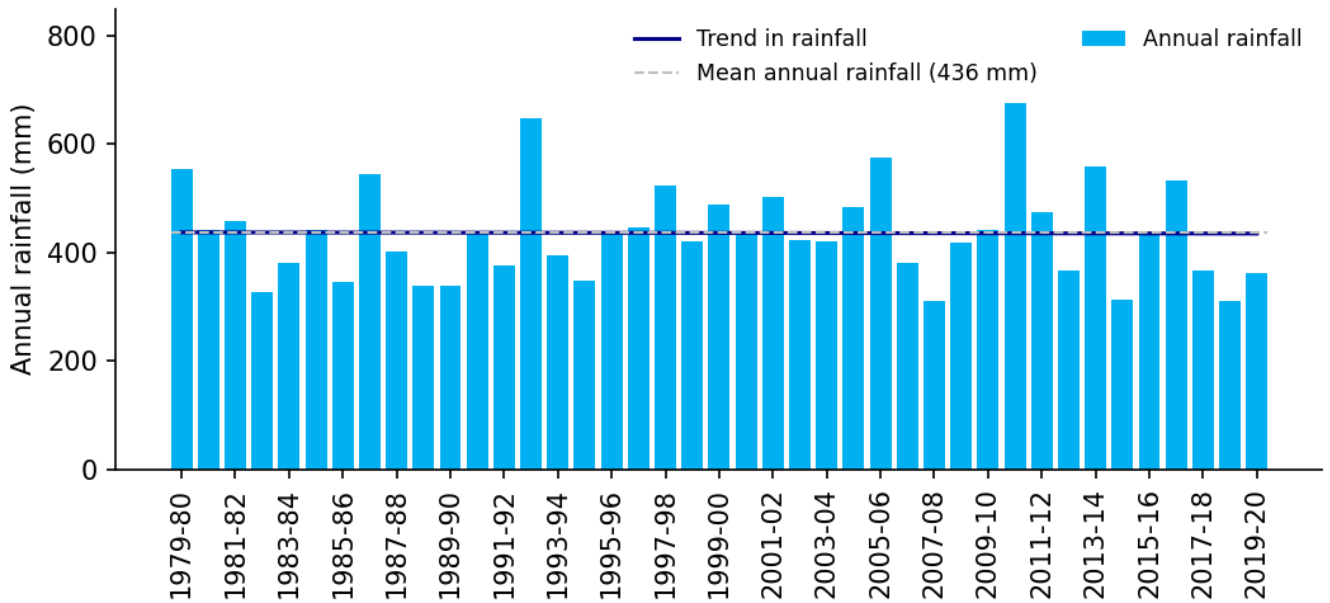


Figure 3.2 Annual rainfall for 1979–80 to 2019–20 at the Gawler rainfall station (23078)

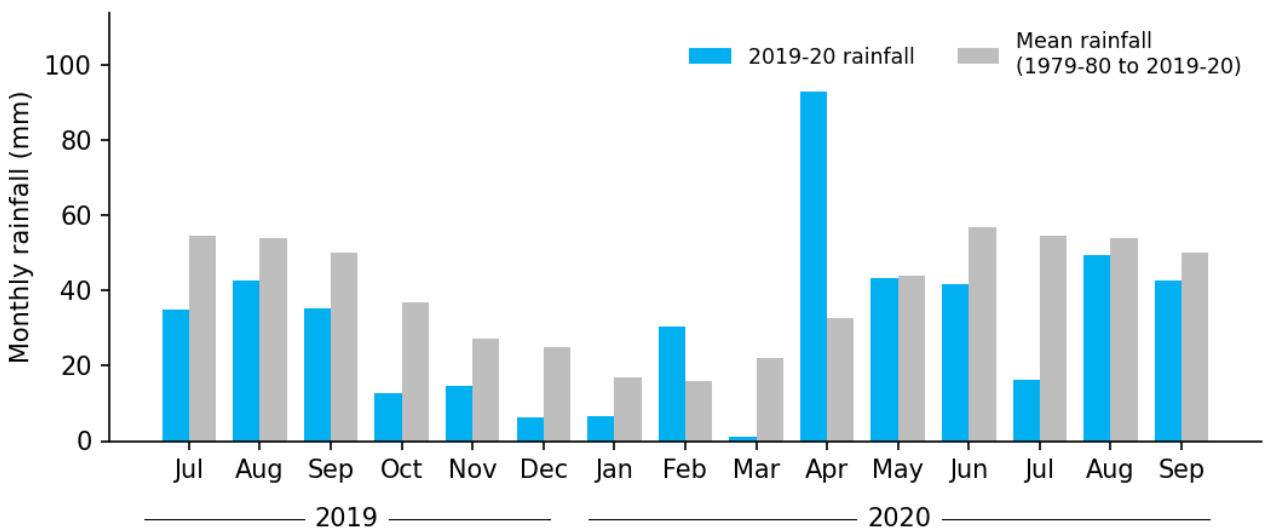


Figure 3.3 Monthly rainfall between July 2019 and September 2020 at the Gawler rainfall station (23078)

The Gawler rainfall station (BoM station 23078) has been selected as a representative rainfall station for the Kangaroo Flat region. Total annual rainfall for 2019–20 is 363 mm which is 73 mm lower than the average rainfall of 436 mm/y (1979–20) (Figure 3.2). Long-term data (1979–2020) indicate that the trend in rainfall (Figure 3.2) has been stable.

Monthly rainfall was below the long-term average throughout 2019–20, with the exception of the months of February and April 2020 (Figure 3.3).

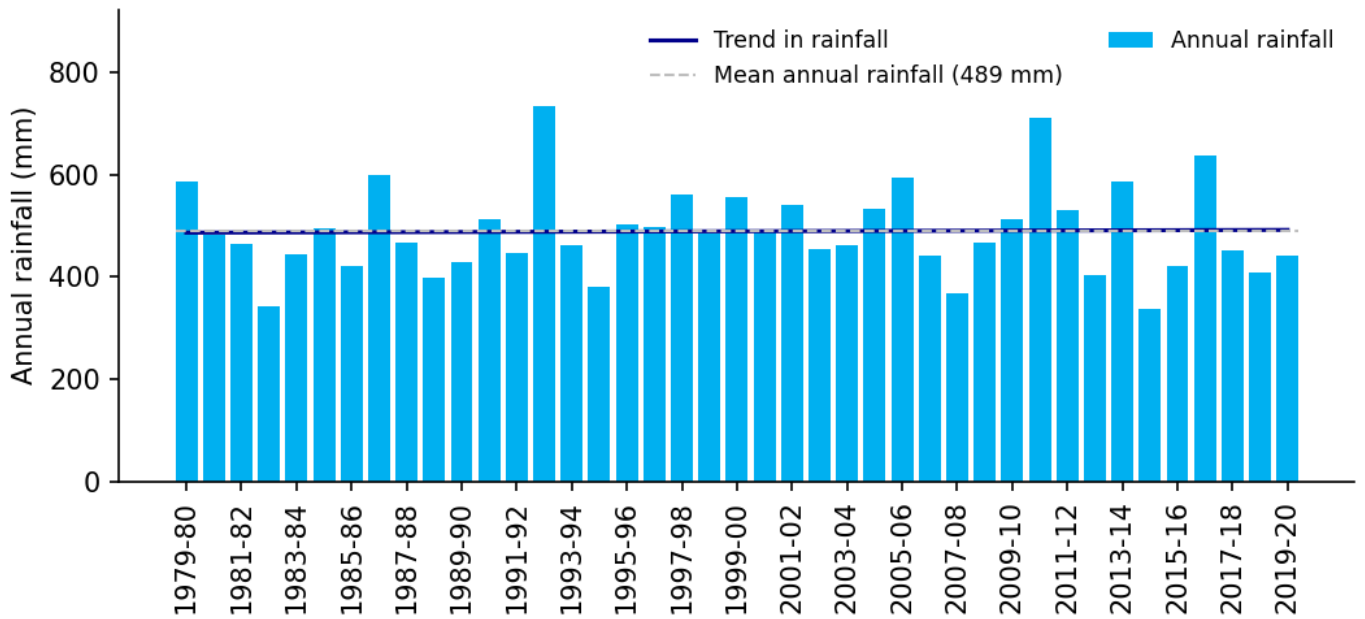


Figure 3.4 Annual rainfall for 1979–80 to 2019–20 at the Smithfield rainfall station (23025)

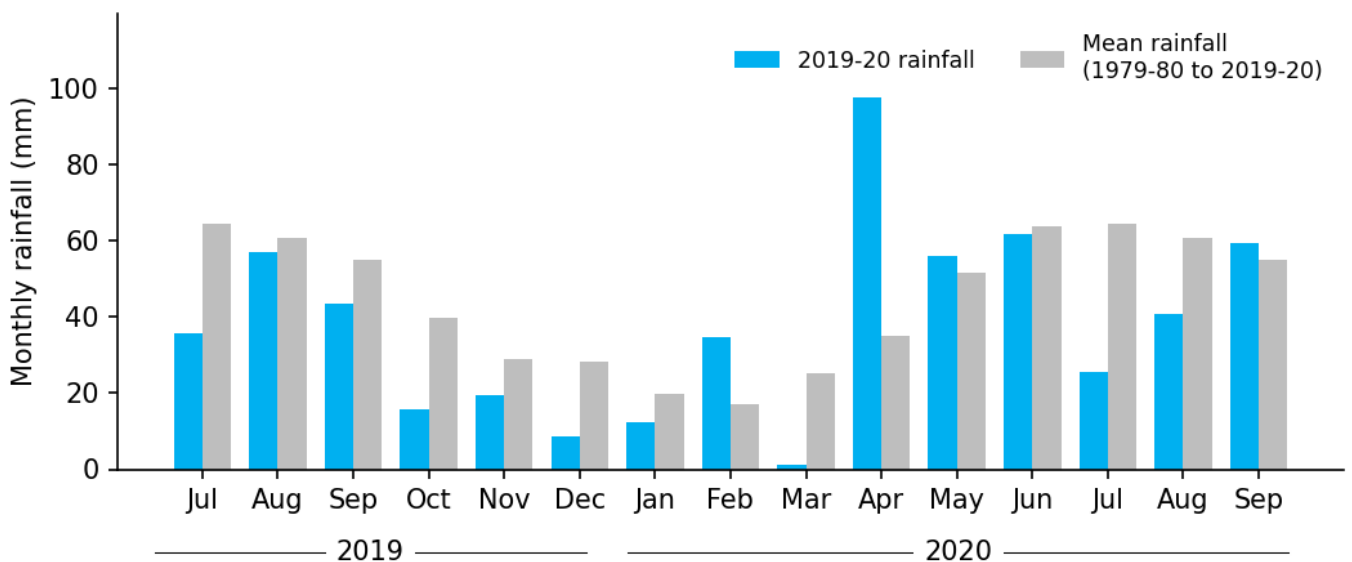


Figure 3.5 Monthly rainfall between July 2019 and September 2020 at the Smithfield rainfall station (23025)

The Smithfield rainfall station (BoM station 23025) has been selected as a representative rainfall station for the Northern Adelaide Plains PWA. Total annual rainfall for 2019–20 is 443 mm. This is 46 mm below the long-term average rainfall of 489 mm/y (1979–20) (Figure 3.4). Long-term data (1979–2020) indicate that the trend in rainfall (Figure 3.4) has been stable.

Monthly rainfall was near or below the long-term average throughout 2019–20, with the exception of the months February, April, May and September 2020 (Figure 3.5).

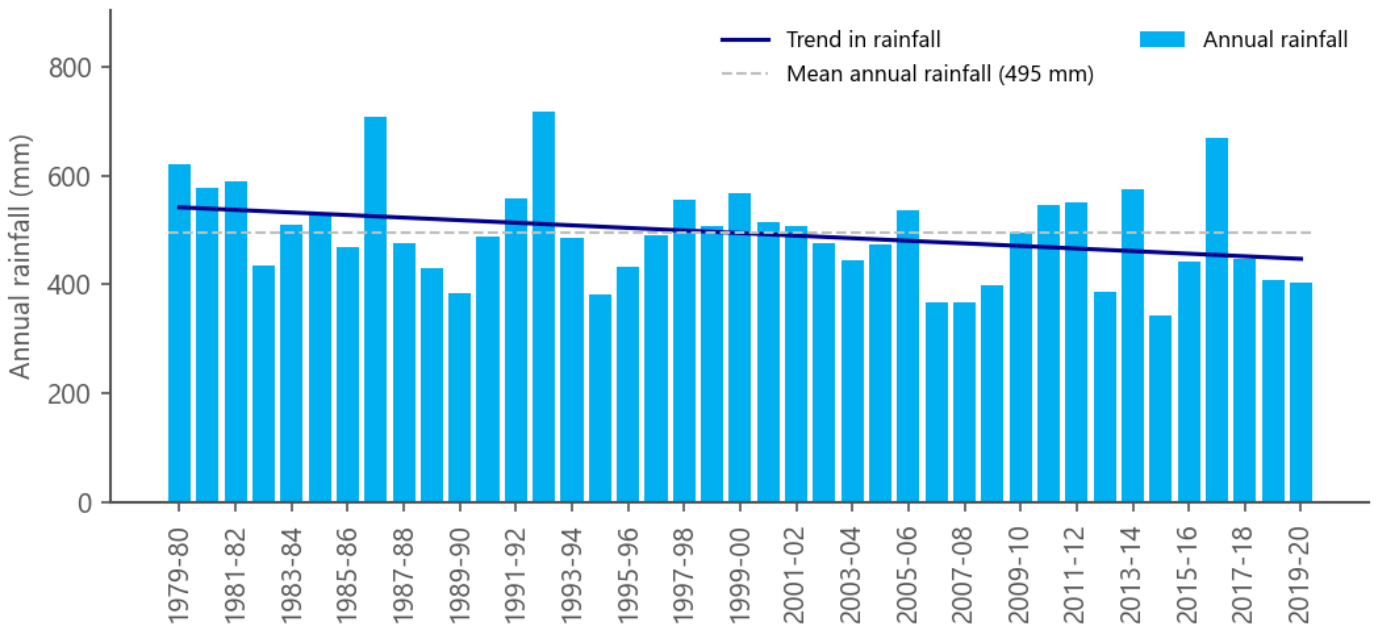


Figure 3.6 Annual rainfall for 1979–80 to 2019–20 at the North Adelaide rainfall station (23011)

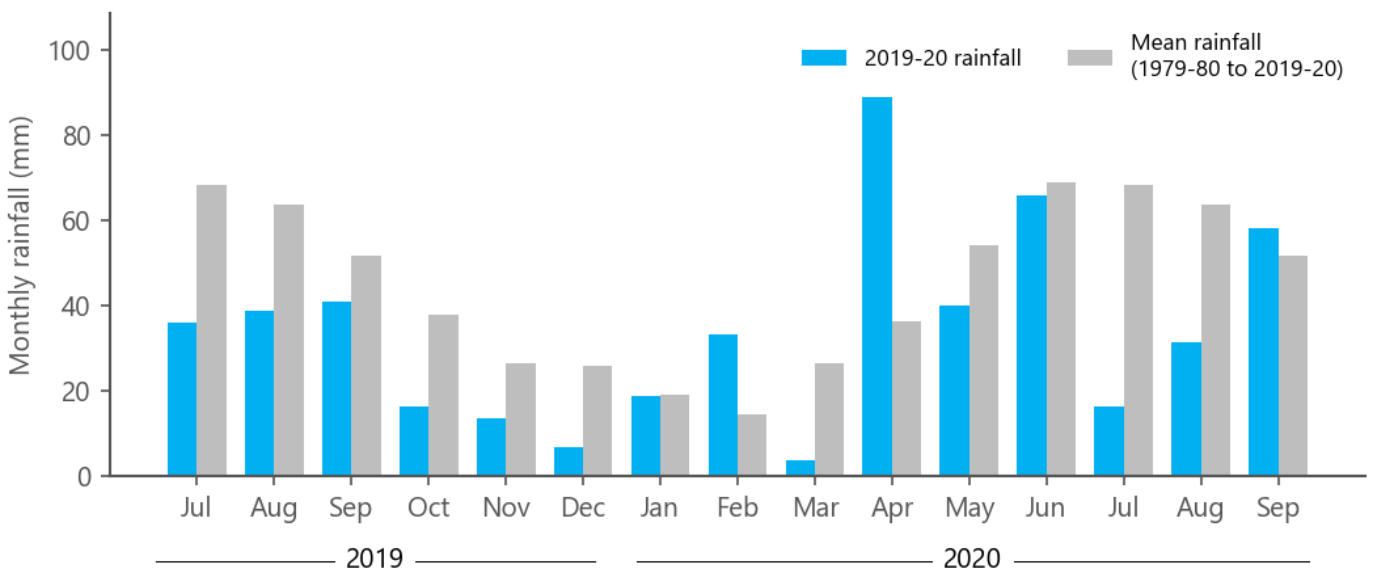


Figure 3.7 Monthly rainfall between July 2019 and September 2020 at the North Adelaide rainfall station (23011)

The North Adelaide rainfall station (BoM station 23011) has been selected as a representative rainfall station for the Central Adelaide PWA. Total annual rainfall for 2019–20 is 404 mm. This is 91 mm below the long-term average rainfall of 495 mm/y (1979–20); the long-term rainfall shows a declining trend (Figure 3.6).

Monthly rainfall was near or below the long-term average throughout 2019–20, with the exception of the months February, April and September 2020 (Figure 3.7).

4 Groundwater

4.1 Hydrogeology

Most groundwater extraction across the Adelaide Plains occurs from the T1 aquifer in the Central Adelaide PWA, the T1 and T2 aquifers in the Northern Adelaide Plains PWA and the T2 aquifer in the Kangaroo Flat region.

4.1.1 T1 aquifer

The T1 aquifer primarily comprises Hallett Cove Sandstone, Dry Creek Sand and limestone of the upper Port Willunga Formation. Tertiary sands that have been deposited immediately adjacent to the faulted boundary between the basin sediments and the Mount Lofty Ranges, are also considered part of the T1 aquifer. The direction of groundwater flow is generally westward from the ranges to the Gulf St Vincent. The two main sources of recharge are thought to be lateral throughflow from fractured rock aquifers of the ranges and infiltration of surface water from streams that flow onto the plains from the ranges. Outflows from the groundwater system occur through groundwater extraction and discharge to Gulf St Vincent.

The T1 aquifer can be divided into two main areas that are separated by the Para Fault: the Adelaide Plains Sub-basin and the Golden Grove Embayment. The T1 aquifer differs markedly in thickness and extent between these two areas. In the Golden Grove Embayment (east of the Para Fault), the T1 aquifer occurs as a semi-confined or unconfined aquifer and is relatively thin. In the Adelaide Plains Sub-basin (west of the Para Fault), the aquifer is thicker, but also more uniform and continuous in terms of thickness and spatial distribution and consequently, most groundwater extraction from the T1 aquifer occurs in this area. The T1 aquifer is absent in the north-east portion of the NAP PWA.

The T1 aquifer is generally confined, except where it becomes shallow or crops out in the northern Golden Grove Embayment, particularly north of the River Torrens, and near the Eden–Burnside Fault (Figure 1.1). Despite the generally confined nature of the T1 aquifer, the intensity and timing of rainfall (and related variations in rates of groundwater extraction) can have an effect on groundwater levels and salinities. For example, if the Central Adelaide PWA experienced above-average rainfall, this could result in less groundwater being extracted from the T1 aquifer for irrigation purposes, and rises in groundwater levels might result. Summer irrigation extraction causes seasonal fluctuations, while industrial extractions are continuous throughout the year.

4.1.2 T2 aquifer

The T2 aquifer consists of well-cemented limestones of the lower Port Willunga Formation. The two main sources of groundwater recharge to the T2 aquifer are thought to be lateral inflow from the adjacent fractured rock aquifers of the Mount Lofty Ranges and the infiltration of surface water from streams that flow onto the plains from the ranges. Outflows from the groundwater system occur through groundwater extraction and discharge to Gulf St Vincent. The T2 aquifer occurs extensively across the Adelaide Plains Sub-basin portion of the Central Adelaide PWA and most of the NAP PWA and Kangaroo Flat region.

Although there is no direct recharge from incident rainfall to the confined T2 aquifer, there may be an indirect relationship between groundwater levels and rainfall, as periods of below-average rainfall will likely result in increased rates of groundwater extraction, which may lead to declines in groundwater levels and increases in salinities. Conversely, above-average rainfall may result in increased recharge and decreases in extractions, which can cause groundwater levels to rise and salinities to stabilise or decrease.

4.2 Central Adelaide PWA T1 aquifer water level

Water levels in most of the T1 monitoring wells (64%) are classified 'Above average' or greater (Section 2.2.1; Figure 4.1). In the central and western parts of the aquifer (near the River Torrens and near the coast, e.g. ADE002, ADE005), water levels are classified 'Average' or 'Above-average'.

Over the past 20 years, wells in the T1 aquifer generally show a rise in water level, with changes ranging from a decline of 1.77 m to a rise of 9.11 m (median is a rise of 2.55 m).

Five-year trends show rising water levels in 50% of wells, while 38% of wells are declining (Figure 4.2) and the remainder is stable (12%). Rates of change range from a rise of 0.02–0.97 m/y (median rate of 0.19 m/y) to a decline of 0.02 –1.09 m/y (median rate of 0.13 m/y).

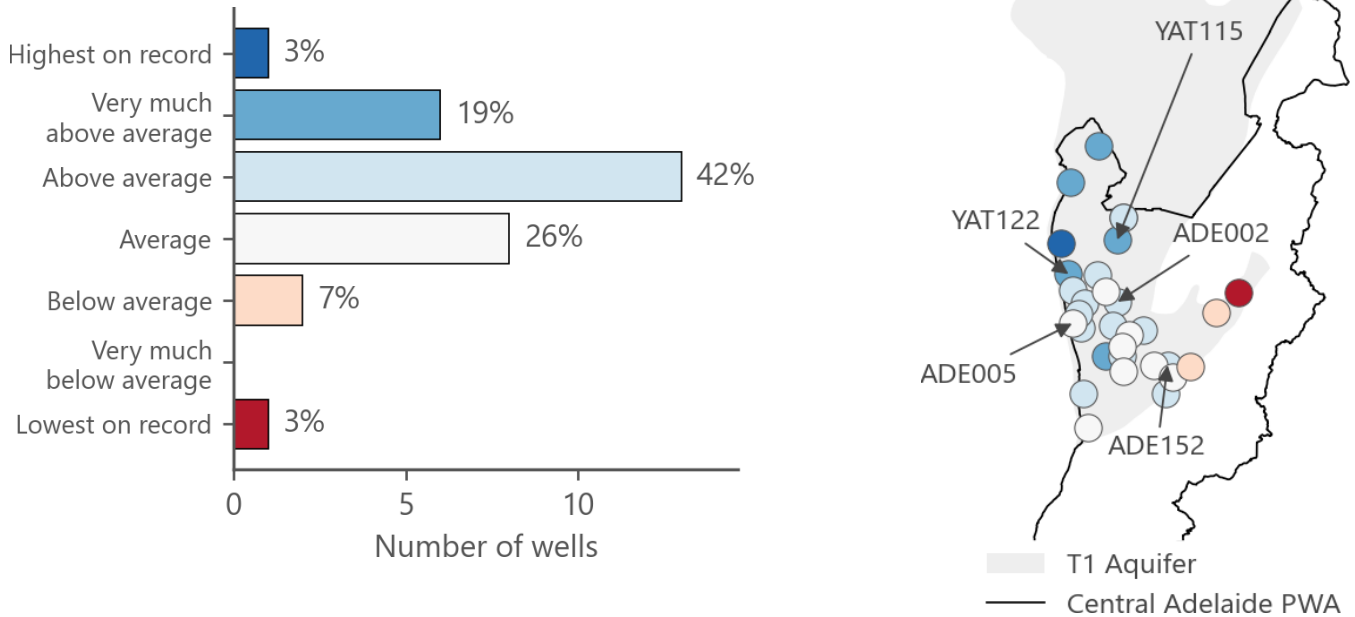


Figure 4.1 2020 water levels for wells in the Central Adelaide T1 aquifer

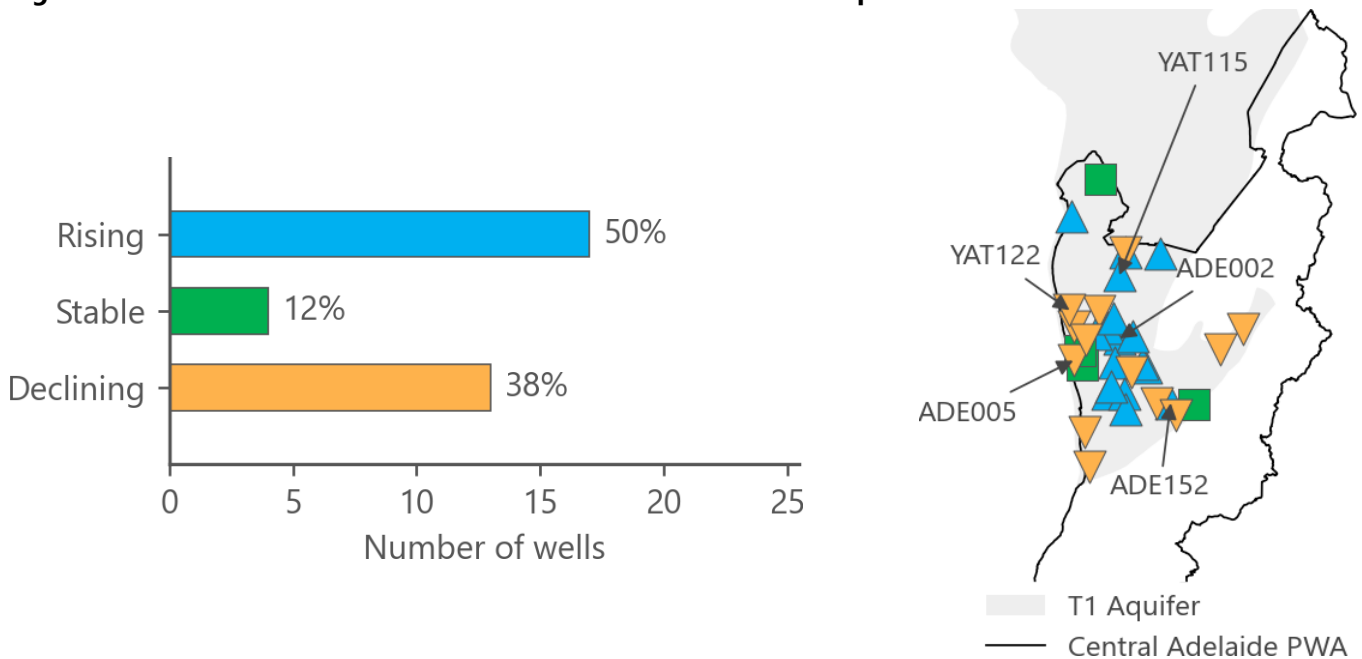


Figure 4.2 2016–20 trend in water levels for wells in the Central Adelaide T1 aquifer

Since 1990, water levels in the T1 aquifer in the Central Adelaide PWA indicate an average rise of 2.06 m (e.g. ADE002 and ADE005; Figure 4.3). The greatest rates of groundwater extraction from the T1 aquifer occur between the suburbs of West Lakes and Grange.

Water levels in the high water-use areas between West Lakes and Grange are classified 'Average' and show a minor declining trend over the five-year period from 2016–20 (e.g. YAT122). A long-standing cone of depression has developed at Grange due to extraction for turf irrigation. This high-use area is also close to managed aquifer recharge (MAR) schemes, which often extract more than they inject (Section 5.2.1).

Towards the north of the Central Adelaide PWA where there is limited extraction, water levels are classified 'Highest on record' (e.g. YAT115). This may be due to a combination of net MAR injection to the T1 aquifer in the southern NAP PWA (Section 5.2.2) and reductions in industrial extraction.

In the southern portion of the Central Adelaide PWA, the Para Fault and Golden Grove Embayment influences groundwater flow directions and levels. Currently, water levels are classified 'Average'. Over the past 30 years, water levels generally show rising trends, with small localised declines near some MAR schemes (e.g. ADE152).

A cone of depression that previously existed at Thebarton has now largely recovered since the rate of industrial extractions have reduced.

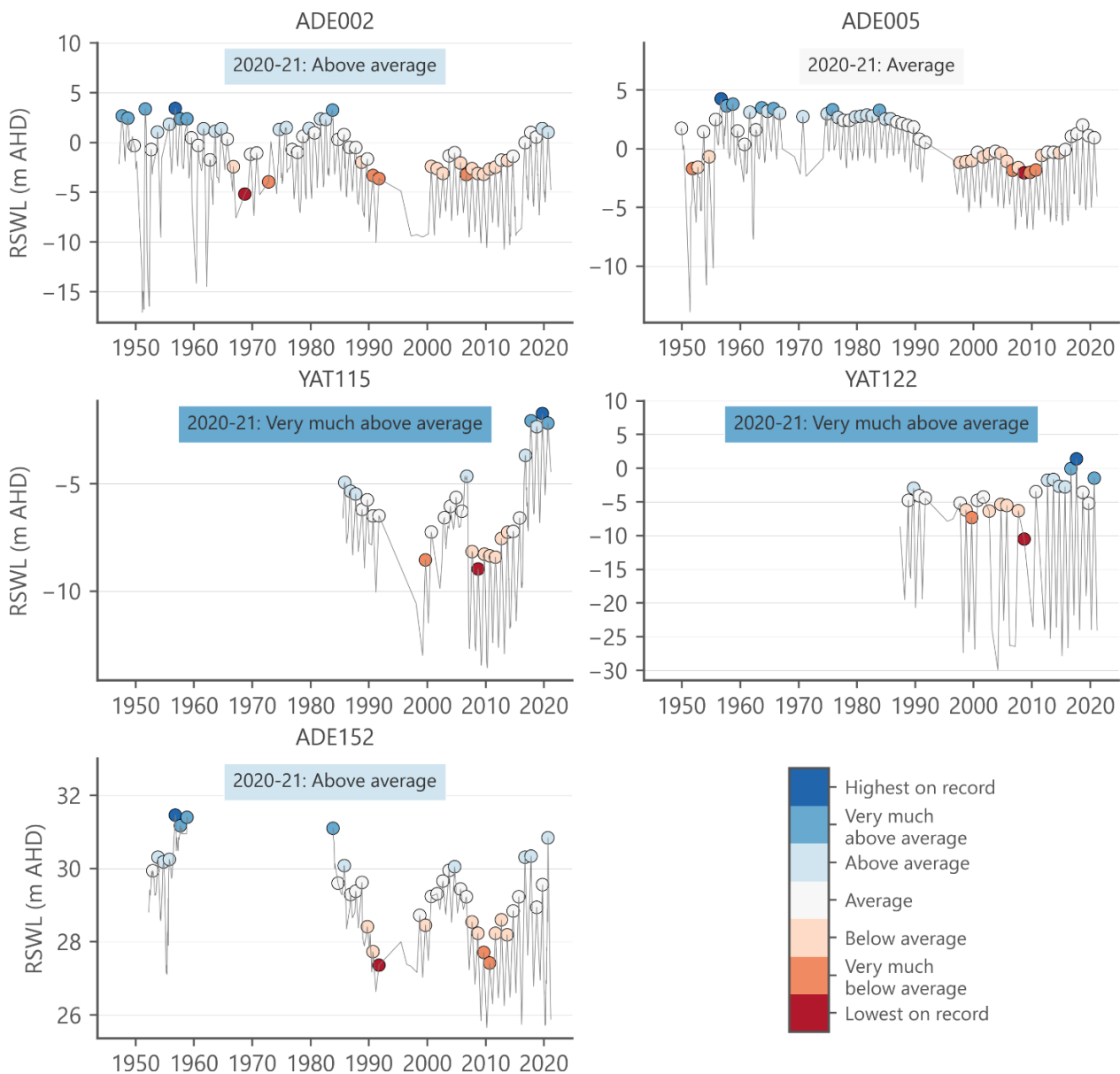


Figure 4.3 Selected Central Adelaide PWA T1 aquifer hydrographs

4.3 Central Adelaide PWA T1 aquifer salinity

In 2020, samples from 26 wells in the T1 aquifer show groundwater salinity varies from fresh to brackish, ranging from 395–3764 mg/L, with a median of 1145 mg/L (Figure 4.4, Section 2.2.2).

In the 10 years to 2020, the majority of monitoring wells (64%) show a decrease in groundwater salinity. Trends in salinity vary from a decrease of 1.24% per year to an increase of 0.55% per year, with a median of 0.07% decrease per year (Figure 4.5).

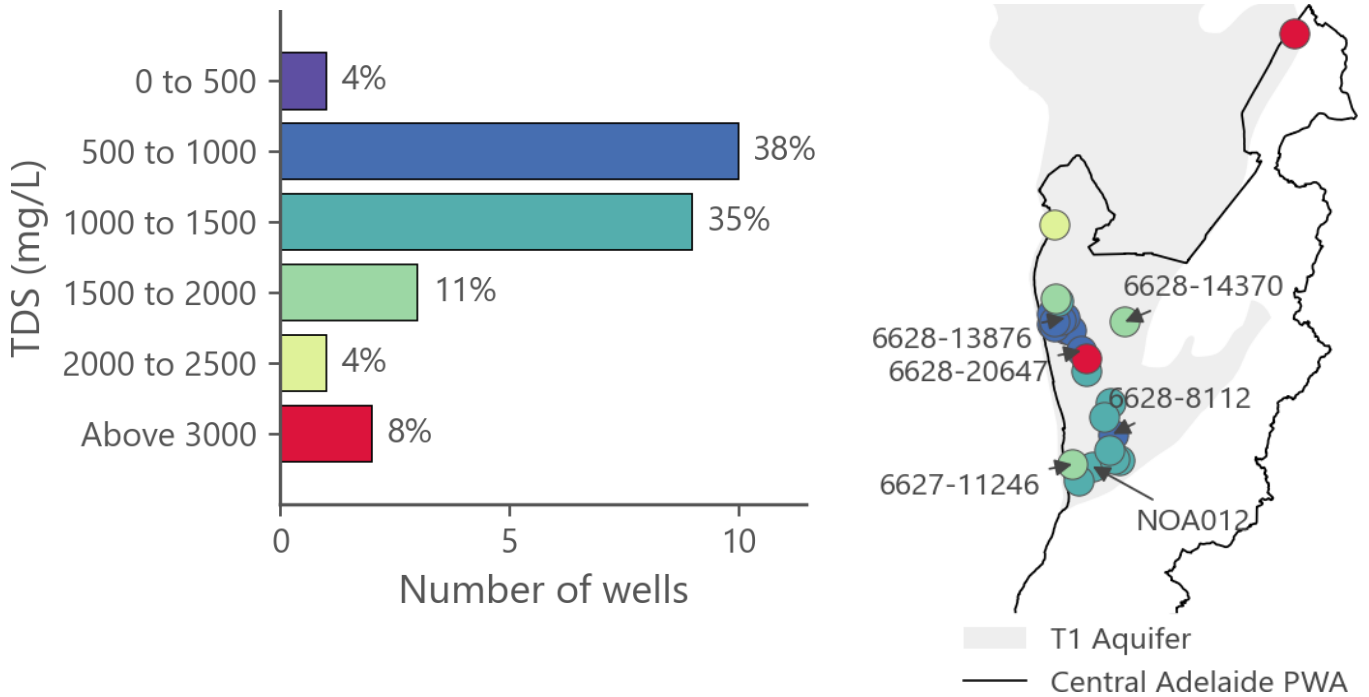


Figure 4.4 2020 salinity observations from wells in the T1 aquifer of the Central Adelaide PWA

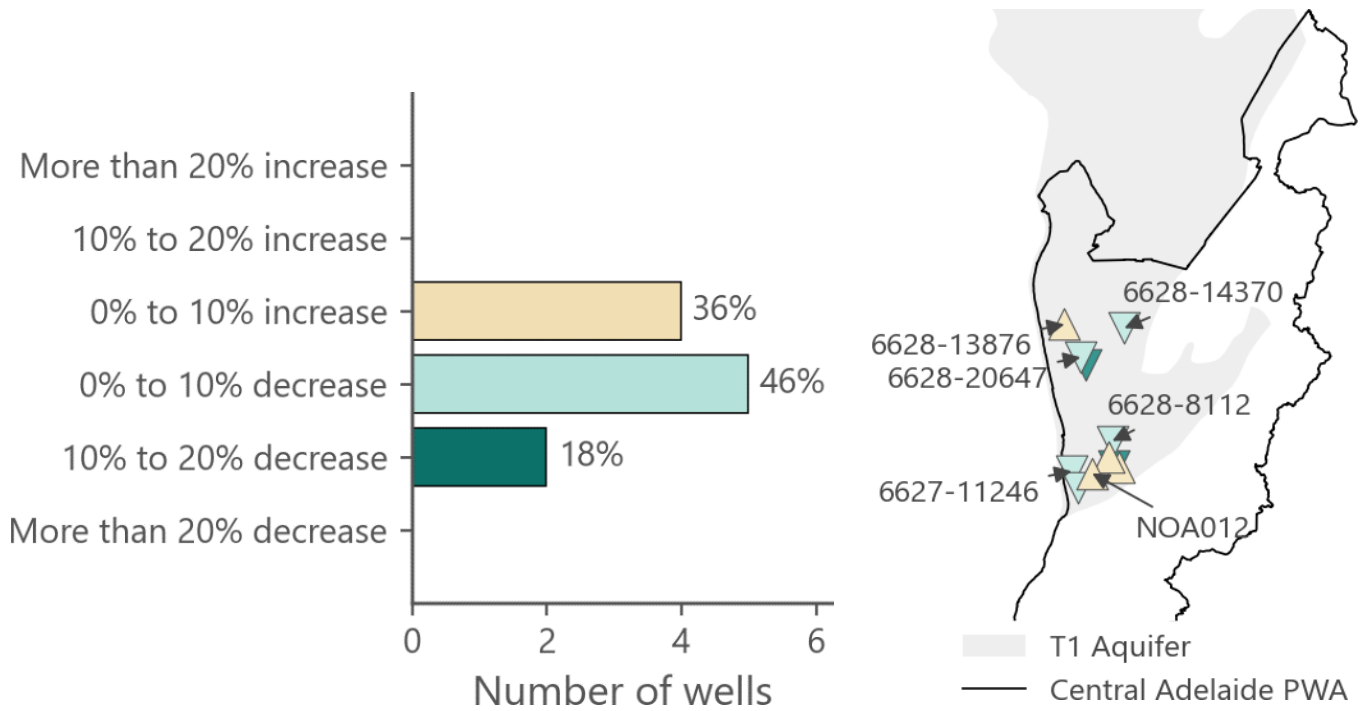


Figure 4.5 Salinity trend in the 10 years to 2020 for wells in the T1 aquifer of the Central Adelaide PWA

Salinity graphs are shown for a selection of confined aquifer monitoring wells in the T1 aquifer of Central Adelaide PWA to illustrate common or important trends (Figure 4.6). In general, long-term salinity data is available only since the early 2000s from groundwater wells used for the irrigation of school ovals. Across the T1 aquifer, salinity is in the range 800–1900 mg/L, and is relatively stable throughout the monitoring period.

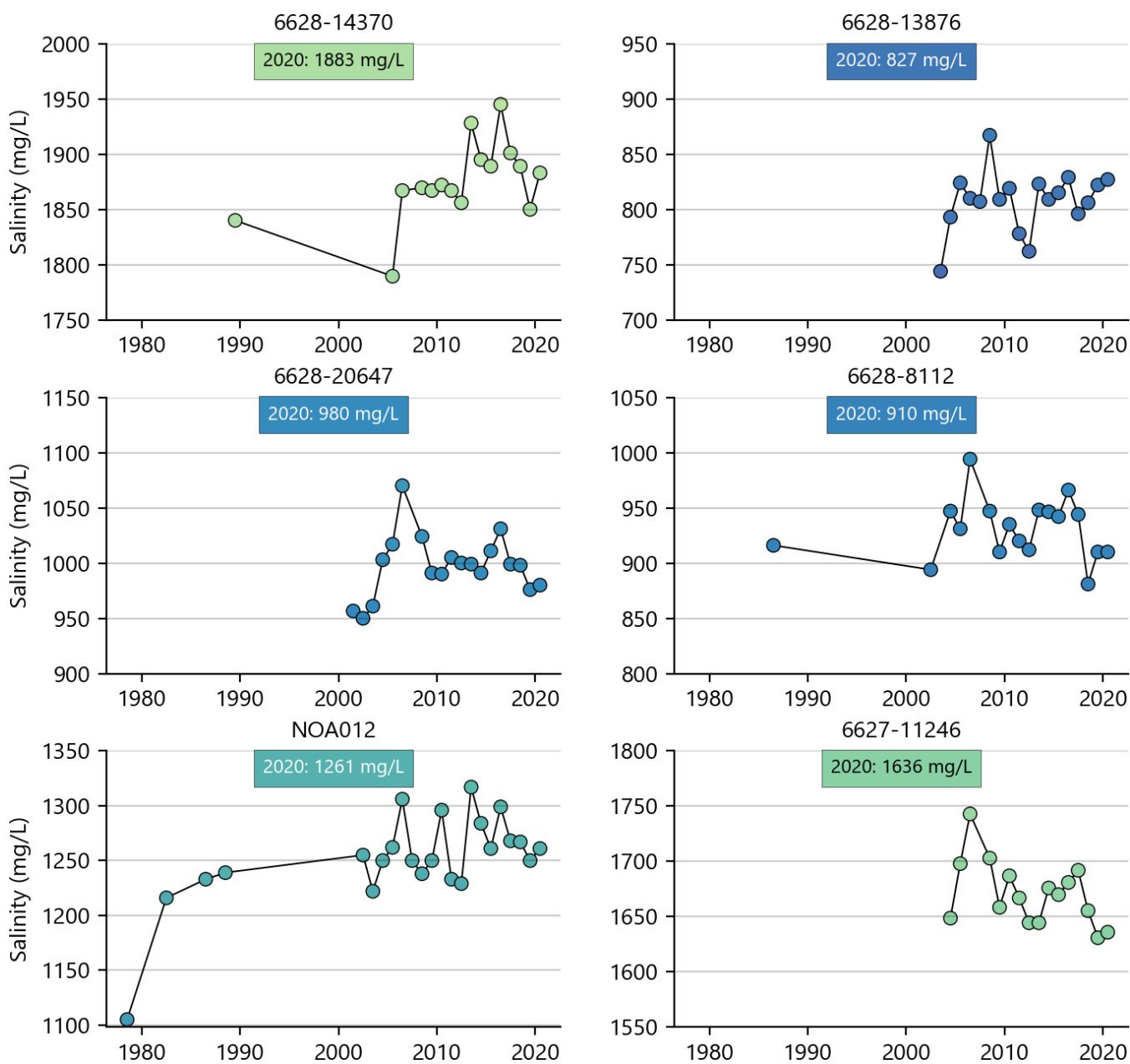


Figure 4.6 Salinity in the T1 aquifer of the Central Adelaide PWA

4.4 Northern Adelaide Plains PWA T1 aquifer water level

Water levels in most NAP PWA T1 aquifer monitoring wells (63%) are classified 'Above-average' or higher compared to their historical record (Figure 4.7). These wells are located mainly towards the south of the PWA. Water levels in a minority of wells (19%) are classified 'Below average' or lower.

Over the past 20 years, the majority of wells in the T1 aquifer (74%) show a rise in water level. Changes in water level range from a decline of 5.00 m to a rise of 8.39 m (median is a rise of 1.79 m).

Five-year trends show declining water levels in 80% of wells and rising water levels in 20% of wells (Figure 4.8). Rates of decline range from 0.12–1.50 m/y (median of 0.32 m/y), and rates of rise range from 0.15–0.92 m/y (median of 0.43 m/y).

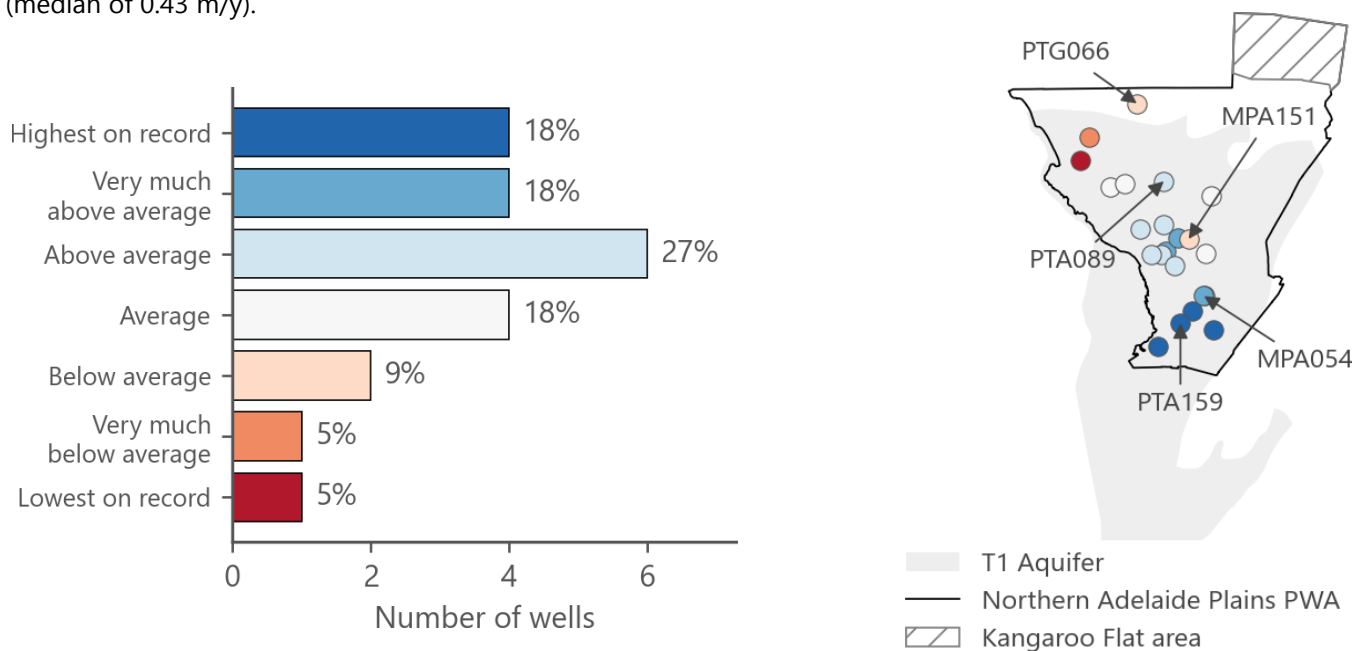


Figure 4.7 2020 water levels for wells in the T1 aquifer of the NAP PWA

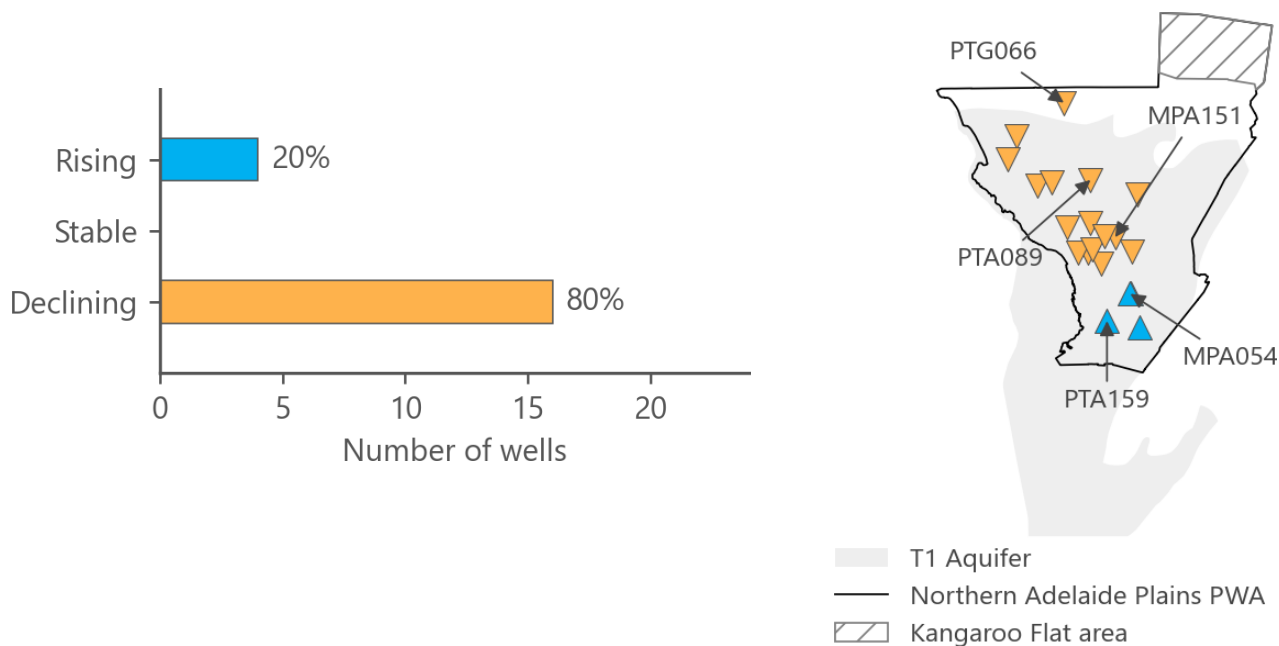


Figure 4.8 2016–20 trend in water levels for wells in the T1 aquifer of the NAP PWA

Groundwater is extracted from the T1 aquifer widely across the Northern Adelaide Plains PWA, with a high spatial density of water use in the vicinity of Waterloo Corner and east of St Kilda. Hydrographs from a selection of monitoring wells completed in the T1 aquifer show water levels in this area are generally classified 'Below average' (e.g. MPA151, Figure 4.9).

Another area of high water use is towards the south of the PWA (e.g. PTA159) where high volumes of extraction (Section 5) are offset by positive net injection from nearby MAR schemes. Positive net injection, in addition to reductions in industrial extraction from the Dry Creek area since 2017, have resulted in T1 aquifer recovery of around 10 m (e.g. PTA159) and consequently, water levels here are classified 'Highest on record'.

Water levels in areas that have low (or nil) licensed extraction for 2019–20 vary in classification between 'Very much above average' (e.g. MPA054, which is located near the Little Para River in the south of the PWA) to 'Below average' (e.g. PTG066, proximal to Two Wells in the north of the PWA). Also, T1 aquifer water levels at Virginia (e.g. PTA089) are classified 'Above average' due to very low rates of water use, as most groundwater is sourced from the T2 aquifer.

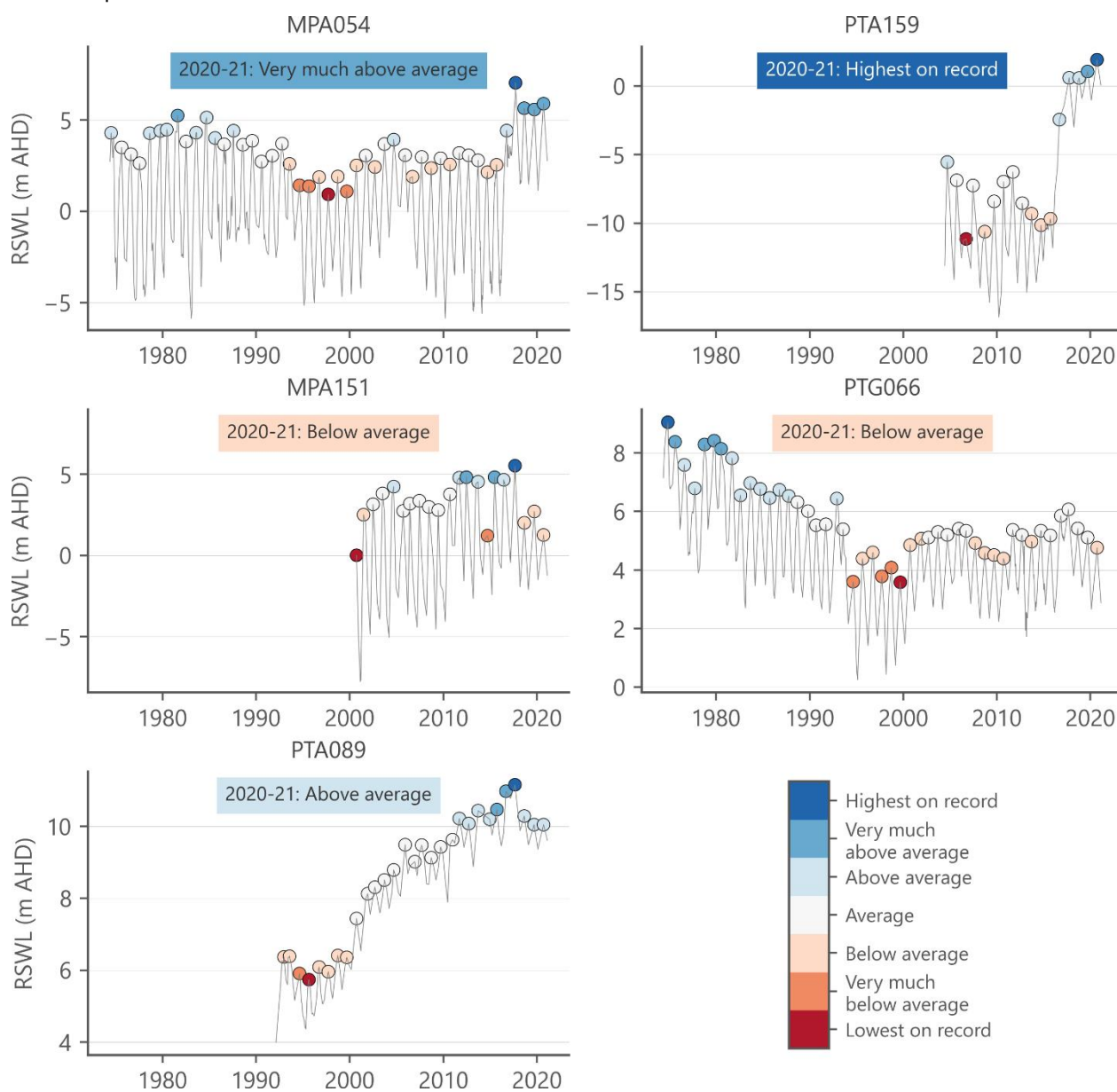


Figure 4.9 Selected NAP T1 aquifer hydrographs

4.5 Northern Adelaide Plains PWA T1 aquifer salinity

In 2020, samples from 76 wells in the T1 aquifer show groundwater salinity ranges between 445–2789 mg/L, with a median of 848 mg/L (Figure 4.10, Section 2.2.2). Most wells (63%) show salinity less than 1000 mg/L; these are located along the Little Para River and towards the centre and east the PWA.

In the 10 years to 2020, trends in groundwater salinity for the majority of monitoring wells (82%) vary within a range of $\pm 10\%$. Mean rates of change in salinity over this period vary from a decrease of 11.02% per year to an increase of 3.37% per year, with a median of 1.41% decrease per year (Figure 4.11).

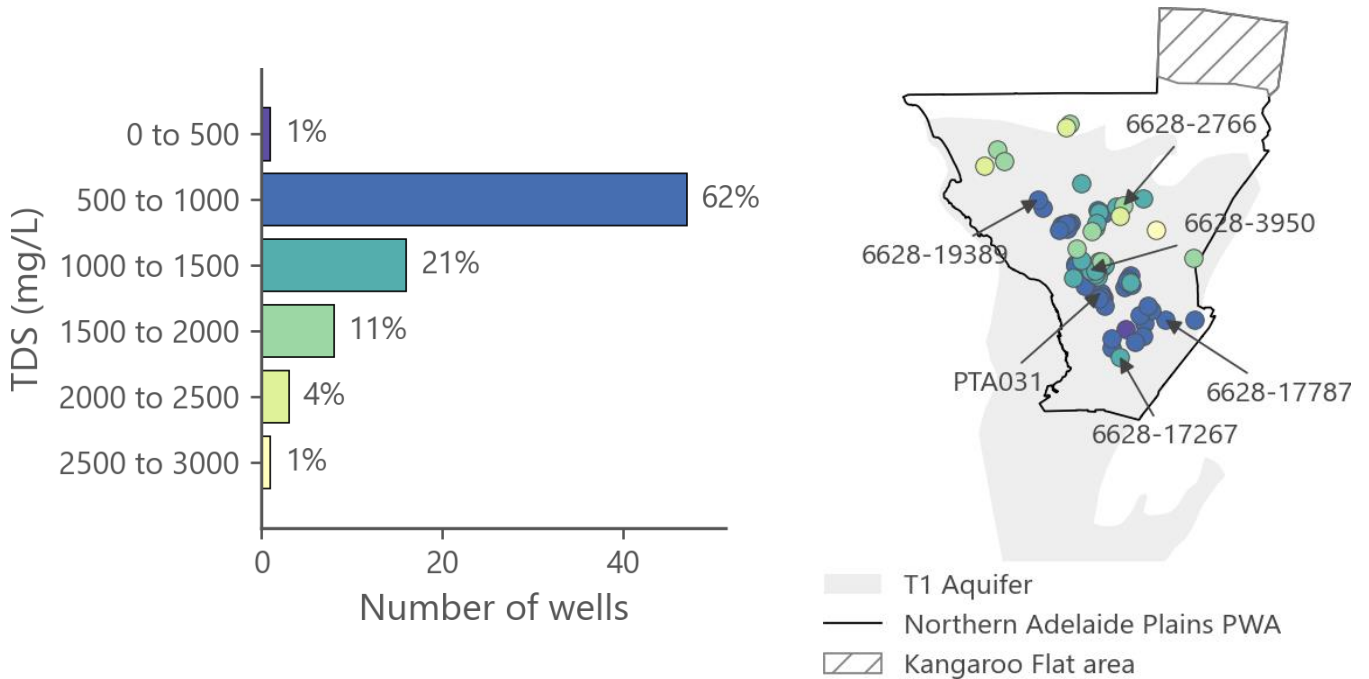


Figure 4.10 2020 salinity observations in the T1 aquifer of the NAP PWA

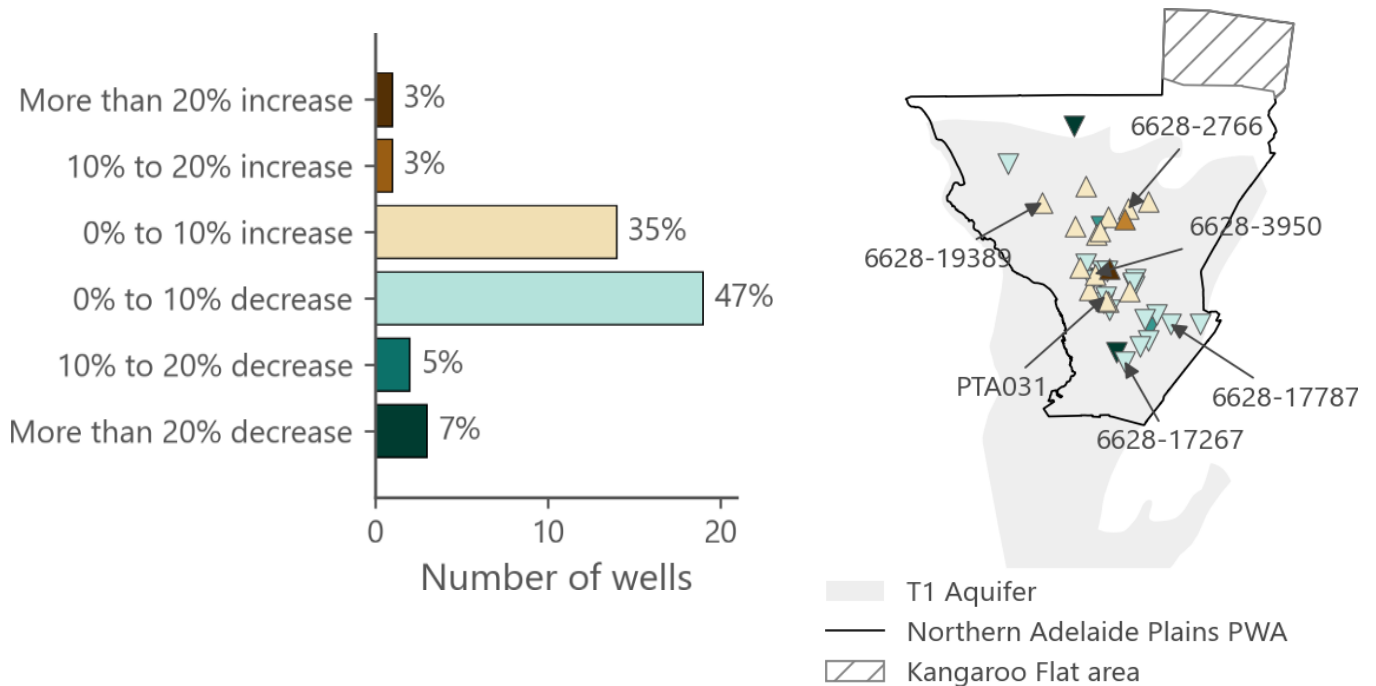


Figure 4.11 Salinity trend in the 10 years to 2020 for wells in the T1 aquifer of the NAP PWA

Salinity graphs are shown for a selection of confined T1 aquifer monitoring wells of the NAP PWA to illustrate common or important trends (Figure 4.12). In Virginia, located to the north of the PWA, the data show increases in groundwater salinity over the long term (e.g. 6628-2766, 6628-19389). A slower rate of increase is apparent in some monitoring wells further south at Waterloo Corner (e.g. 6628-3950).

In the central and southern parts of the PWA, salinity is relatively stable since monitoring began in the 1960s (e.g. PTA031, 6628-17787 and 6628-17267).

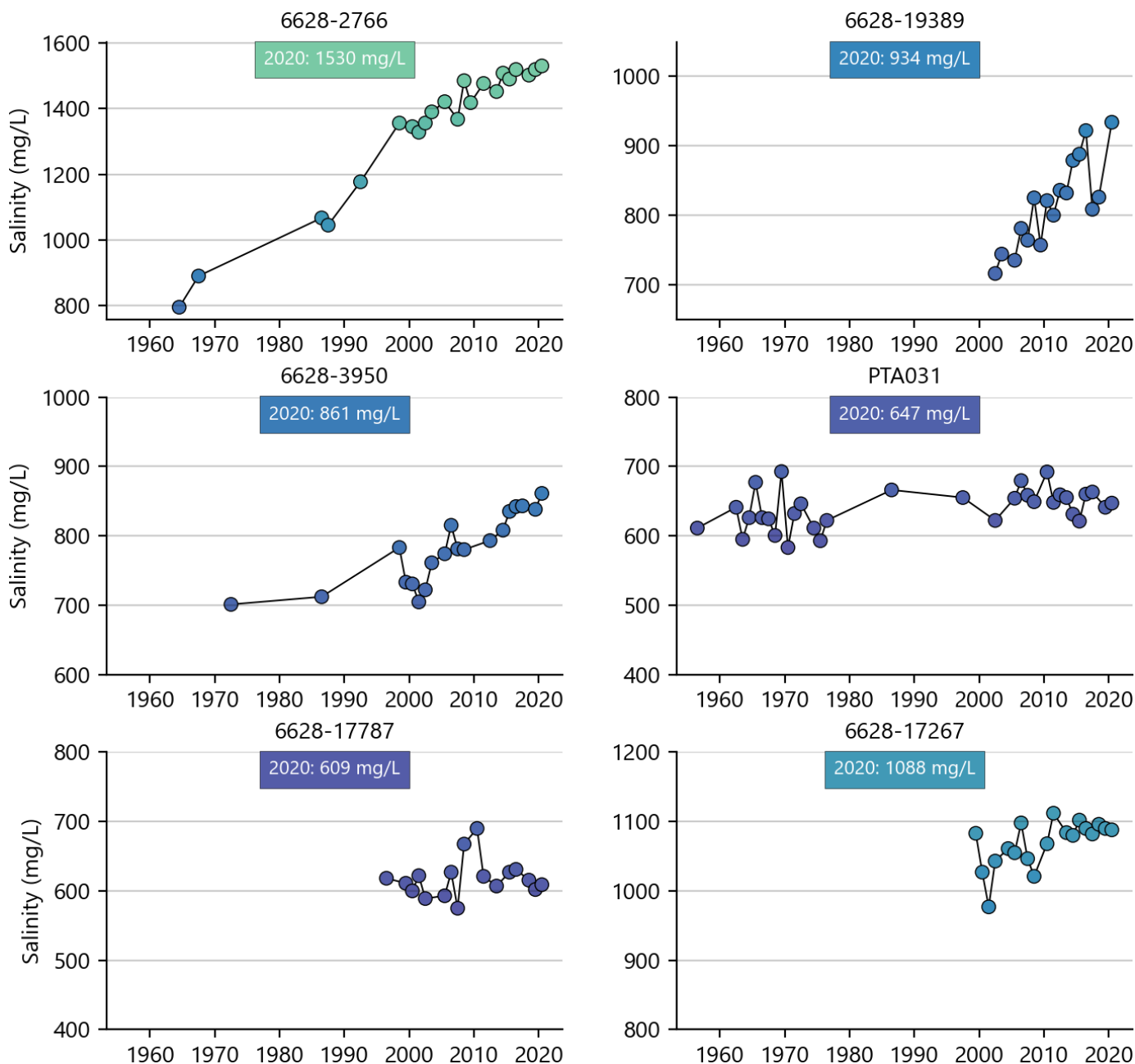


Figure 4.12 Salinity in the T1 aquifer of the NAP PWA

4.6 Northern Adelaide Plains PWA T2 aquifer water level

In 2020, water levels in most of the T2 monitoring wells (47%) are classified 'Below average' or lower, while levels in 42% of monitoring wells are classified 'Average' (Section 2.2.1; Figure 4.13).

Over the past 20 years, changes in water level range from a decline of 6.12 m to a rise of 10.48 m (median is a decline of 0.41 m). Water levels in most wells (61%) have declined over this period.

Five-year trends show water levels are declining in all wells, with rates of decline ranging from 0.12–4.12 m/y (median rate of 1.10 m/y) (Figure 4.14).

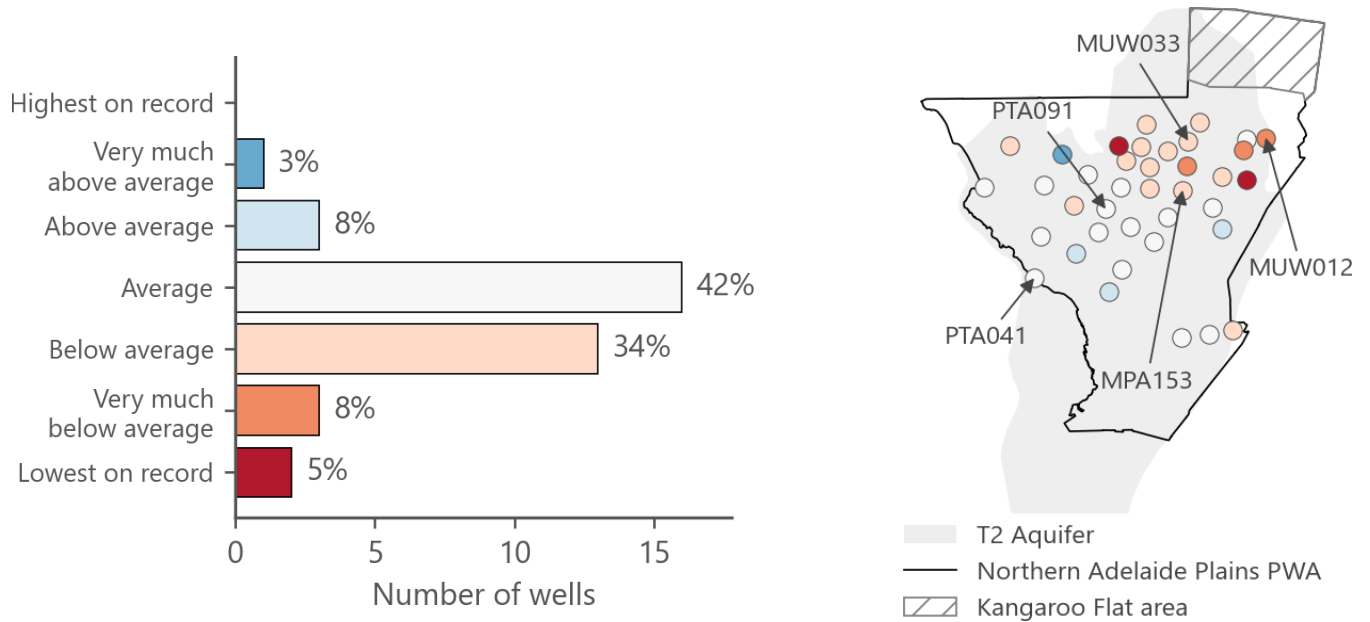


Figure 4.13 2020 winter-recovered water levels for the T2 aquifer of the NAP PWA

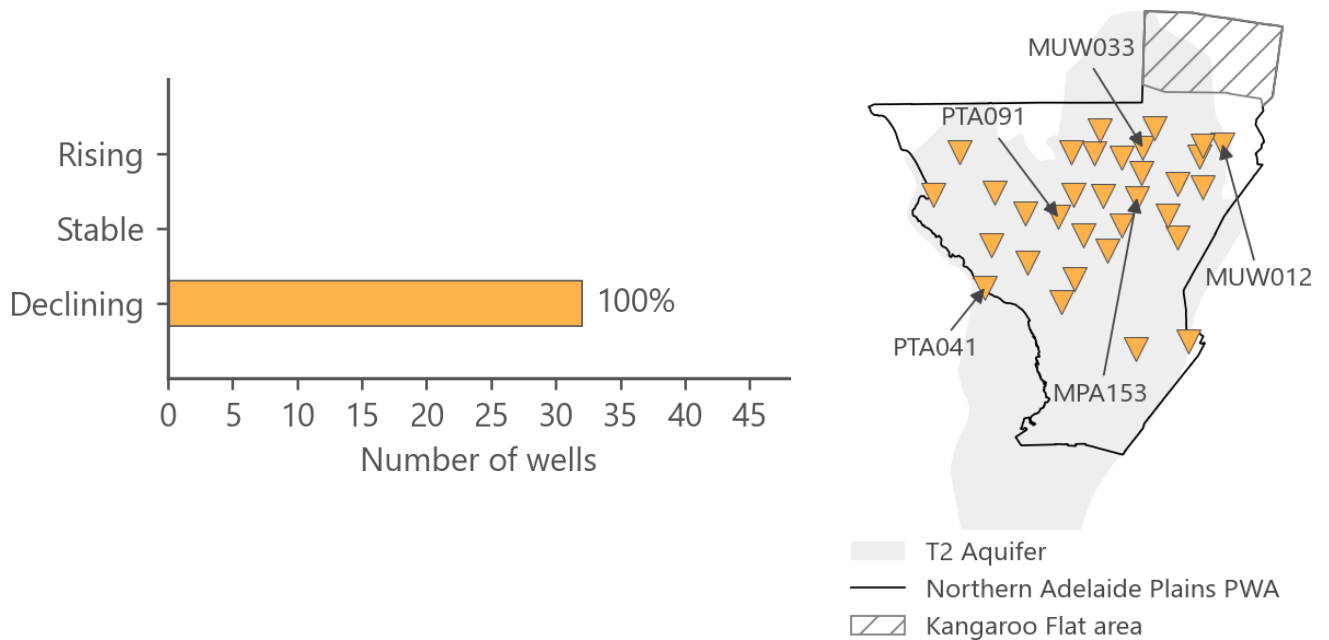


Figure 4.14 2016–20 trend in recovered water levels for wells in the T2 aquifer of the NAP PWA

Hydrographs are shown from a selection of monitoring wells completed in the T2 aquifer of the NAP PWA to illustrate common or important trends (Figure 4.15). The greatest annual volume of groundwater extraction in the Adelaide Plains occur from the T2 aquifer in the NAP PWA (Section 5.1). Most water use is located in the vicinity of Angle Vale and Virginia (e.g. PTA091) and is generally associated with the local horticultural industry.

Over the past five-year, water levels in most of the wells across the PWA have declined, with four wells east of Angle Vale classified 'Below-average' (e.g. MUW033, MUW012).

In 2016–17, there is a marked increase in rainfall (Section 3) that correlates with a rise in water levels in areas that are typically subject to high rates of extraction (e.g. MPA153 and PTA091). It is likely that above-average rainfall reduced the requirement for irrigation. The above-average recovery in water levels in 2016 has influenced many of the five-year trends in water levels such that a five-year declining trend is likely to be observed.

Locations along the coast indicate average water levels in 2020 (e.g. PTA041); these coastal wells are located more than nine kilometres west of Virginia, in an area of very low groundwater use.

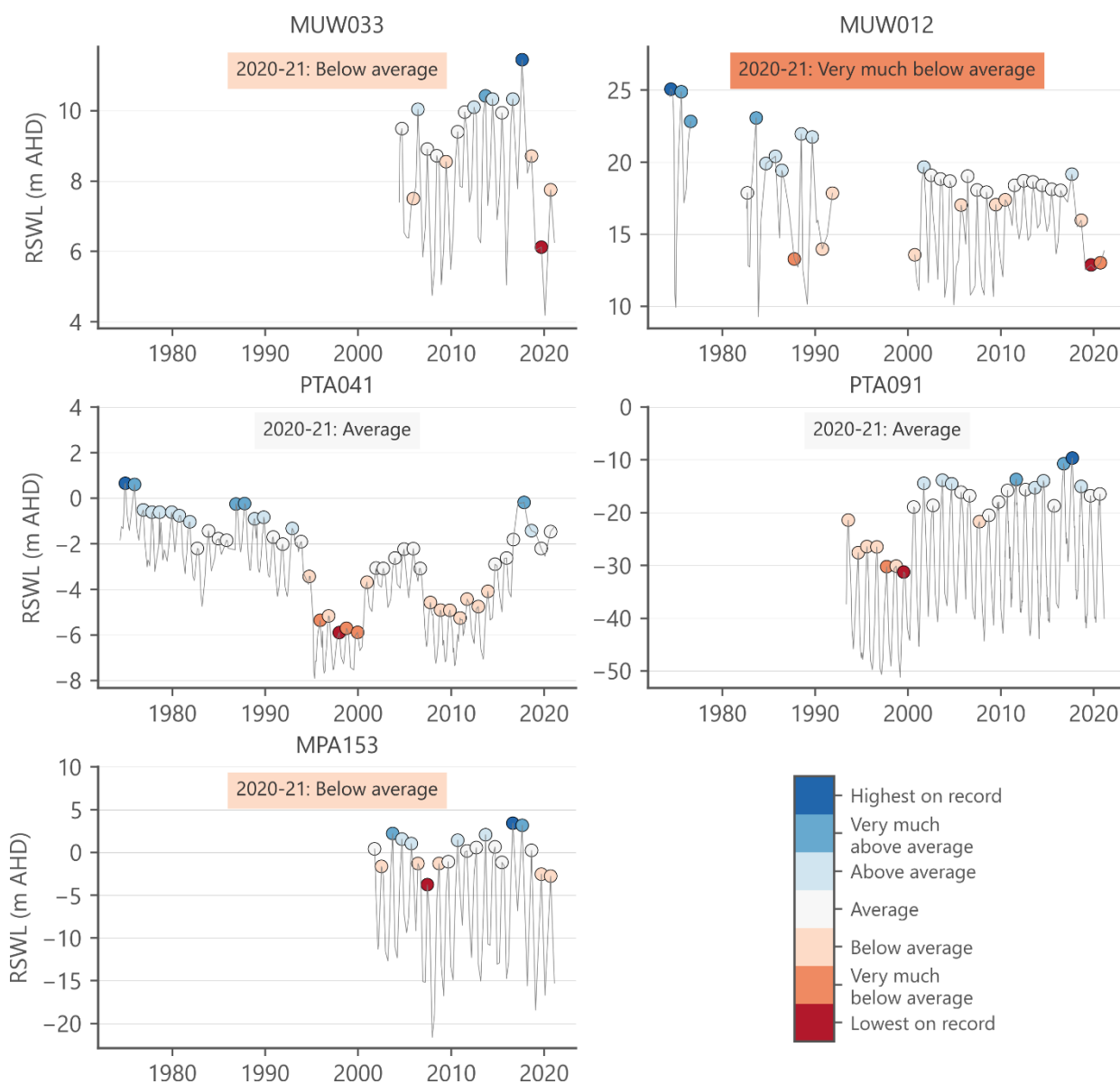


Figure 4.15 Selected NAP T2 aquifer hydrographs

4.7 Northern Adelaide Plains PWA T2 aquifer salinity

In 2020, salinity samples from 282 wells in the T2 aquifer range between 562–3892 mg/L, with a median of 1000 mg/L. Salinity in most wells (81%) is less than 1500 mg/L, and these wells are distributed towards the centre and north of the PWA (Figure 4.16).

In the 10 years to 2020, trends in groundwater salinity for the majority of wells (78%) vary within a range of $\pm 10\%$. Mean rates of change in salinity over this period vary from a decrease of 4.89% per year to an increase of 4.73% per year, and the median rate of change is stable (Figure 4.17).

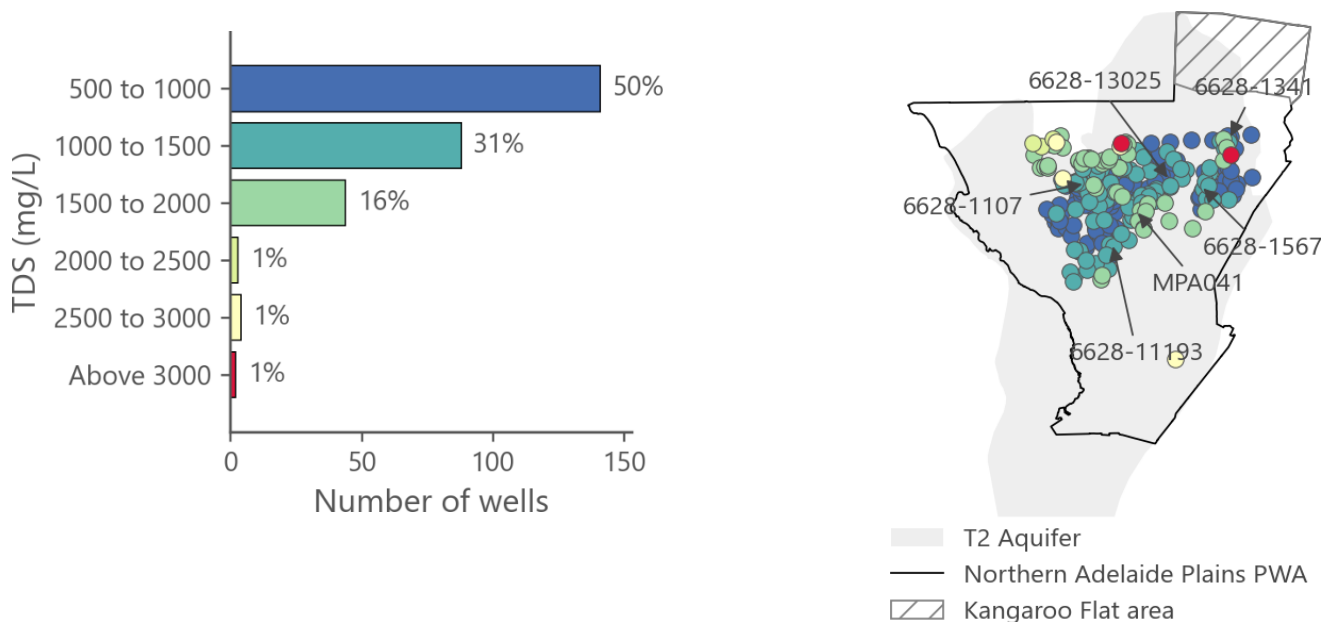


Figure 4.16 2020 salinity observations in the T2 aquifer of the NAP PWA

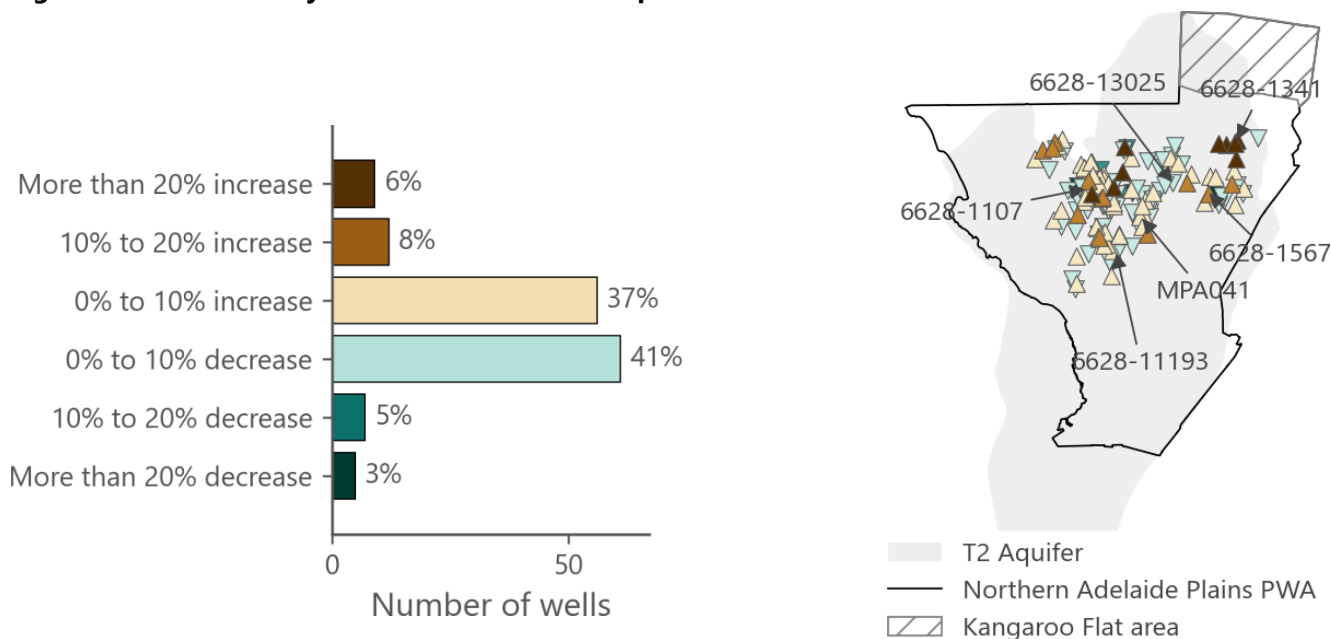


Figure 4.17 Salinity trend in the 10 years to 2020 for wells in the T2 aquifer of the NAP PWA

Figure 4.18 shows salinity graphs from a selection of monitoring wells completed in the T2 aquifer of the Northern Adelaide Plains PWA. Groundwater is extracted from this aquifer across the PWA, with numerous users in the vicinity of Angle Vale and Virginia. Monitoring wells 6628-1341 and 6628-1567 to the east of the PWA are showing a steady increase of groundwater salinity since the commencement of monitoring in the area. Corroded casing and leakage of shallow saline groundwater into these wells could be responsible for these increases in groundwater salinity.

Monitoring wells 6628-13025 and MPA041, located between Angle Vale and Virginia where most of irrigation extraction occurs, show relatively stable salinities with some periods of large variations at MPA041.

6628-11193 at Waterloo corner shows increases in salinity during the 2000s which corresponds with increases in groundwater extraction in the area (Figure 5.1). To the north of Virginia, 6628-1107 shows a gradual increase since monitoring began in the 1960s, although salinity has stabilised in recent years.

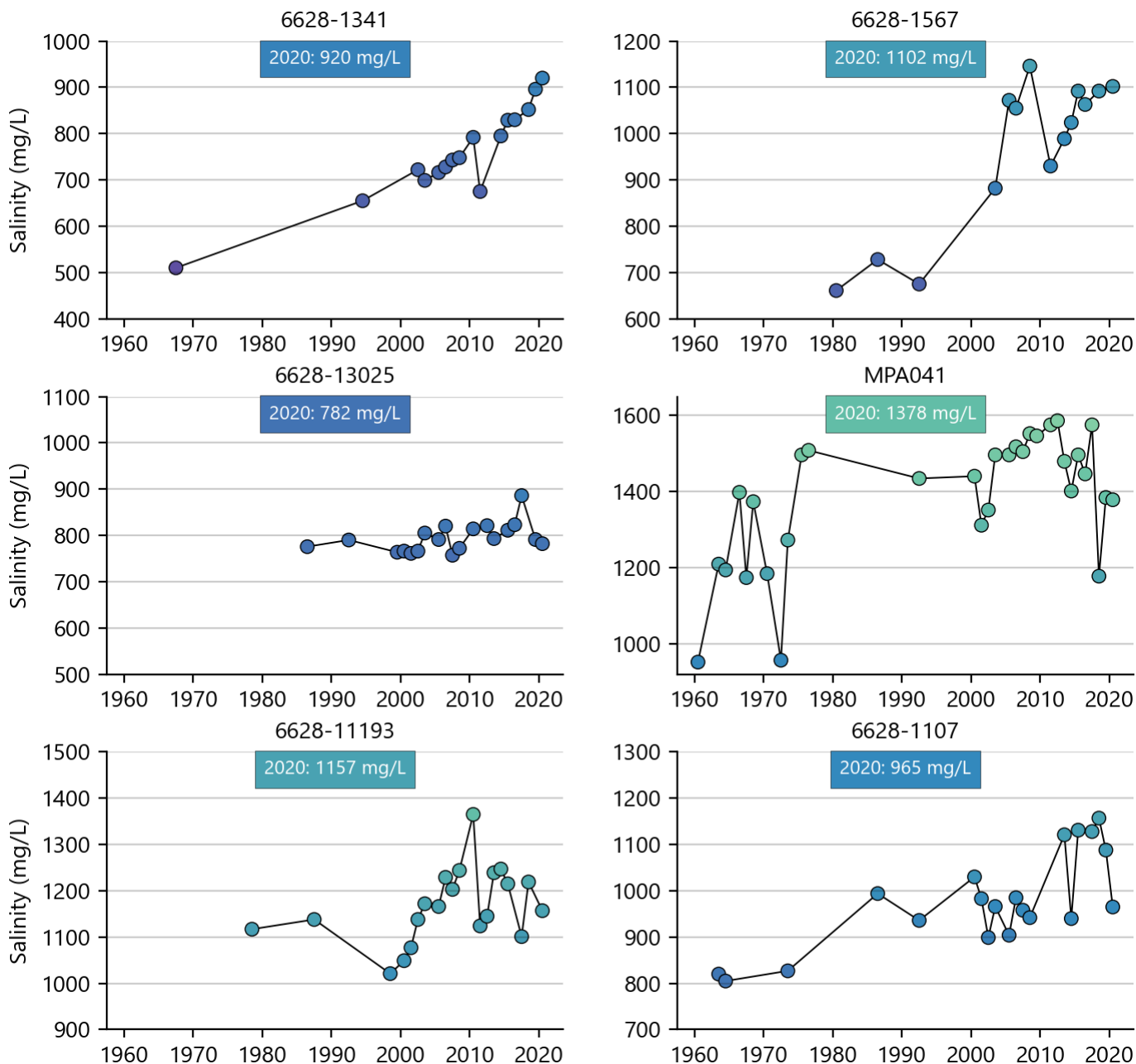


Figure 4.18 Selected salinity graphs for wells in NAP T2 aquifer

4.8 Kangaroo Flat T2 aquifer water level

In 2019–20, there are four monitoring wells in the T2 aquifer in the Kangaroo Flat region (Figure 4.19). Water levels in two of the four wells are classified 'Lowest on record'.

Over the past 20 years, water levels in three wells (Section 2.1.1) have declined by 0.90 m, 2.12 m and 2.23 m.

Five-year trends show declining water levels in all four wells, with rates of decline ranging between 0.29–1.48 m/y (median of 0.37 m/y) (Figure 4.20).

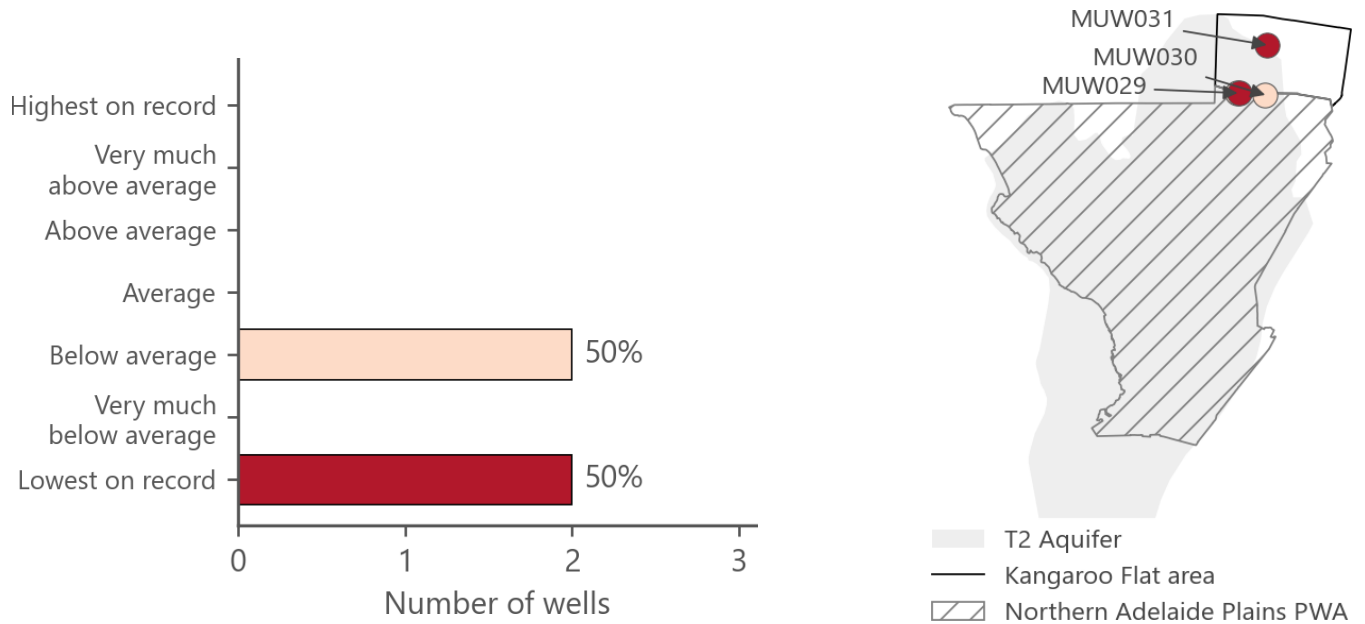


Figure 4.19 2020 winter-recovered water levels for the T2 aquifer of the Kangaroo Flat region

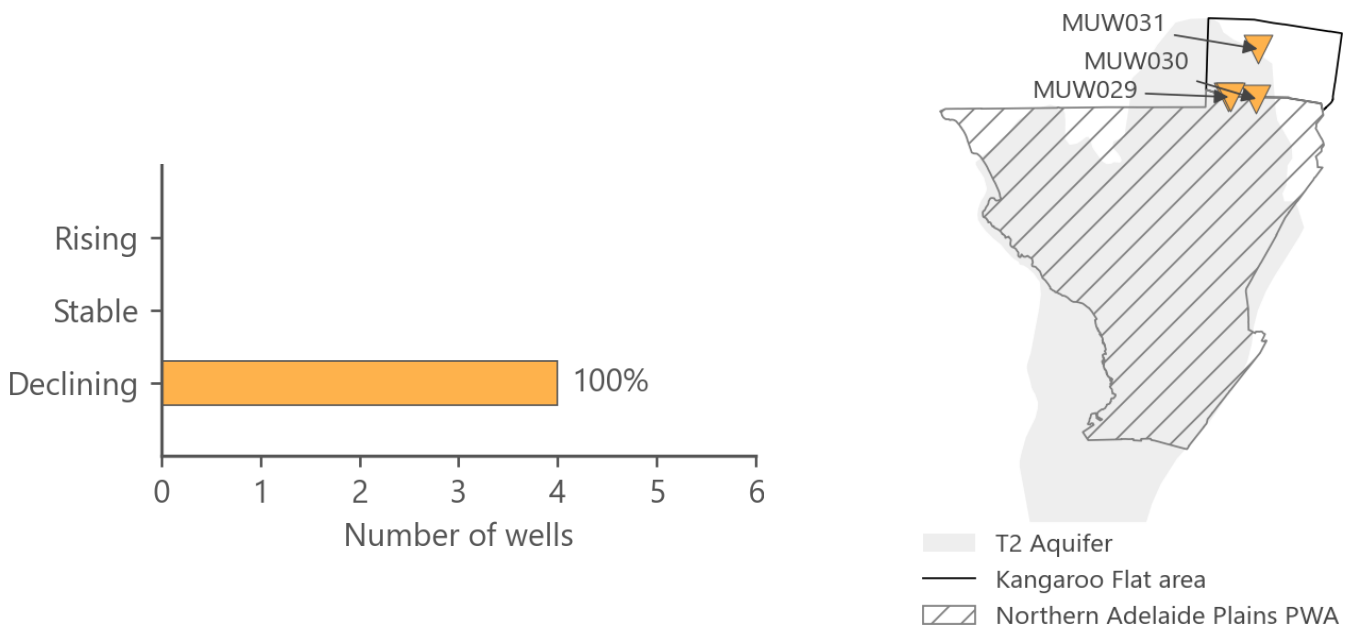


Figure 4.20 2016–20 trend in recovered water levels for wells in the T2 aquifer of the Kangaroo Flat region

Hydrographs are shown for three T2 aquifer monitoring wells in the Kangaroo Flat region to illustrate some common or important long-term trends (Figure 4.21). Groundwater extraction occurs predominantly towards the southern boundary of the region, where water levels show a slight decline of around 0.07 m/y over the past five years (e.g. MUW029 and MUW030).

A localised cone of depression in the T2 aquifer has been observed since 2011, which is due to the intensive spring/early-summer extraction regime, and is centred towards the south-west of the region (DEW 2019b). A consistent decline in winter-recovered water levels towards the north (e.g. MUW031) is most likely due to the gradual expansion of the cone of depression (Barnett 2013).

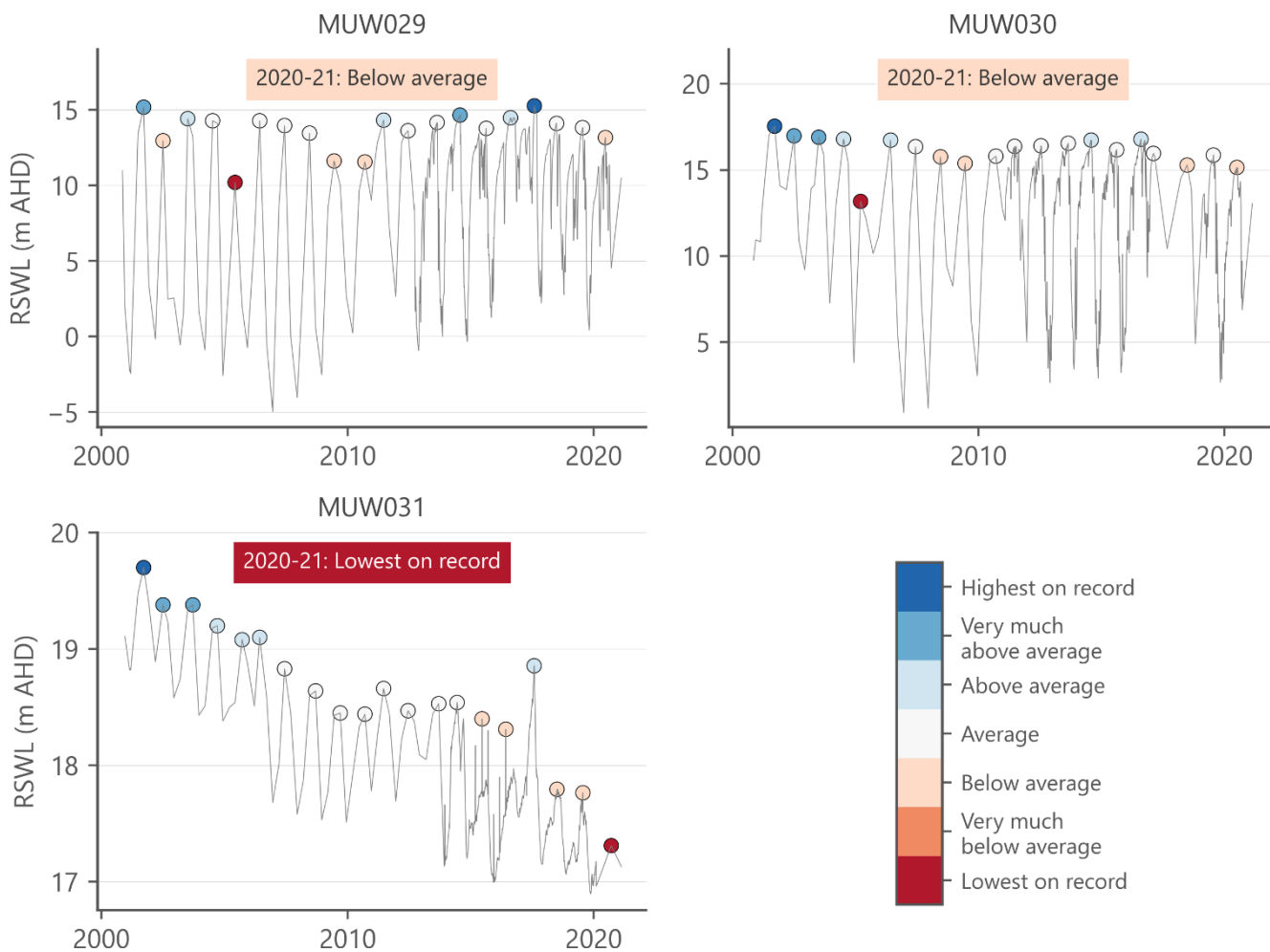


Figure 4.21 Selected T2 aquifer hydrographs in the Kangaroo Flat region

4.9 Kangaroo Flat T2 aquifer salinity

In 2020, salinity samples from 11 wells in the T2 aquifer range between 1284–4473 mg/L, with a median of 1957 mg/L (

Figure 4.22). Most wells (82%) show salinity between 1000 mg/L–2500 mg/L.

In the 10 years to 2020, three of four monitoring wells show an increase in groundwater salinity (Figure 4.23). Mean rates of change in salinity over this period vary from a decrease of 0.03% per year to an increase of 2.50% per year, and the median rate of change is an increase of 0.22% per year.

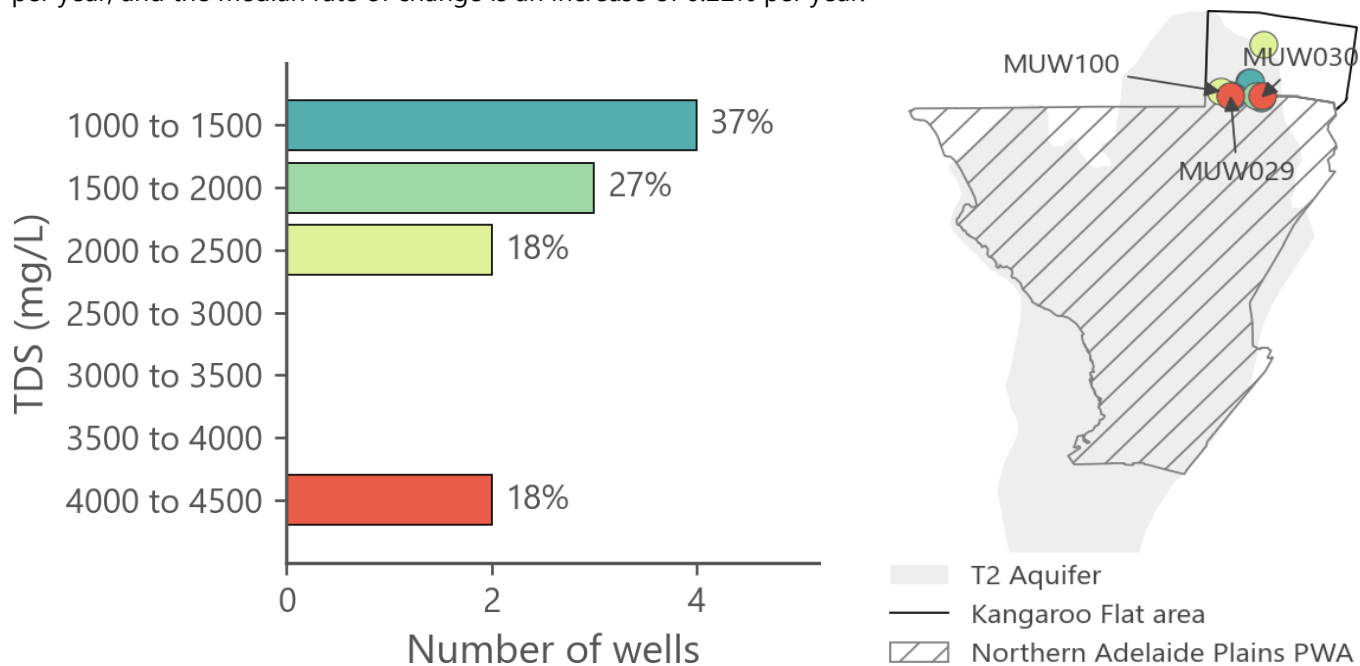


Figure 4.22 2020 salinity observations in the T2 aquifer of the Kangaroo Flat region

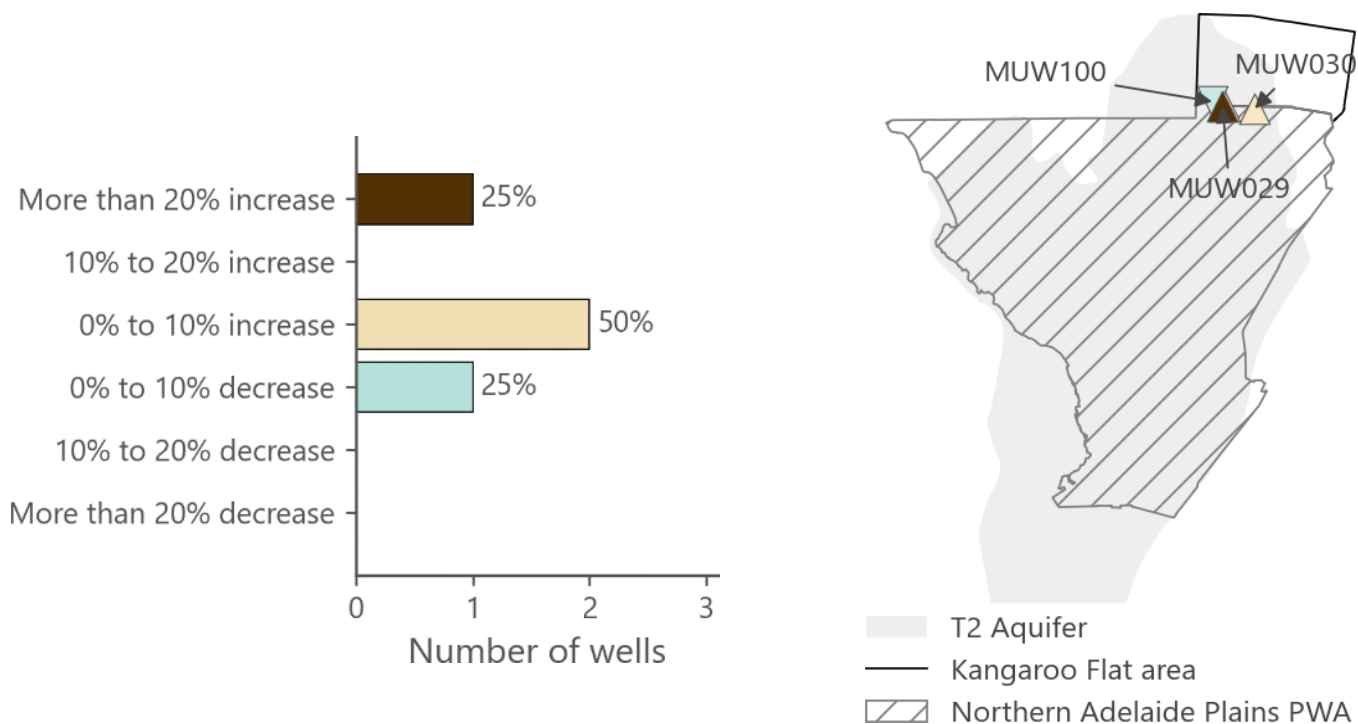


Figure 4.23 Salinity trend in the 10 years to 2020 for wells in the T2 aquifer of the Kangaroo Flat region

Salinity graphs are shown for three T2 aquifer monitoring wells in the Kangaroo Flat region to illustrate some common or important trends (Figure 4.24; Section 2.2.2). The monitoring wells MUW029 and MUW030 are completed in the upper part of the T2 aquifer which appears to be in full or partial connection with the overlying Quaternary Carisbrook Sand aquifer. The sharp increase in groundwater salinity in these wells (Figure 4.21) may be due to downward leakage of more saline groundwater during the irrigation season when pressure levels are at their lowest.

A steady rate of increasing salinity occurs until 2016, after which rates of groundwater extraction decreased (Figure 5.1) and subsequently, salinity either stabilised (MUW029) or decreased (MUW030). Compared with MUW029, the magnitude of increased salinity between 2003–16 is lower at MUW030, where lithological logs suggest the presence of a thin clay horizon between the T2 aquifer and the higher-salinity Carisbrook Sand aquifer.

MUW100 displays larger variations in groundwater salinity that generally correspond with variations in rates of extraction, also suggesting connection with the overlying Carisbrook Sand aquifer and downward leakage during the irrigation season.

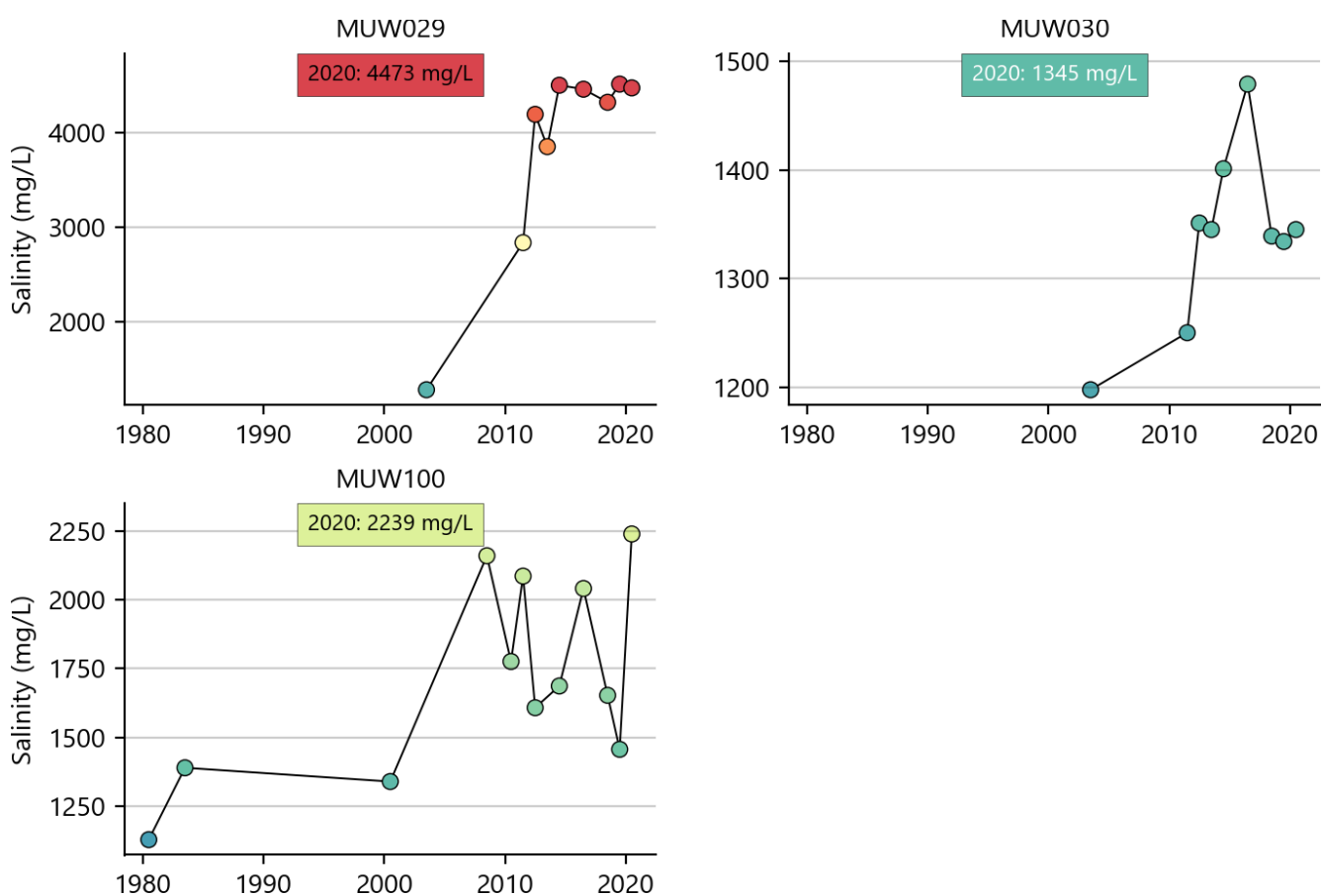


Figure 4.24 Salinity in the T2 aquifer of the Kangaroo Flat region

5 Water use

Water-use data reported herein comprises groundwater extracted from licensed wells, and net extraction (i.e. the balance of water injected into and extracted from) the T1 and T2 aquifers by MAR schemes. The year of lowest extraction volumes (2016–17) aligns with a widespread increase in total annual rainfall (Section 3) that led to a marked increase in aquifer injection volumes. Currently, within the Central Adelaide PWA, water-use data are available only for MAR schemes (which operate in both the T1 and T2 aquifers), until such time as the implementation of water meters for licensed use is complete.

5.1 Groundwater extraction

In 2019–20, licensed groundwater extractions (from the T1 and T2 aquifers of the Kangaroo Flat region and NAP PWA, excluding MAR schemes extraction) are 13 194 ML, compared to 14 025 ML in 2018–19, and 12 270 ML in 2017–18 (Figure 5.1).

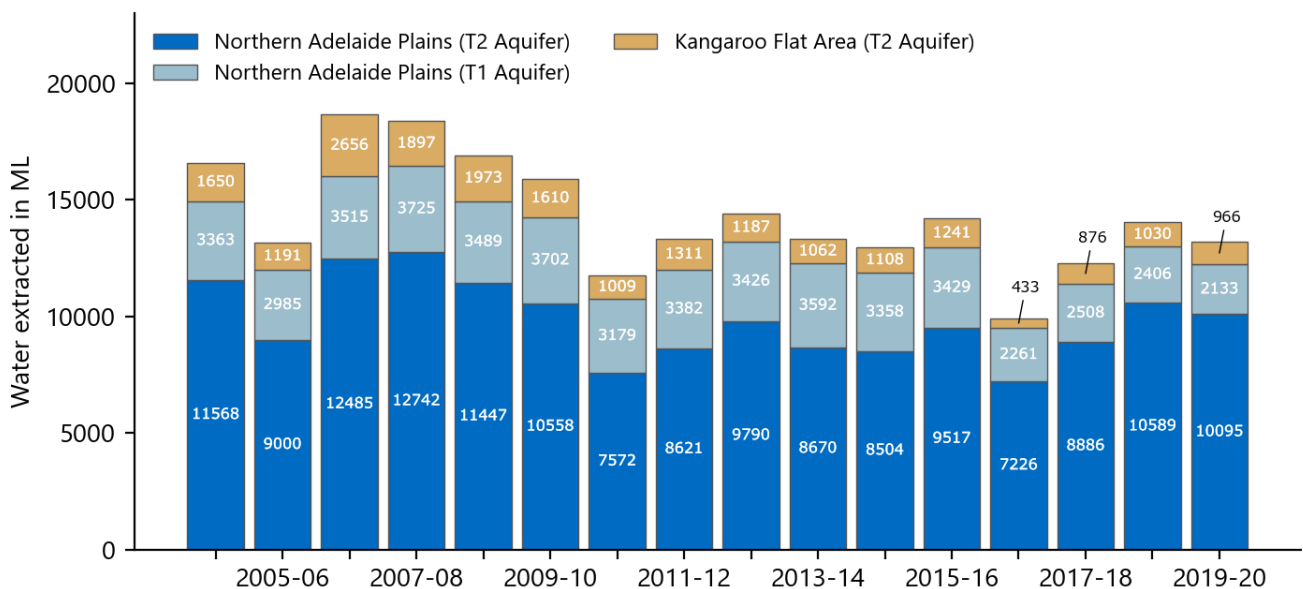


Figure 5.1 Licensed groundwater extraction from aquifers of the NAP PWA (including the Kangaroo Flat region) from 2004–20

5.2 Managed aquifer recharge

5.2.1 Central Adelaide PWA

In 2019–20, licensed groundwater injections to the T1 aquifer of the Central Adelaide PWA totalled 749 ML, an increase from 645 ML in the previous reporting period (2018–19) (Figure 5.2). Injections into the T2 aquifer were marginally lower in 2019–20 at 751 ML, compared to the previous water-use year (776 ML).

Extraction from the T1 aquifer has exceeded injection since 2009–10. Predominantly, these MAR schemes are associated with golf course and racecourse maintenance. Conversely, injection has exceeded extraction in the T2 aquifer of the Central Adelaide PWA since 2010–11, resulting in a net gain to the T2 aquifer in the order of 2 GL.

5.2.2 Northern Adelaide Plains PWA

In 2019–20, licensed groundwater injections to the T1 aquifer of the NAP PWA increased to 373 ML, from 342 ML in 2018–19. Injection volumes for the T2 aquifer also increased, with 3136 ML recorded for 2019–20 and 2788 ML for the 2018–19 reporting period (Figure 5.3). Both of these annual injection volumes were considerably lower than 491 ML (T1) and 5636 ML (T2) in 2016–17, which coincided with above-average annual rainfall that allowed the schemes to harvest large volumes of stormwater for injection.

Injection typically exceeds extraction in the T1 and T2 aquifers in the NAP PWA. This has resulted in a net gain since 2004–05 of just over 4 GL and 11.7 GL, to the T1 aquifer and the T2 aquifer, respectively.

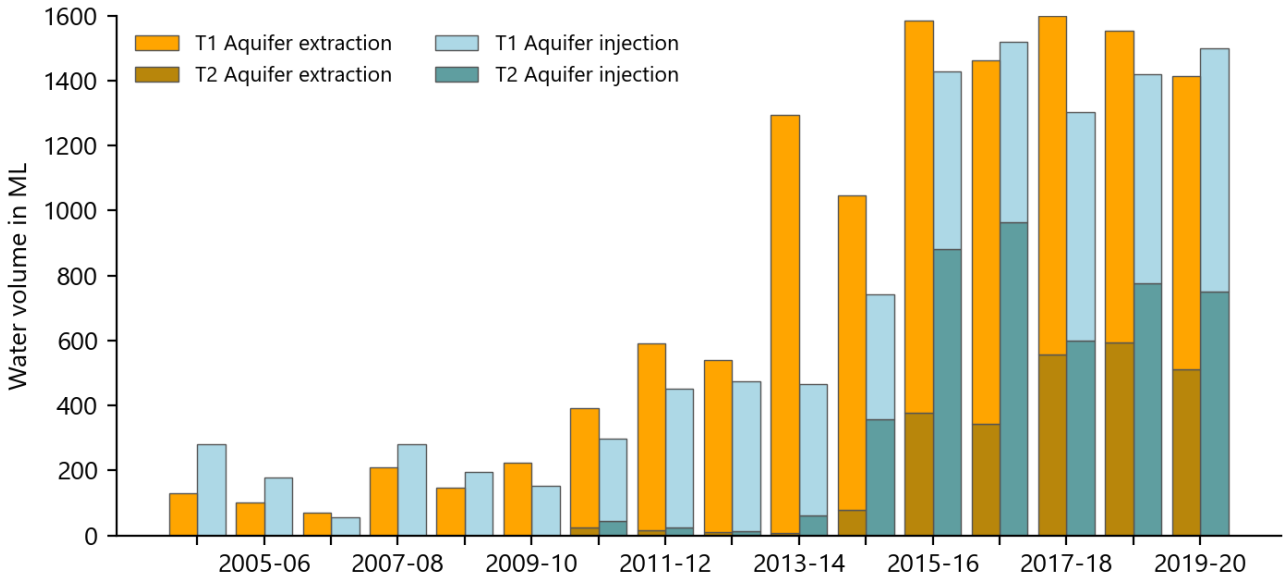


Figure 5.2 Metered water injection and extraction volumes during 2004–20 for MAR schemes in the T1 and T2 aquifers of the Central Adelaide PWA

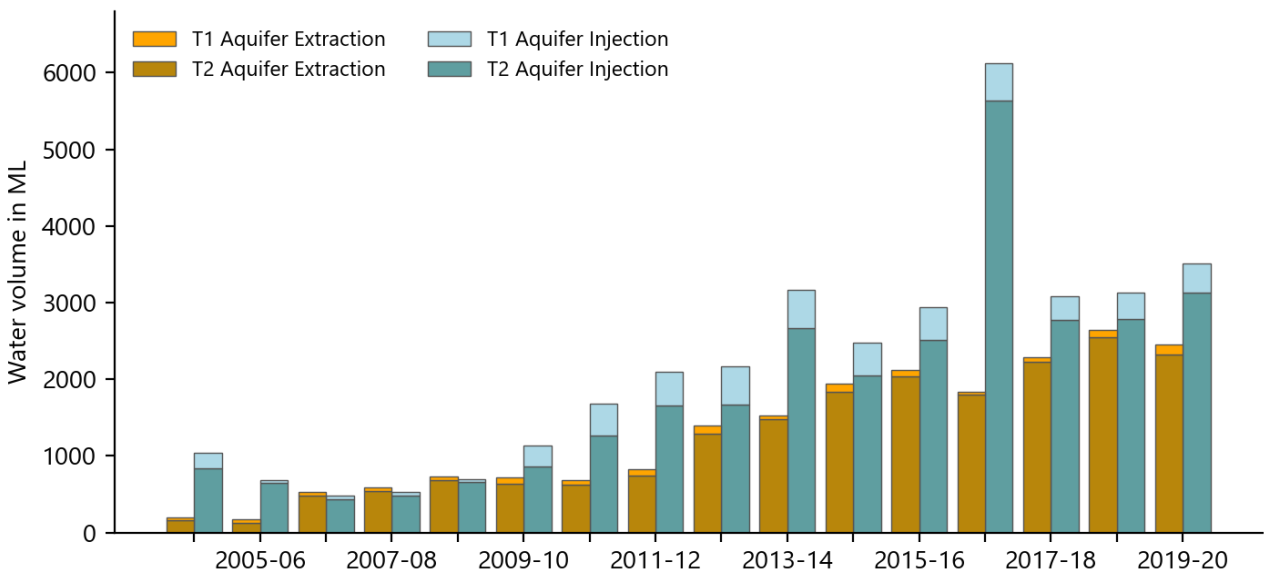


Figure 5.3 Metered water injection and extraction volumes during 2004–20 for MAR schemes in the T1 and T2 aquifers of the NAP PWA

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