Musgrave and Southern Basins Prescribed Wells Areas
2019–20 water resources assessment

Department for Environment and Water
December, 2021

DEW Technical Note 2021/15

Government of South Australia
Department for Environment and Water

Department for Environment and Water

Government of South Australia

December 2021

81-95 Waymouth St, ADELAIDE SA 5000

Telephone +61 (8) 8463 6946

Facsimile +61 (8) 8463 6999

ABN 36702093234

www.environment.sa.gov.au

ISBN 978-1-922027-12-2

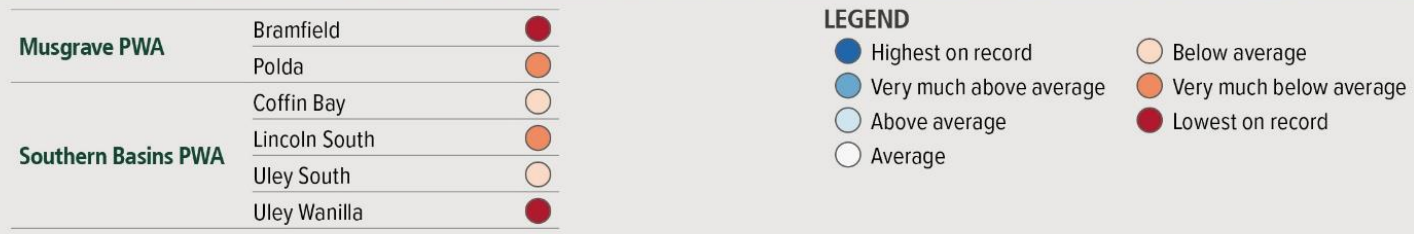
Preferred way to cite this publication

DEW (2021) *Musgrave and Southern Basins Prescribed Wells Area 2019–20 water resources assessment*, DEW Technical Note 2021/15, Government of South Australia, Department for Environment and Water, Adelaide.

Download this document at https://www.waterconnect.sa.gov.au

Contents

1 Summary



Rainfall

- In the Musgrave Prescribed Wells Area (PWA) in 2020, rainfall at Elliston (BoM Station 18069) was 339 mm, which is 20% below the long-term average of 423 mm (1970–2020). Trends in the long-term data indicate declining annual rainfall at Elliston and Terrah Winds (BoM Station 18165).
- In the Southern Basins PWA, rainfall at Big Swamp (BoM Station 18017) was 567 mm, which is commensurate with the long-term average of 555 mm (1970–2020).

Groundwater

- In the Musgrave PWA, most water levels in the Quaternary Limestone aquifer are classified 'Very much below average' (50% of wells) or 'Lowest on record' (33% of wells), compared to their respective historical record.
- In the Southern Basins PWA, most water levels in the Quaternary Limestone aquifer are classified 'Below average' (35%) or 'Lowest on record' (34%), compared to their respective historical record.
- In the Uley Wanilla Public Water Supply (PWS) consumptive pools, the majority of wells (74%) are classified 'Lowest on record'.
- In the Uley South PWS, Coffin Bay and Lincoln South PWS consumptive pools, the median ranked well in each pool is classified 'Below average', compared to their respective historical record.
- Across both PWAs, five-year trends show that water levels in almost all wells (92–100%) in each of the consumptive pools are declining.
- Across both PWAs, groundwater salinity in the majority of wells (74%) is stable.

Water use

- Surface water flows are generally scarce and unreliable in Eyre Peninsula. Consequently, the fresher groundwater resources in both the Musgrave and Southern Basins PWAs are used for a variety of purposes, but mainly reticulated town water supplies, stock and domestic, recreation (e.g. irrigation of golf courses and sports grounds) and industrial uses.
- Licensed extraction in the Musgrave PWA in 2019–20 totalled 70 ML, all of which was sourced from the Bramfield consumptive pool.
- Licensed extraction in the Southern Basins PWA in 2019–20 totalled 5442 ML, the majority of which (93%) was sourced from the Uley South PWS consumptive pool. Licenced extraction from the other main groundwater resources in 2019–20 are from the Uley Wanilla PWS (85 ML), Lincoln South PWS (163 ML) and Coffin Bay (110 ML) consumptive pools.

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 Musgrave Prescribed Wells Area (PWA) and Southern Basins PWA for 2019–20 and collates rainfall and water use 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 Musgrave PWA (Figure 1.1) and Southern Basins PWA (Figure 1.2) are located within the Eyre Peninsula Landscape region. The PWAs comprise undulating topography which is the remnant of ancient dune systems which were deposited during the Pleistocene era (from around 2.7 million years ago). Thin soils and calcrete across common to both PWAs. Groundwater is the main source of fresh water on the Eyre Peninsula and is used for town water supply, stock and domestic, irrigation, recreational and industrial purposes. There are at least four groundwater systems located in the region: the uppermost unconfined Quaternary Limestone aquifer, an underlying unconfined to confined Tertiary Sands aquifer, a high-salinity Jurassic sedimentary aquifer (that is exclusive to the Musgrave PWA) and a fractured rock aquifer occurring in basement rocks. The Water Allocation Plan (WAP) for the Southern Basins and Musgrave Prescribed Wells Areas (EP NRM Board, 2016) was adopted in 2016 and provides for sustainable management of the groundwater resources.

The lowest-salinity groundwater generally resides within the Quaternary Limestone aquifers, which occur widely in both the Musgrave and Southern Basins PWAs. Groundwater resources in the Quaternary limestone are subdivided into discrete basins, which are used to delineate groundwater resources discussed in this Technical Note. These basins, some of which contain considerable volumes of groundwater in storage, comprise geologically controlled fresh groundwater lenses that are separated by areas where the Quaternary limestone is dry or has very low saturated thickness.

The WAP describes six consumptive pools, where the areal extent of each consumptive pool is based on the spatial distribution the main groundwater basins. In the Musgrave PWA (Figure 1.1), the WAP defines:

- The Bramfield consumptive pool, which extends to the north-east of the township of Elliston
- The Polda consumptive pool, located around 50 km inland from Elliston.

In the Southern Basins PWA (Figure 1.2), the WAP defines:

- The Coffin Bay consumptive pool, located immediately inland of the township of Coffin Bay
- The Uley South Public Water Supply (PWS) consumptive pool, located around 30 km west of Port Lincoln
- The Uley Wanilla PWS consumptive pool, located inland about 15 km east of Coffin Bay
- The Lincoln South PWS consumptive pool, located between Port Lincoln and Sleaford Bay.

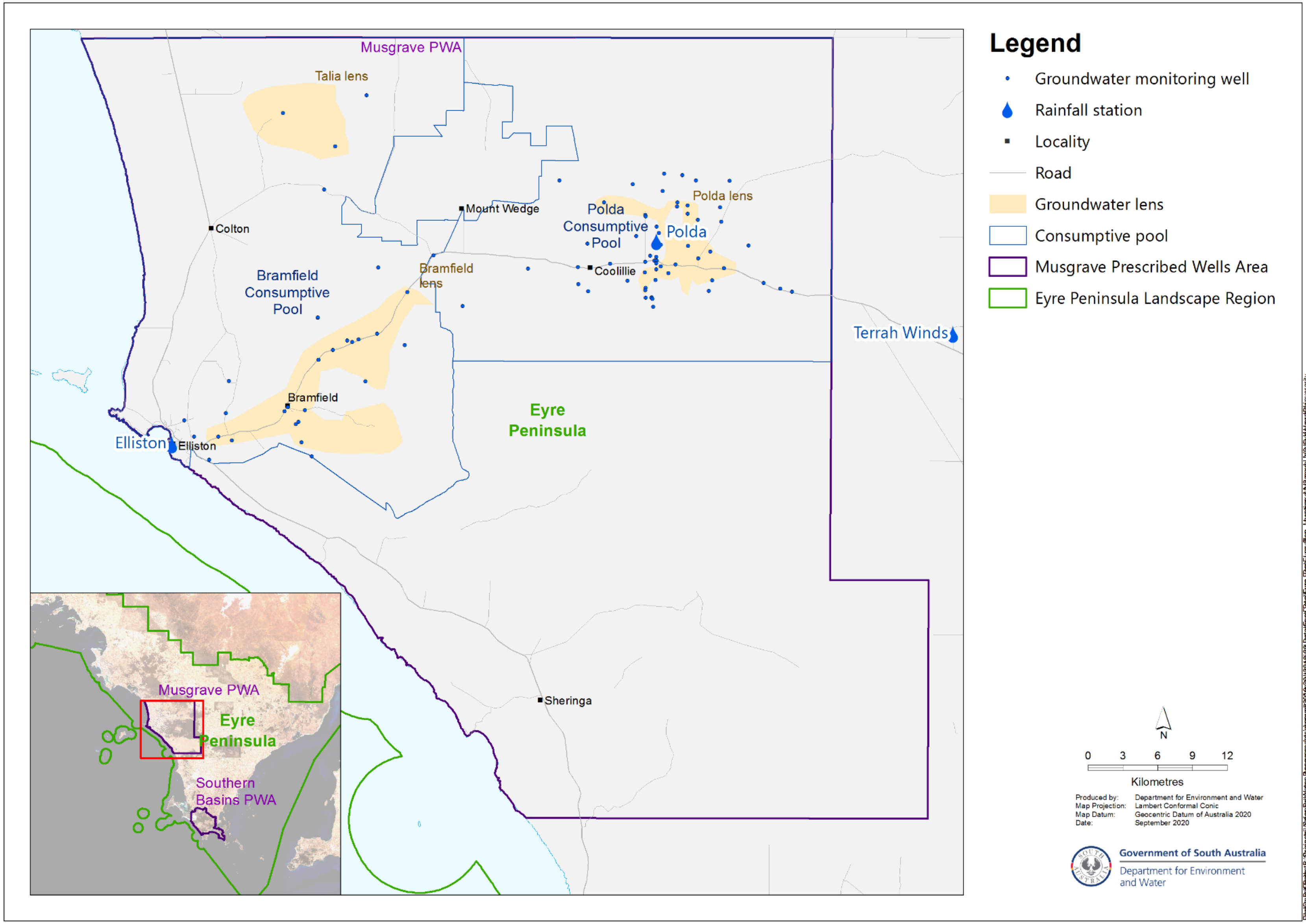


Figure 1.1. Location of Musgrave PWA

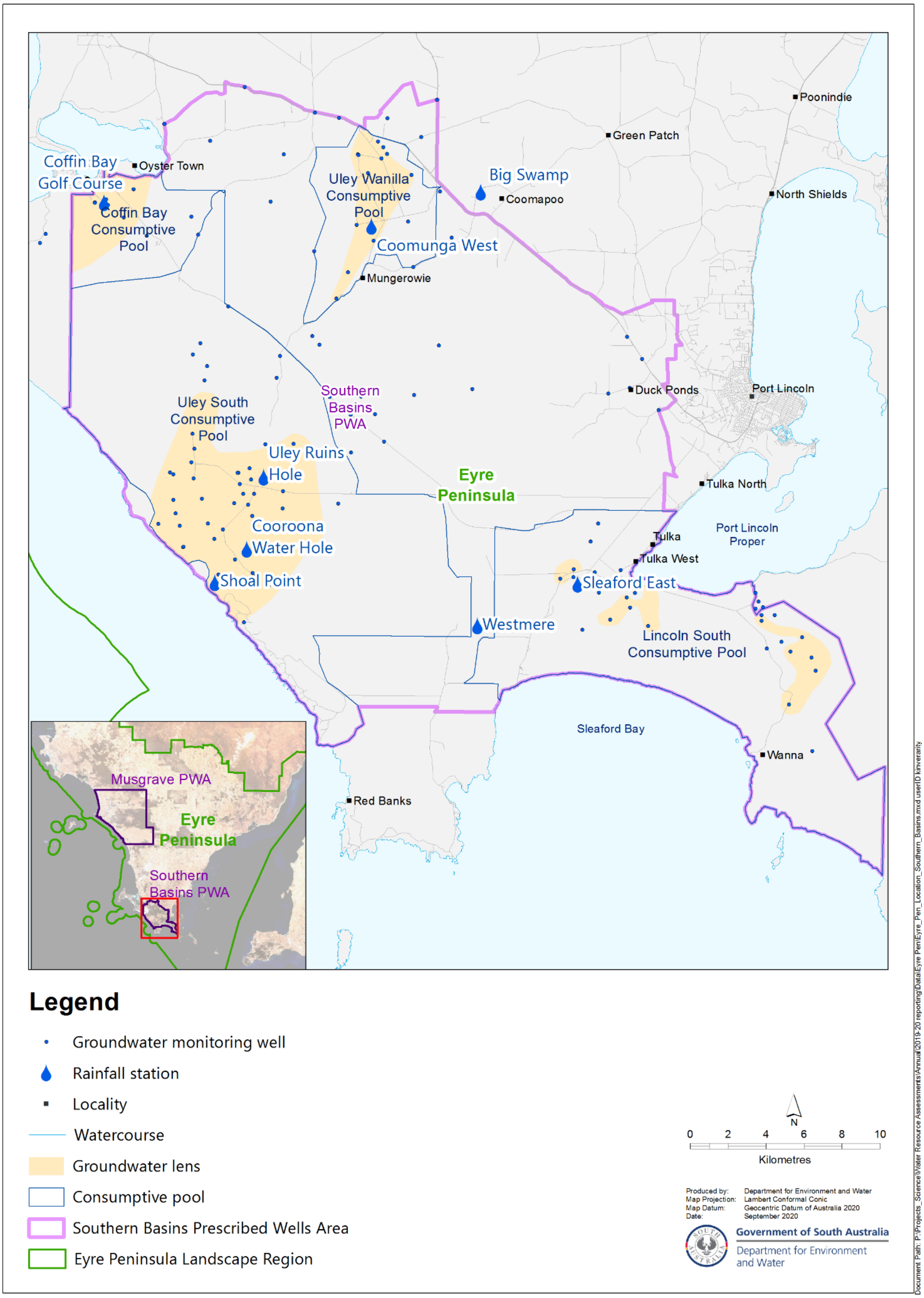


Figure 1.2. Location of Southern Basins PWA

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 DEW and Bureau of Meteorology (BoM) stations in order to calculate monthly and annual totals. Bureau of Meteorology data were obtained from the SILO Patched Point Dataset service provided by the Queensland Government, which provides interpolated values to fill gaps in observations (see figures in Section 3). Annual rainfall totals are calculated for calendar years.

Rainfall maps were compiled using gridded datasets obtained from the Bureau of Meteorology (Figure 3.1). The long-term average annual rainfall map (1986–2015) was obtained from Climate Data Online. The map of total rainfall in 2018–19 was compiled from monthly rainfall grids obtained for the months between July 2018 and June 2019 from the Australian Landscape Water Balance website.

2.2 Groundwater

2.2.1 Water level

Water level[1] 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, town water supply, stock and domestic 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 for unconfined aquifer wells in the Eyre Peninsula the long-term trend in water level is larger than the seasonal effect, but the return to a maximum level mostly occurs between July and December.

For those wells with suitable long-term records, the annual recovered water levels were then ranked from lowest to highest and given a description based on their decile[2] (Table 2.1). The definition of a suitable long-term record varies depending on the history of monitoring activities in different areas; for the Musgrave and Southern Basins PWAs, any well with 10 years or more of recovered water level data is included, except for the Bramfield consumptive pool in the Musgrave PWA, where only those wells with 30 years or more of recovered water level data are 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). Hydrographs are shown for a selection of wells to illustrate common or important trends (e.g. Figure 4.3).

[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.

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 Bureau of Meteorology[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 4.2). Sedimentary unconfined aquifers with limited areal extent such as those in Eyre Peninsula considered in this report are given tolerance thresholds of 4 mm/y. This is consistent with past practice in the Eyre Peninsula (e.g. DEW, 2019).

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. 1989–91) and the average water level in 2019. 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. 1999–2001).

2.2.2 Salinity

Water samples are collected from monitoring wells located across the two PWAs by a variety of methods. Samples are collected through a combination of pumping samples from dedicated monitoring wells and by collecting samples from operational SA Water production wells.

Water samples are tested for electrical conductivity (EC) and the salinity (total dissolved solids measured in mg/L, abbreviated as TDS) is calculated. Salinity data collected by SA Water from pumping wells in use for public water supply as also included. Where more than one water sample has been collected in the course of a year from one well, the annual mean salinity is used for analysis. An example of the results is shown in Figure 4.4.

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 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).

[3] Bureau of Meteorology Annual climate statement

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

2.3 Water use

Meter readings are used to estimate licensed extraction for groundwater sources (Section 5).

2.4 Further information

Groundwater data can be viewed and downloaded using the *Groundwater Data* page 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 on the prescribed resources of the Eyre Peninsula are:

- The most recent summary report on the groundwater resources of the Eyre Peninsula (DEWNR, 2010a,b), and annual groundwater level and salinity status reports such as DEW (2019a,b,c,d,e,f,g);
- The Water Allocation Plan for the Southern Basins and Musgrave Prescribed Wells Area (EP NRM Board, 2016);
- Stewart et al. (2012), Stewart et al. (2013) and Stewart (2015) provide assessments of the groundwater resources in the Southern Basins PWA and Musgrave PWA in order to support the water allocation plan.

3 Rainfall

In general, rainfall totals across Eyre Peninsula's PWAs are higher in coastal areas than in inland areas. Average annual rainfall varies from approximately 550 mm/y in the Southern Basins PWA to 400 mm/y in the north-west of the Musgrave PWA. In 2019–20, rainfall was generally below the long-term average (1986-2015), particularly around the Lincoln South PWS consumptive pool (Figure 3.1)[4].

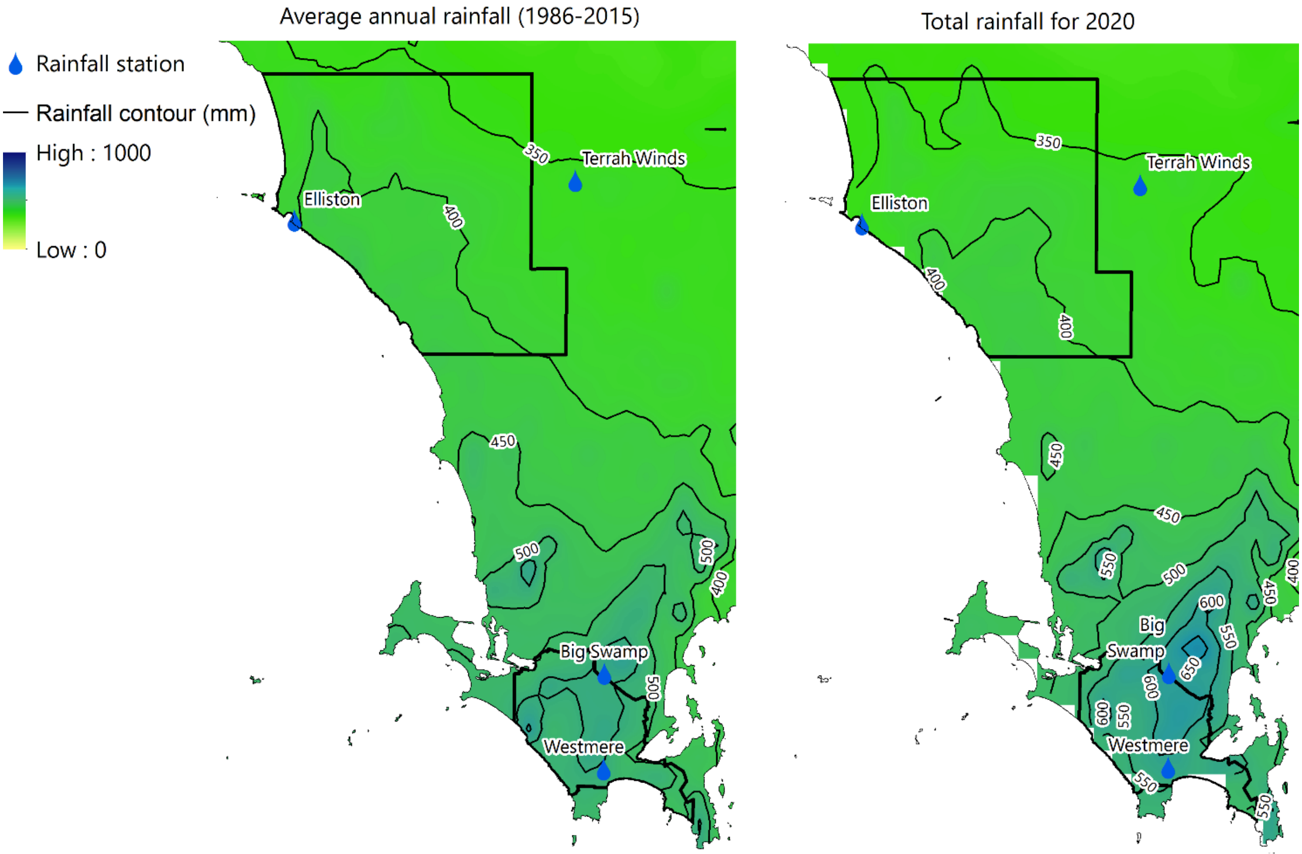


Figure 3.1. Rainfall in the Musgrave PWA and Southern Basins PWA for 2020 compared to the 30-year average (1986–2015).

[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; further detail is provided in Section 2.1.

The past forty years of annual and monthly rainfall are shown below for rainfall stations operated by the BoM (Figure 1.1). Data from these stations are used to calculate long-term averages and changes in rainfall.

- Musgrave PWA
  - Elliston (BoM Station 18069), which is the main township within the Musgrave PWA and is located on the coast (Figure 3.2 and Figure 3.3)
  - Terrah Winds (BoM Station 18165), which is located around 25 km east of the Polda groundwater lens (Figure 3.4 and Figure 3.5)
- Southern Basins PWA
  - Big Swamp (BoM Station 18017), which is located halfway between Coffin Bay and Port Lincoln (Figure 3.9 and Figure 3.10)
  - Westmere (BoM Station 18137), which is located southwest of Port Lincoln near Sleaford Bay (Figure 3.11 and Figure 3.12).

In addition, the past ten years of annual and monthly rainfall is shown for rainfall sites operated by DEW and Landscape South Australia Eyre Peninsula:

- Musgrave PWA
  - Polda rainfall station (DEW station A0211001), which is located within the Polda consumptive pool (Figure 3.6 and Figure 3.7)
- Southern Basins PWA
  - Coffin Bay Golf Course rainfall station (Figure 3.13 and Figure 3.14)
  - Shoal Point rainfall station, which is located near the coastal cliffs of the Uley South PWS consumptive pool (Figure 3.15 and Figure 3.16).

3.1 Musgrave PWA

The Elliston rainfall station (BoM station 18069) is located on the coast at the south-western boundary of the Bramfield consumptive pool. Total annual rainfall in 2020 is 339 mm (Figure 3.2), which is 20% below the long-term average of 423 mm/y (1971 to 2020).

The Terrah Winds rainfall station (BoM station 18165) is located 25 km east of the Polda groundwater lens, just outside the eastern boundary of the Musgrave PWA. Total annual rainfall in 2020 is 384 mm (Figure 3.4). This was 4% above the long-term average of 369 mm/y (1971 to 2020).

The Polda rainfall station (DEW station A0211001; Figure 1.2) is located in the centre of the Polda lens. Total annual rainfall in 2020 is 332 mm (Figure 3.3), which is 7% below the long-term average of 358 mm/y (2010–20). This is well below the nearby Terrah Winds rainfall station total for 2020 (see above).

At all three Musgrave PWA stations, monthly rainfall was well below average between July 2019 and December 2019, with the exception of Polda and Terrah Winds, which recorded high rainfall in September 2019. At all three stations in 2020, rainfall was well below average in February, March and June, with the exception of high rainfall at Terrah Winds in February. High rainfall also fell at Polda in January 2020, and at all three stations in April 2020. Groundwater levels in the Quaternary Limestone aquifer monitoring well SQR002, which is located near the Polda rainfall station, did not show winter recovery in 2019 or 2020 (Figure 3.8).

Rainfall across the Musgrave PWA shows a declining at trend in the long term (1971 to 2020). This trend is evident at both BoM stations, with a greater rate of decline at Elliston. Rainfall from 2010 to 2020 at the DEW Polda station also shows a declining trend.

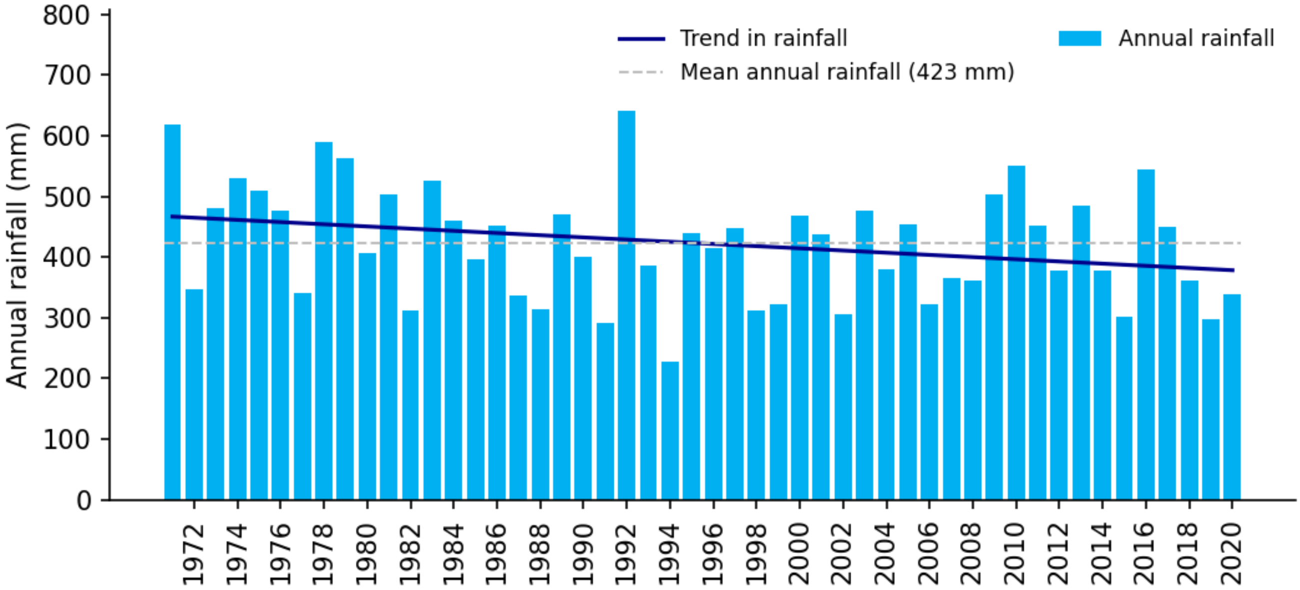


Figure 3.2. Annual rainfall for 1971 to 2020 at the Elliston rainfall station (BoM station 18069)

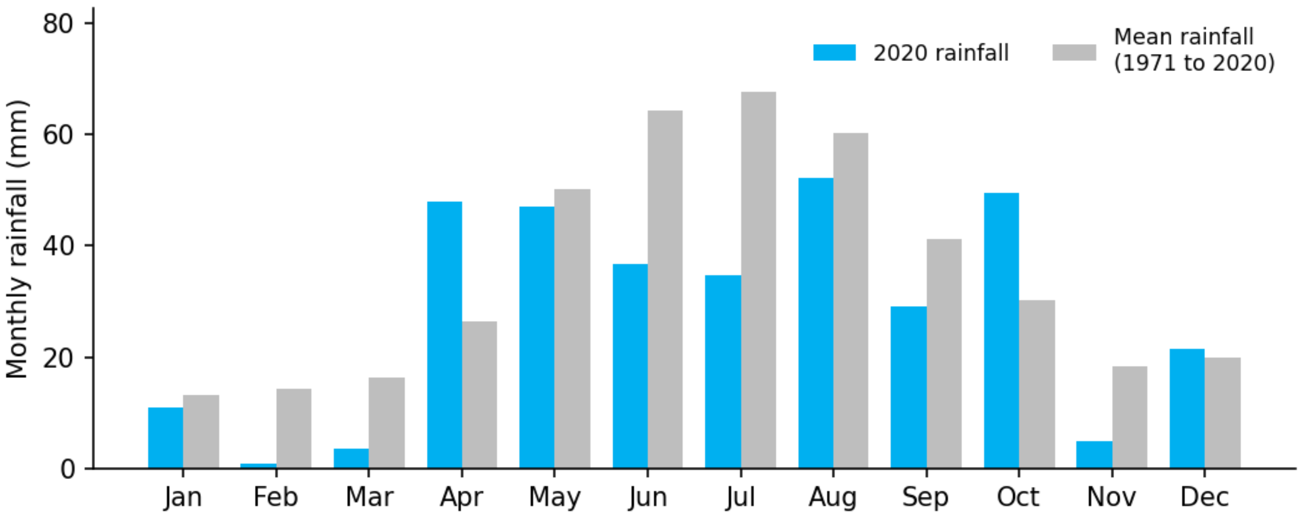


Figure 3.3. Monthly rainfall between January and December 2020 at the Elliston rainfall station (BoM station 18069)

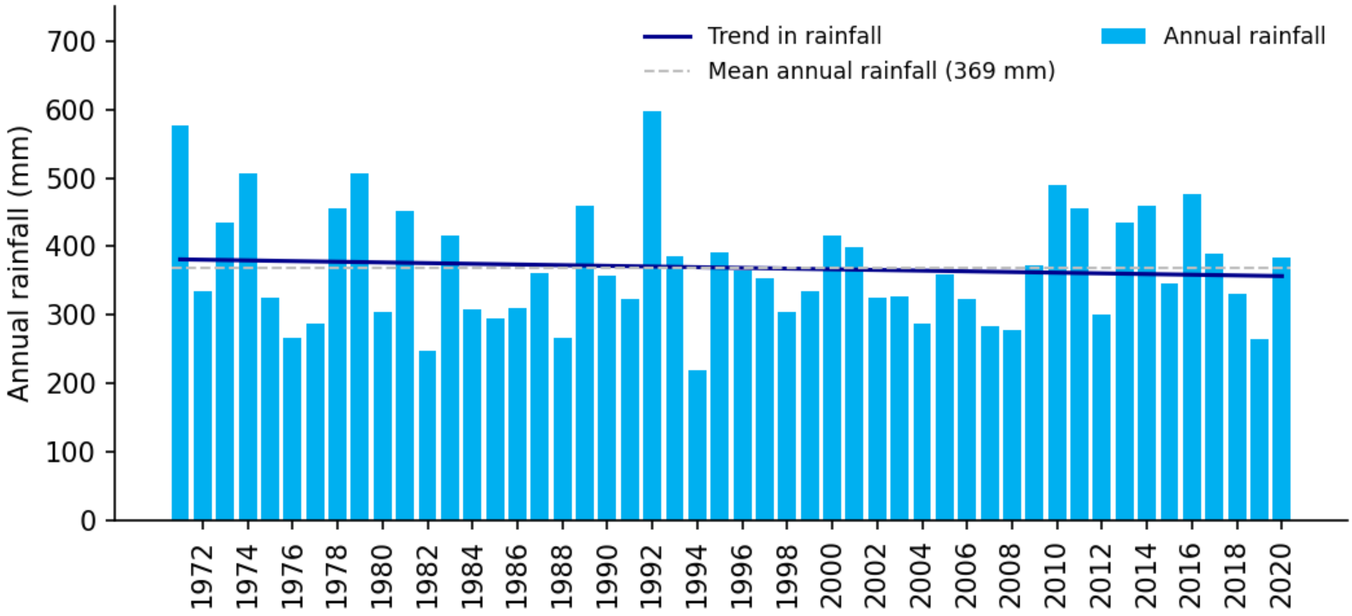


Figure 3.4. Annual rainfall for 1971 to 2020 at the Terrah Winds rainfall station (BoM station 18165)

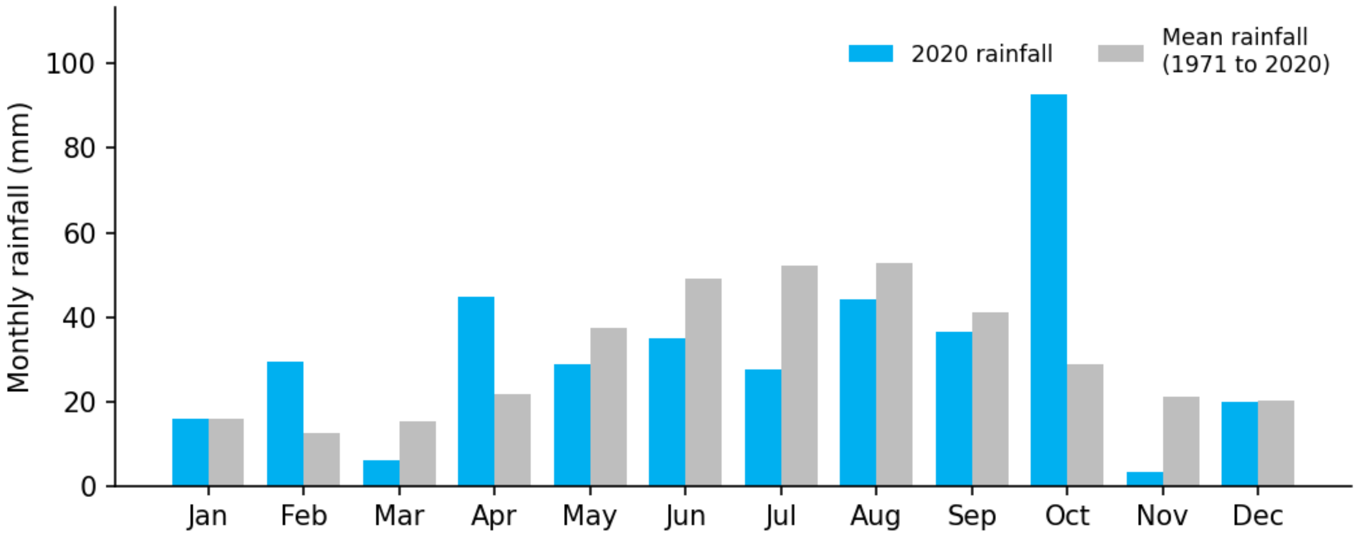


Figure 3.5. Monthly rainfall between January and December 2020 at the Terrah Winds rainfall station (BoM station 18165)

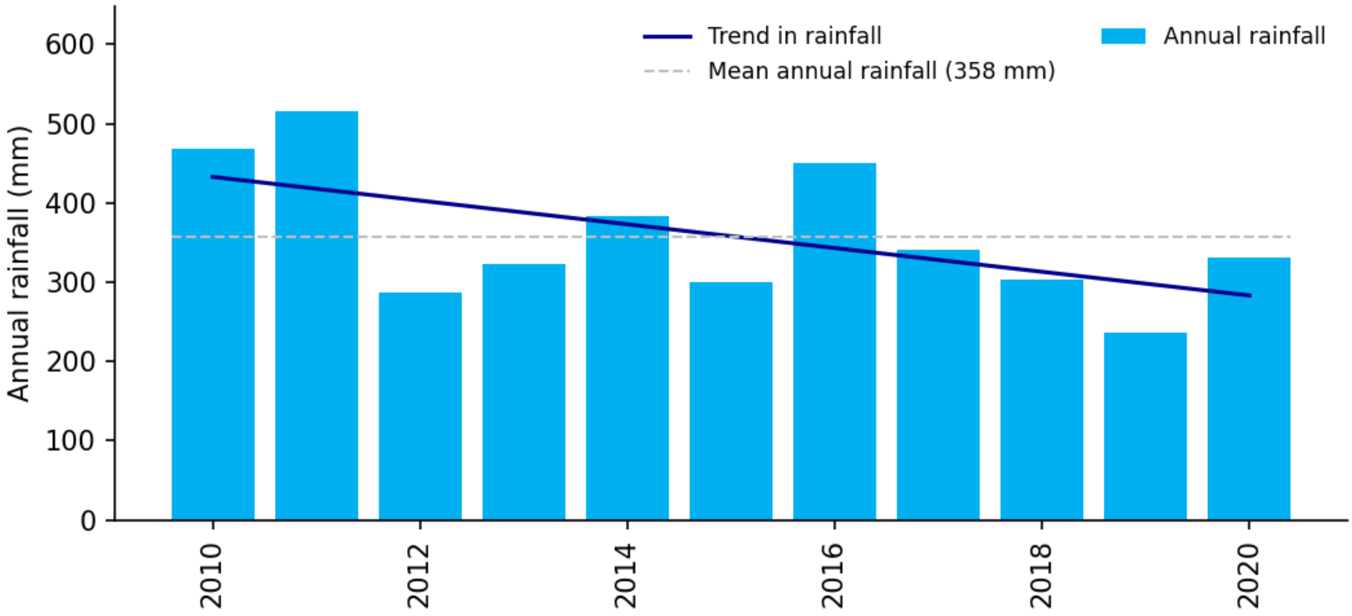


Figure 3.6. Annual rainfall for 2010 to 2020 at the Polda rainfall station (DEW station A0211001)

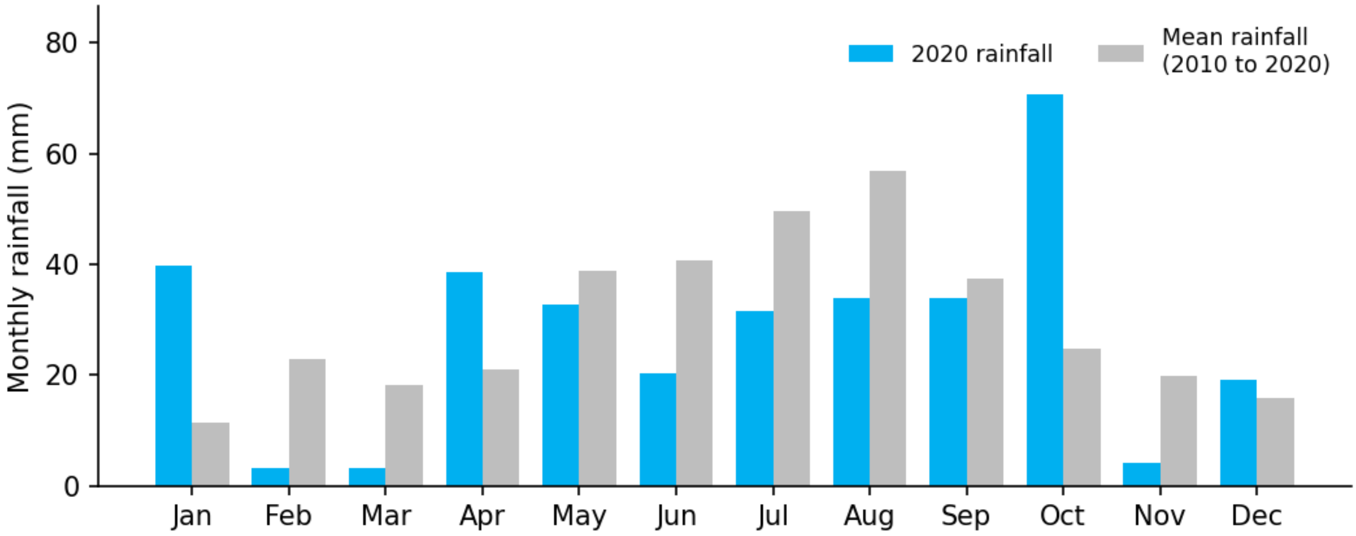


Figure 3.7. Monthly rainfall between January and December 2020 at the Polda rainfall station (DEW station A0211001)

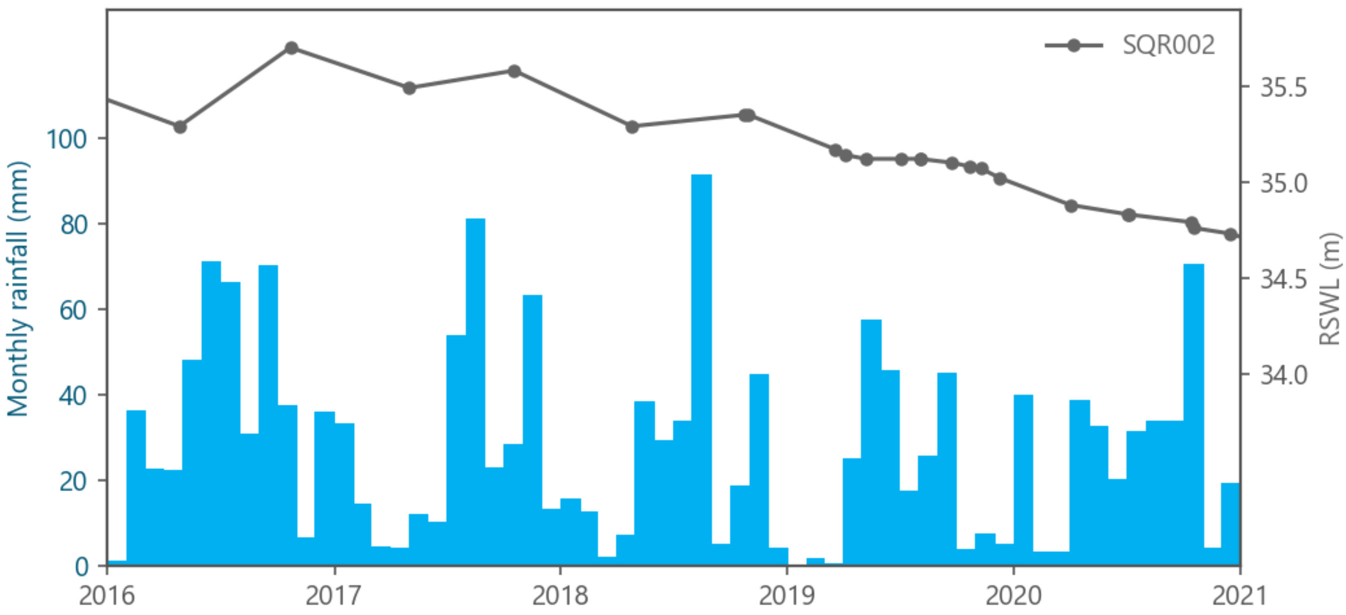


Figure 3.8. Monthly rainfall between 2016 and 2020 at Polda rainfall station (DEW station A0211001) compared to nearby Quaternary Limestone aquifer levels from SQR002.

3.2 Southern Basins PWA

The Big Swamp rainfall station (BoM station 18017) is located just outside the northern boundary of the Southern Basins PWA, near the Uley Wanilla lens. Total annual rainfall in 2020 is 567 mm (Figure 3.9), which is 2% above the long-term average of 555 mm/y (1971 to 2020). Monthly rainfall was above average in April and May 2020.

The Westmere rainfall station (BoM station 18137) is located in the central part of the Southern Basins PWA, just outside the western boundary of the Lincoln South PWS consumptive pool. Total annual rainfall in 2020 is 564 mm (Figure 3.11), which is commensurate with the long-term average of 556 mm/y (1971 to 2020). Monthly rainfall was above average in August 2019 and January, April, and May 2020.

Monthly rainfall at both stations was high in April 2020. Rainfall was very low throughout the second half of 2019, particularly at Big Swamp, and also very low in March and June 2020 at both stations.

There are five DEW rainfall stations in the Southern Basins PWA (Figure 1.2) that have been in operation since 2010 (annual averages and charts are not shown for Coomunga West and Sleaford East, as these stations have short records that start in 2016). In 2020, total annual rainfall at

- Coffin Bay Golf Course (DEW station A5121002) is 478 mm (Figure 3.13), which is commensurate with the long-term average of 484 mm/y (2010 to 2020)
- Shoal Point (DEW station A5121003) is 429 mm (Figure 3.15), which is 5% below the long-term average of 450 mm/y (2010 to 2020)
- Uley Ruins Hole (DEW station A5121005) is 475 mm, which is 5% above the long-term average of 452 mm/y (2010 to 2020)
- Coomunga West (DEW station A5121007) is 576 mm
- Sleaford East (DEW station A5121008) is 508 mm.

Rainfall across the Southern Basins PWA shows a declining at trend in the long term (1971 to 2020). This trend is evident at both BoM stations and also at the DEW rainfall stations that have been operating since 2010.

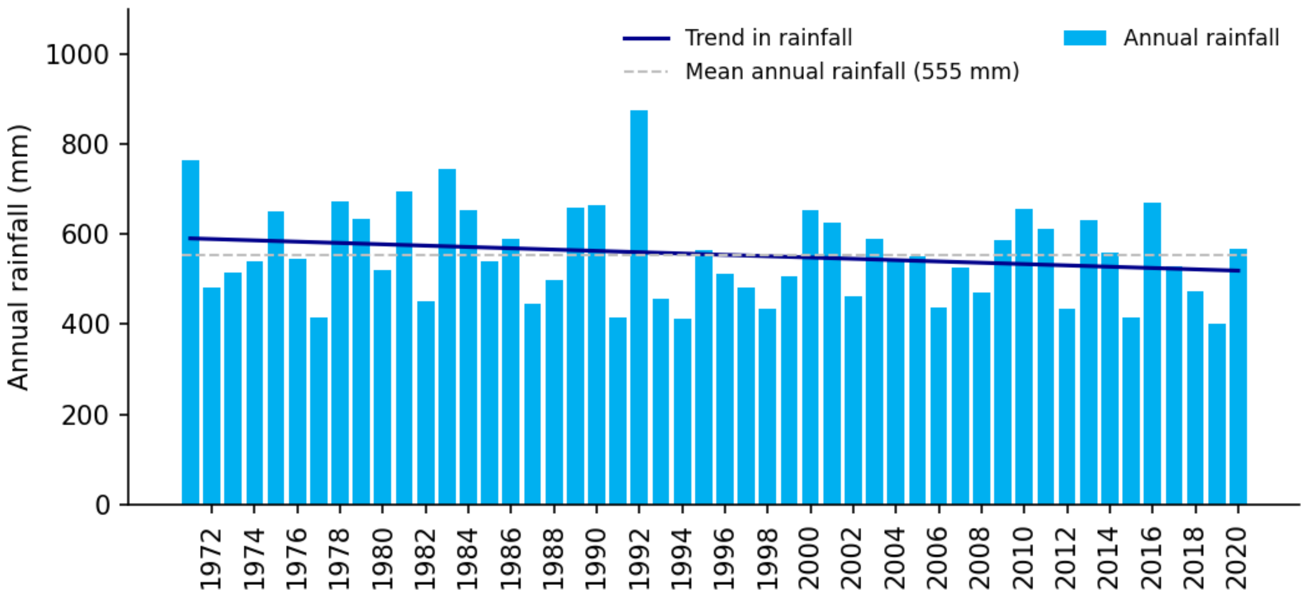


Figure 3.9. Annual rainfall for 1971 to 2020 at the Big Swamp rainfall station (BoM station 18017)

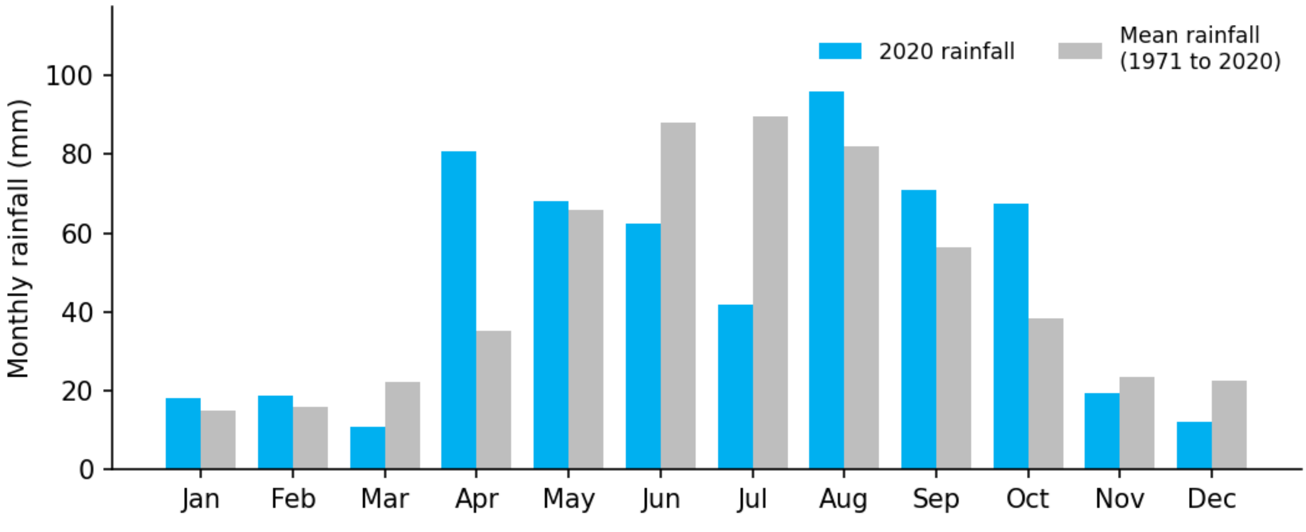


Figure 3.10. Monthly rainfall between January and December 2020 at the Big Swamp rainfall station (BoM station 18017)

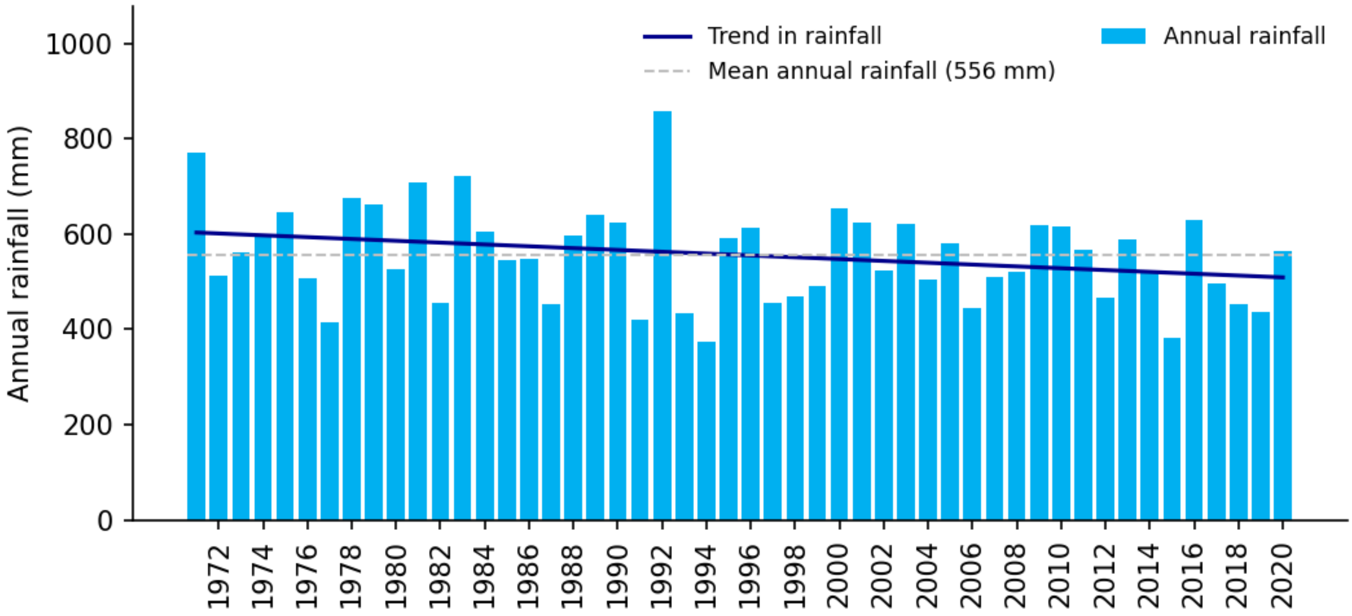


Figure 3.11. Annual rainfall for 1971 to 2020 at the Westmere rainfall station (BoM station 18137)

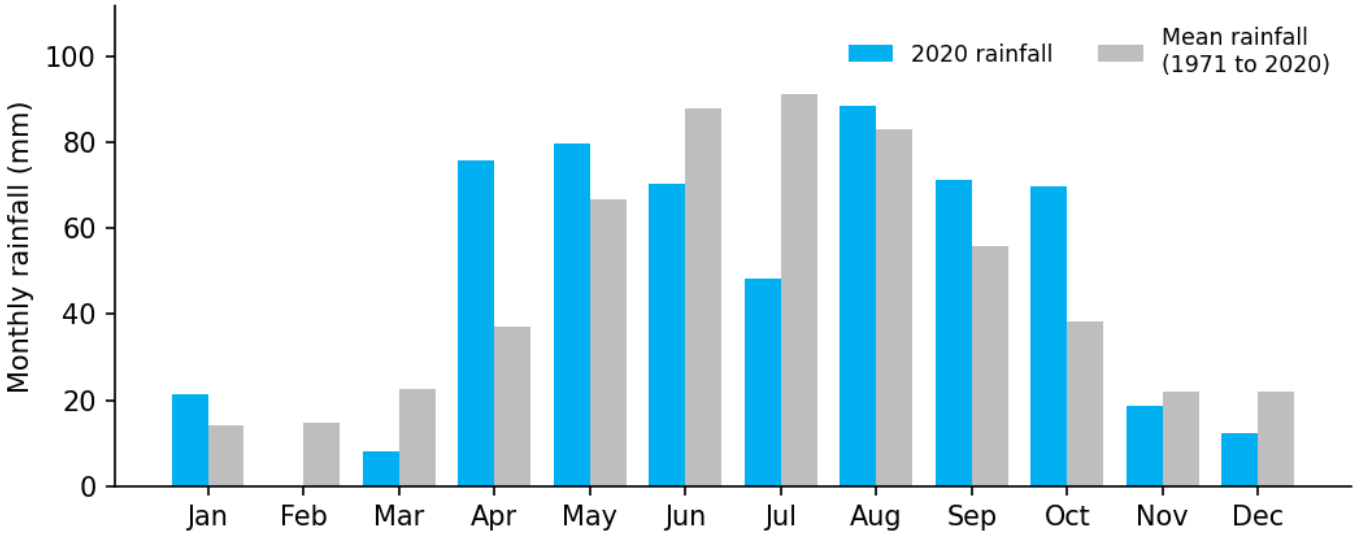


Figure 3.12. Monthly rainfall between January and December 2020 at the Westmere rainfall station (BoM station 18137)

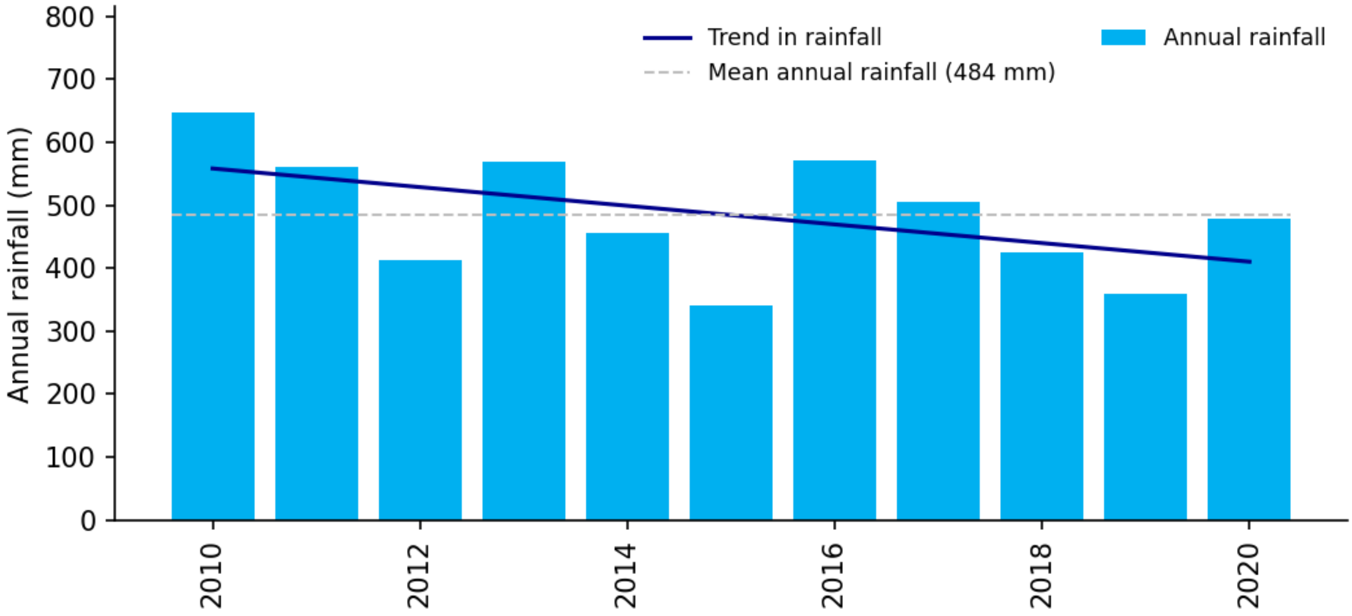


Figure 3.13. Annual rainfall for 2010 to 2020 at the Coffin Bay Golf Course rainfall station (DEW station A5121002)

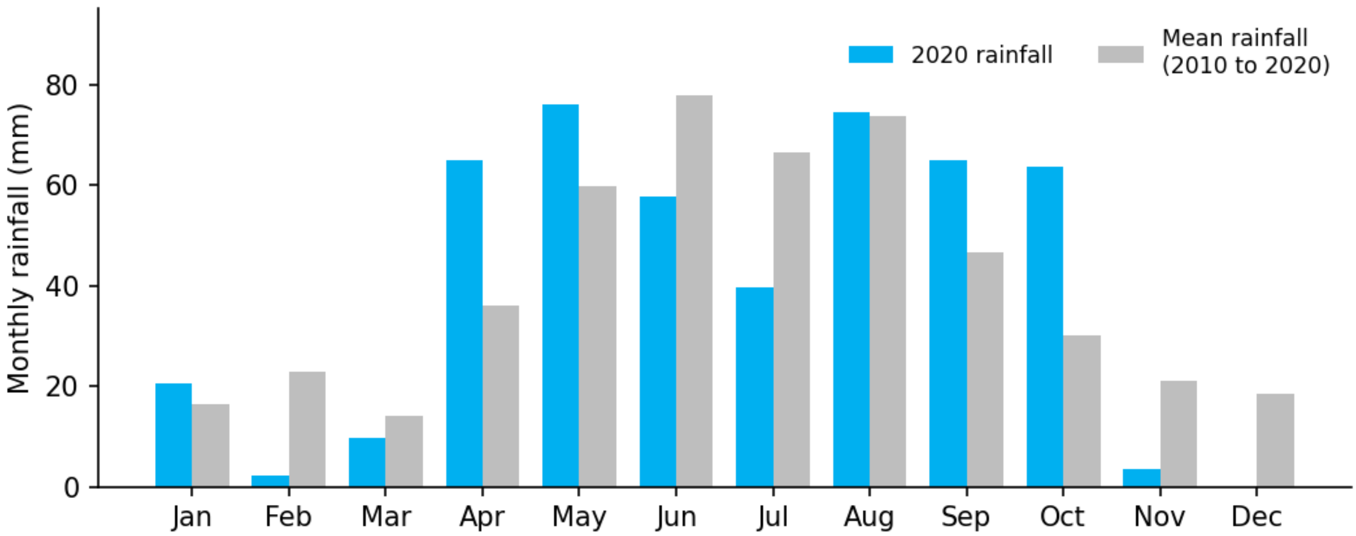


Figure 3.14. Monthly rainfall between January and December 2020 at the Coffin Bay Golf Course rainfall station (DEW station A5121002)

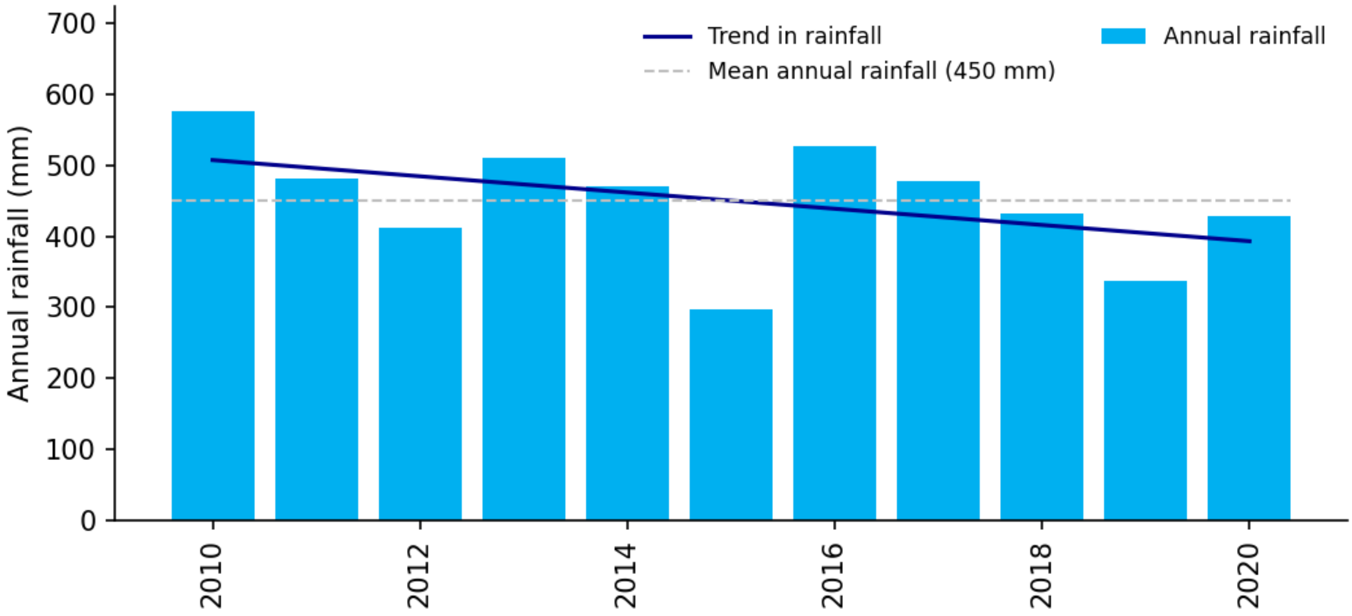


Figure 3.15. Annual rainfall for 2010 to 2020 at the Shoal Point rainfall station (DEW station A5121003)

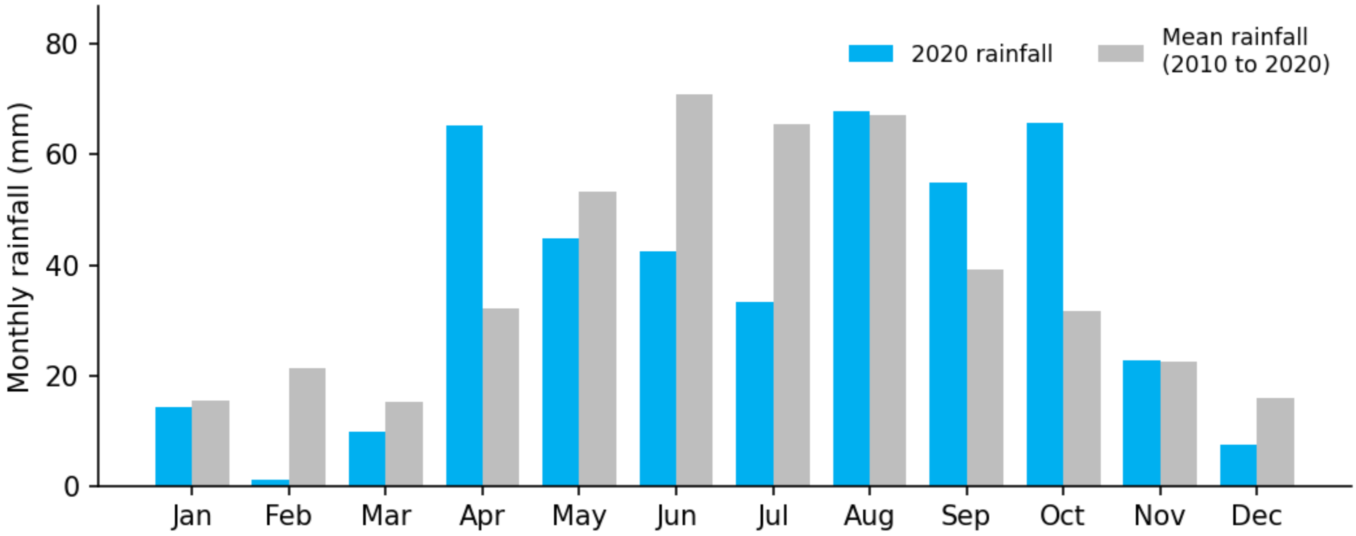


Figure 3.16. Monthly rainfall between January and December 2020 at the Shoal Point rainfall station (DEW station A5121003)

4 Hydrogeology

The Eyre Peninsula is underlain by basement rocks of the Gawler Craton, with limited supplies of fresh groundwater. The only significant sedimentary basin is the Polda Trough, which is located in the Musgrave PWA and has been infilled with Permian, Jurassic and Tertiary sediments during periods of marine transgressions and regressions.

A relatively thin cover of Quaternary and Tertiary sediments occurs across large parts of the western and southern Eyre Peninsula in both the Musgrave and Southern Basins PWAs. Variations in basement topography have led to the development of small basins containing spatially separated fresh groundwater resources in the Quaternary Limestone aquifer. The potable resources in the Quaternary Limestone aquifer are referred to as fresh groundwater lenses and are separated by areas where the saturated thickness of the aquifer is thinner or dry. The water allocation plan defines management zones (i.e. consumptive pools) which extend beyond the physical boundary of the lens(es). There are also underlying Tertiary Sands aquifers and fractured rock aquifers, many of which are low-yielding aquifers and often show higher salinities and consequently, these aquifers are not widely utilised.

Quaternary Limestone aquifer groundwater levels and salinities in both PWAs are highly responsive to recharge from incident rainfall and trends in groundwater level and salinity are primarily climate driven: below-average rainfall results in a reduction in recharge to the aquifers. Below-average summer rainfall can also result in increasing extractions and when both of these elements are combined, groundwater levels may decline and salinities may increase. Conversely, above-average rainfall can result in increases in recharge, decreases in extractions and groundwater levels may rise and salinities may stabilise or decrease. Historical rainfall data indicate that trends of above or below-average rainfall can last for up to 25 years and that high-intensity rainfall events can result in rapid groundwater level responses (i.e. recharge).

4.1 Musgrave PWA

In the Musgrave PWA, the Quaternary Limestone aquifer generally comprises a thin veneer of aeolianite sediments of the Bridgewater Formation. These sediments are underlain by thin Tertiary clays and sands of the Uley Formation and Poelpena Formation, which respectively form a thin aquitard and the underlying Tertiary Sands aquifer. Generally, the Tertiary Sands aquifer is of higher salinity than the Quaternary Limestone aquifer and also presents well development and yield problems due to fine-grained flowing sediments and is not widely used. The thin Tertiary clay aquitard which separates the two aquifers is ubiquitous across the PWA.

The largest Quaternary Limestone fresh groundwater resources in the Musgrave PWA are the Bramfield and Polda lenses, which both have a history of use for town water supply, irrigation and stock and domestic use, with a number of other minor lenses throughout the PWA. However, the primary use across the PWA is for stock and domestic purposes (around 467 ML/y) (Stewart et al., 2012), the vast majority of which is brackish groundwater sourced from the Quaternary Limestone aquifer. The Quaternary Limestone aquifer is also an important water source for groundwater-dependent ecosystems. The main source of recharge to the Quaternary Limestone aquifer is the direct infiltration of incident rainfall, and the direction of groundwater flow is predominantly is from the east toward the west and south-west.

4.2 Southern Basins PWA

In the Southern Basins PWA, the Quaternary Limestone aquifer generally comprises aeolianite sediments of the Bridgewater Formation, which is equivalent to the unconfined aquifer in the Musgrave PWA. These sediments are underlain by a layer of Tertiary clays, sands and gravels of the Uley and Wanilla Formations. The Uley Formation acts as a confining layer and aquitard between the Quaternary Limestone and Tertiary Sands aquifers, but it is not present in all locations.

The largest potable groundwater resources in the Southern Basins PWA are freshwater lenses located within the Uley South PWS, Coffin Bay, Uley Wanilla PWS and Lincoln South PWS consumptive pools.

The main source of recharge to the Quaternary Limestone aquifer is the direct infiltration of incident rainfall. Groundwater flows are radial, in directions predominantly toward the coast.

4.3 Musgrave PWA

4.3.1 Bramfield consumptive pool – water level

In the Bramfield consumptive pool, all winter-recovered water levels in 2020 are classified either "Very much below average' (three out of seven wells) or 'Lowest on record' (four wells) (Section 2.2.1), compared to their respective historical record (Figure 4.1).

Water levels have declined in all seven wells in the long term, over the periods of 10, 20 and 30 years (median declines of 0.77, 1.08, and 2.13 m, respectively).

More recently, five-year trends show declining water levels for 92% of wells, with rates ranging from a decline of 0.67 m/y to a rise of 0.04 m/y (median rate is a decline of 0.19 m/y; Figure 4.2).

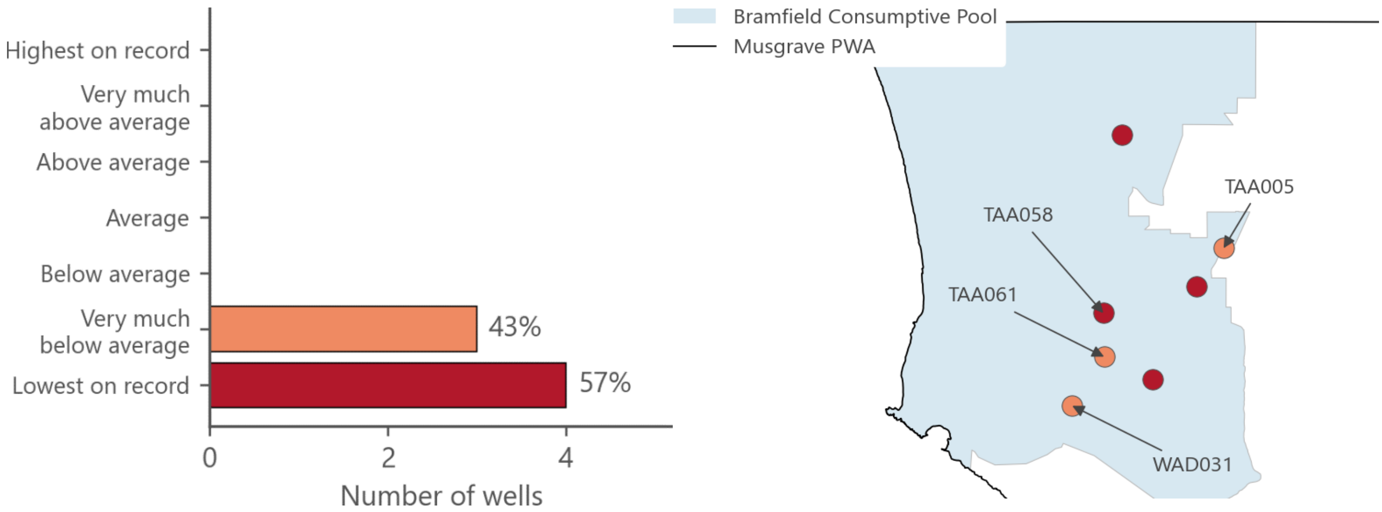


Figure 4.1. 2020 winter-recovered water levels for wells in the Quaternary Limestone aquifer in the Bramfield consumptive pool

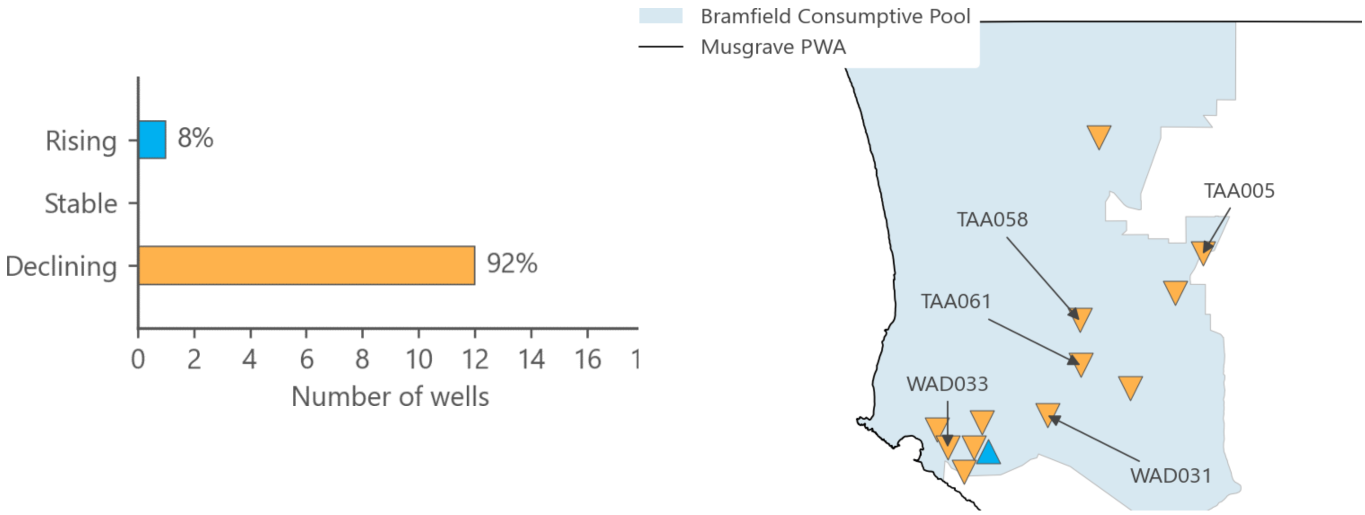


Figure 4.2. 2016–20 trend in winter-recovered water levels for wells in the Quaternary Limestone aquifer in the Bramfield consumptive pool

Long-term water level declines have occurred since 1990 in all representative wells in the Quaternary Limestone aquifer in the Bramfield consumptive pool (Figure 4.3). Most wells show their lowest level on record in 2008, during the Millennium Drought (circa 2001–09), following two consecutive years of very low rainfall. The only exception is TAA005, which is located on the western edge of the Bramfield lens (Figure 4.2), and is classified 'Lowest on record' in 1966.

Water levels in all wells showed some recovery following generally above-average rainfall between 2009–13 and 2016–17. However, it can be seen that the extent of water level recovery was greater for those wells nearer the coast e.g. WAD031 and TAA061. More recently, below-average rainfall since 2018 has led to another decline in water levels, and some wells (e.g. TAA058 and TAA005) are approaching water level minima that were measured during the Millennium Drought.

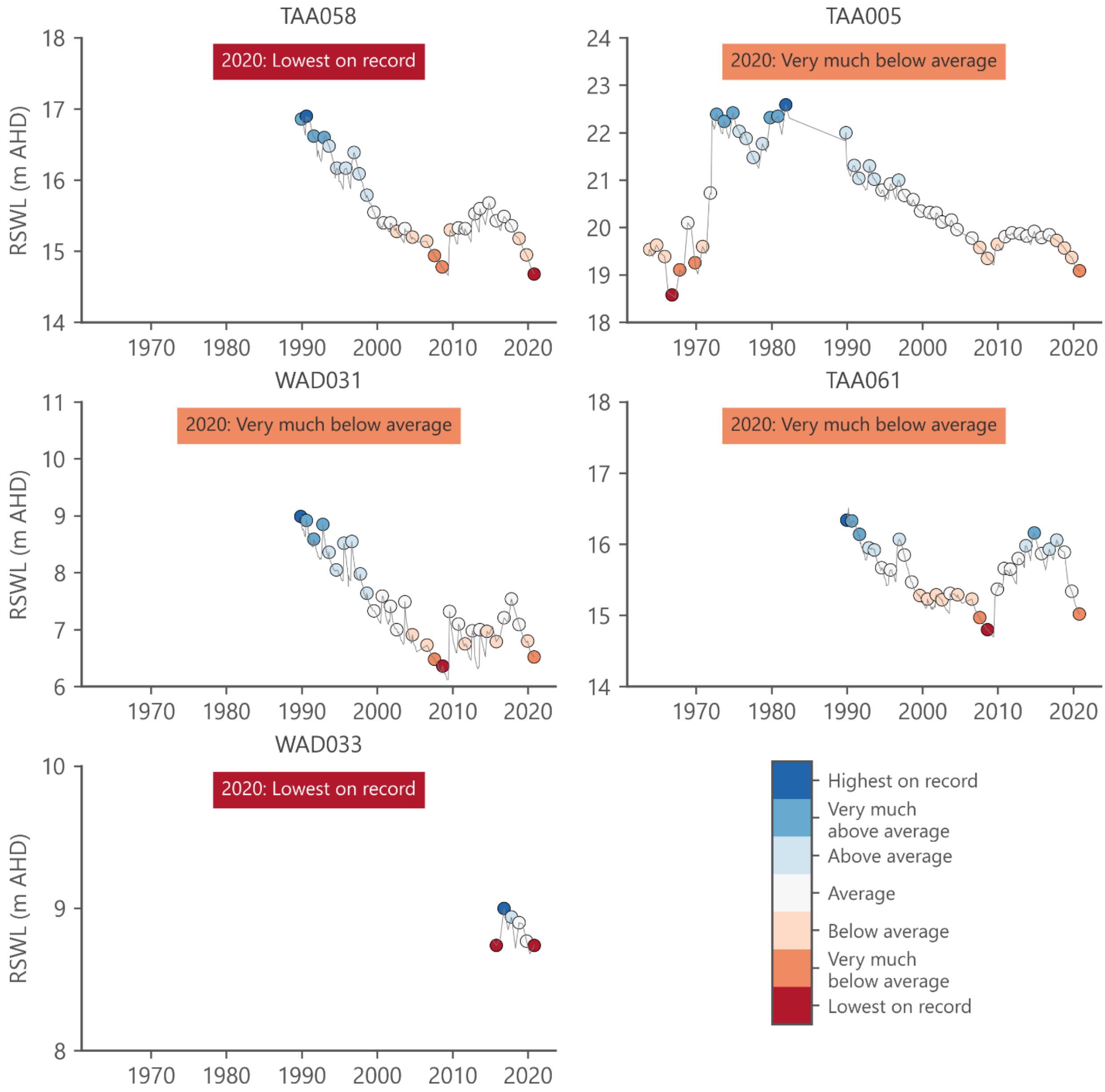


Figure 4.3. Selected hydrographs for wells in the Quaternary Limestone aquifer in the Bramfield consumptive pool

4.3.2 Bramfield consumptive pool – salinity

In 2020, groundwater salinity in the Quaternary Limestone aquifer ranges from 458 mg/L to 1009 mg/L (Figure 4.4). Almost all wells (83%) show salinity less than 1000 mg/L (median of 545 mg/L).

In the ten years to 2020, two of four wells show an increase in salinity. Both of these wells are used for Elliston town water supply and show a trend of 0.39% and 0.58% increase per year over the past 10 years (Figure 4.5).

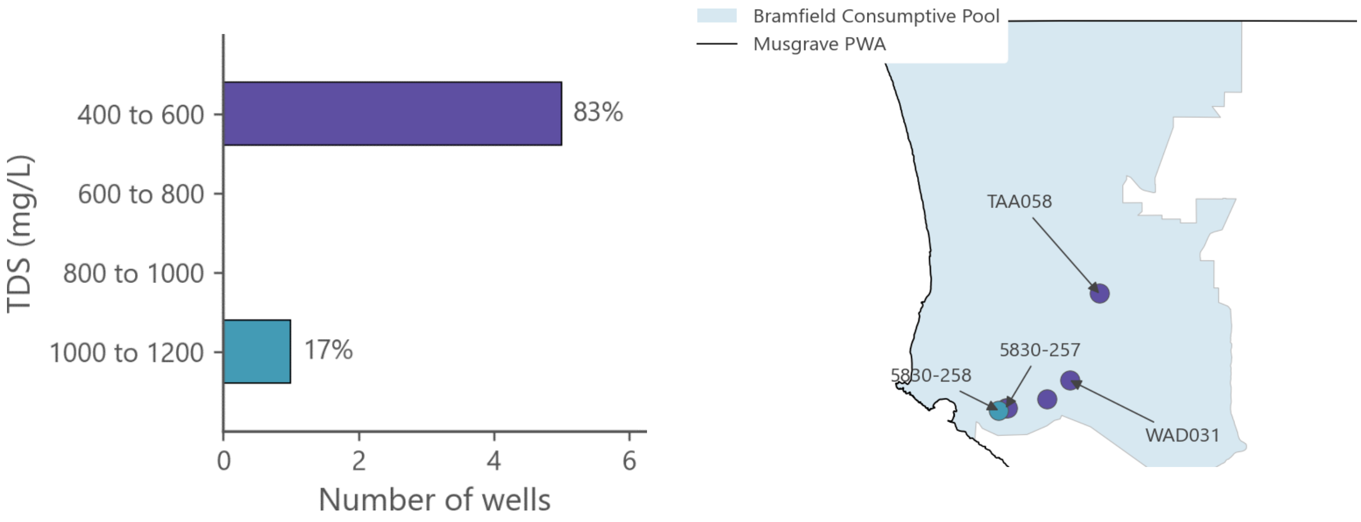


Figure 4.4. 2020 salinity observations from wells in the Quaternary Limestone aquifer in the Bramfield consumptive pool

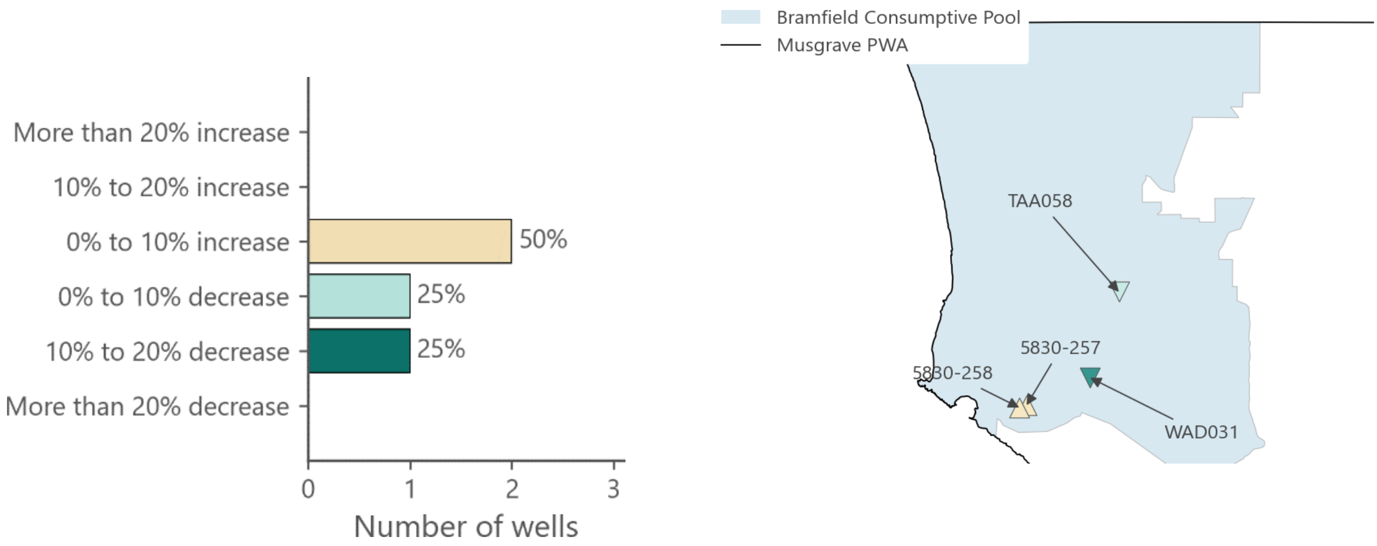


Figure 4.5. Salinity trend in the 10 years to 2020 for wells in the Quaternary Limestone aquifer in the Bramfield consumptive pool

Salinity data for representative wells completed in the Quaternary Limestone aquifer in the Bramfield area (Figure 4.6) show gradual increases in salinity since 2010 (e.g. 5830-257 and 5830-258).

Observation well WAD031 is located in the township of Bramfield while TAA058 is located to the north-east of Bramfield (Figure 4.2). Both WAD031 and TAA058 show relatively stable groundwater salinity despite declines in water level since 2017 and 2014, respectively (Figure 4.3).

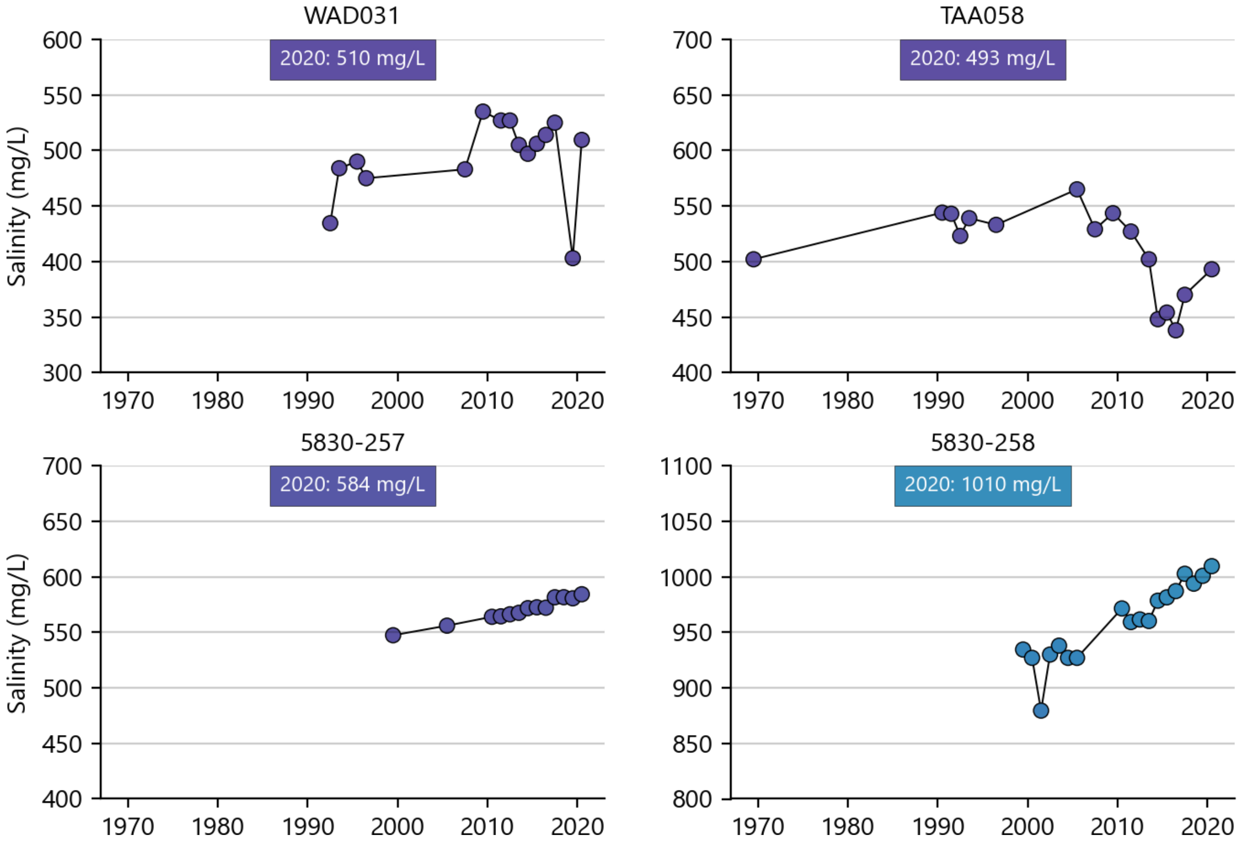


Figure 4.6. Selected salinity graphs for wells in the Quaternary Limestone aquifer in the Bramfield consumptive pool

4.3.3 Polda consumptive pool – water level

In 2020, winter-recovered water levels for half of Quaternary Limestone aquifer wells (52%) in the Polda consumptive pool are classified 'Very much below average' (Section 2.2.1) when compared to their historical levels (Figure 4.7). Around one quarter of wells (27%), which are located mainly to the north-east, are classified 'Lowest on record'.

All wells over the past 20 years has shown a decline in water level (Figure 4.8), with declines ranging between 1.34–0.41 m (median decline of 0.61 m).

More recently, five-year trends show water levels are declining in all 33 wells, at rates ranging between 0.11–0.35 m/y (Figure 4.8). Wells showing rates of decline greater than 0.20 m/y are located mainly towards the northern extent of, and centrally to the Polda monitoring network.

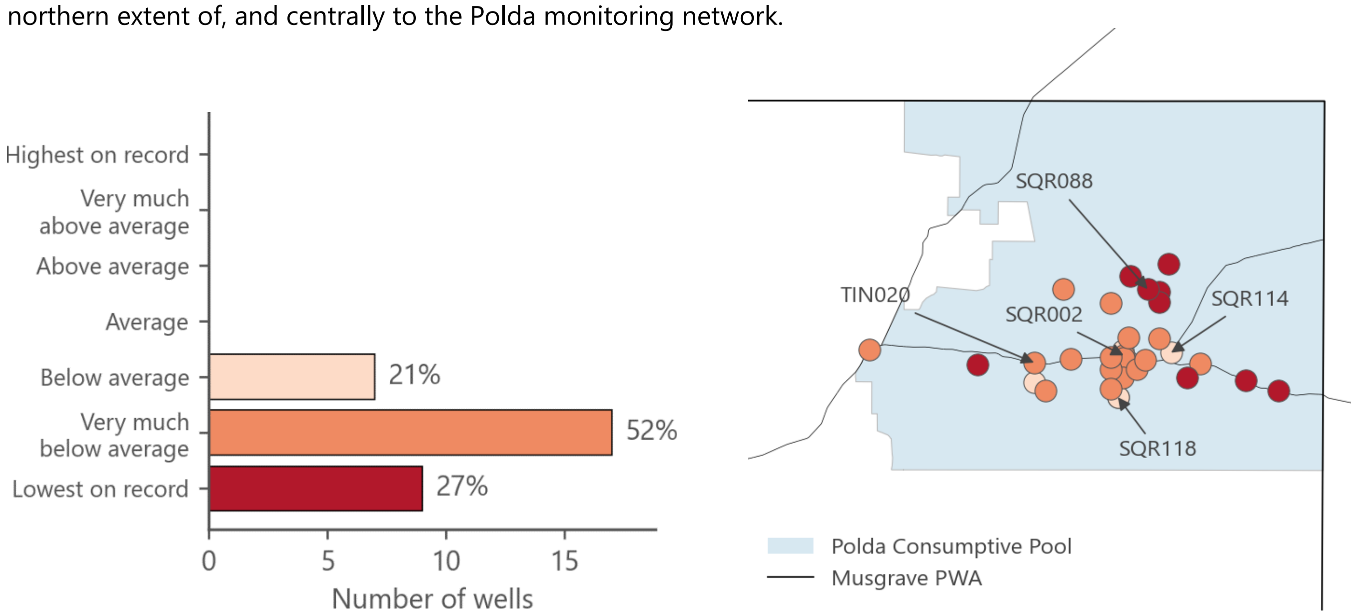


Figure 4.7. 2020 winter-recovered water levels for wells in the Quaternary Limestone aquifer in the Polda consumptive pool

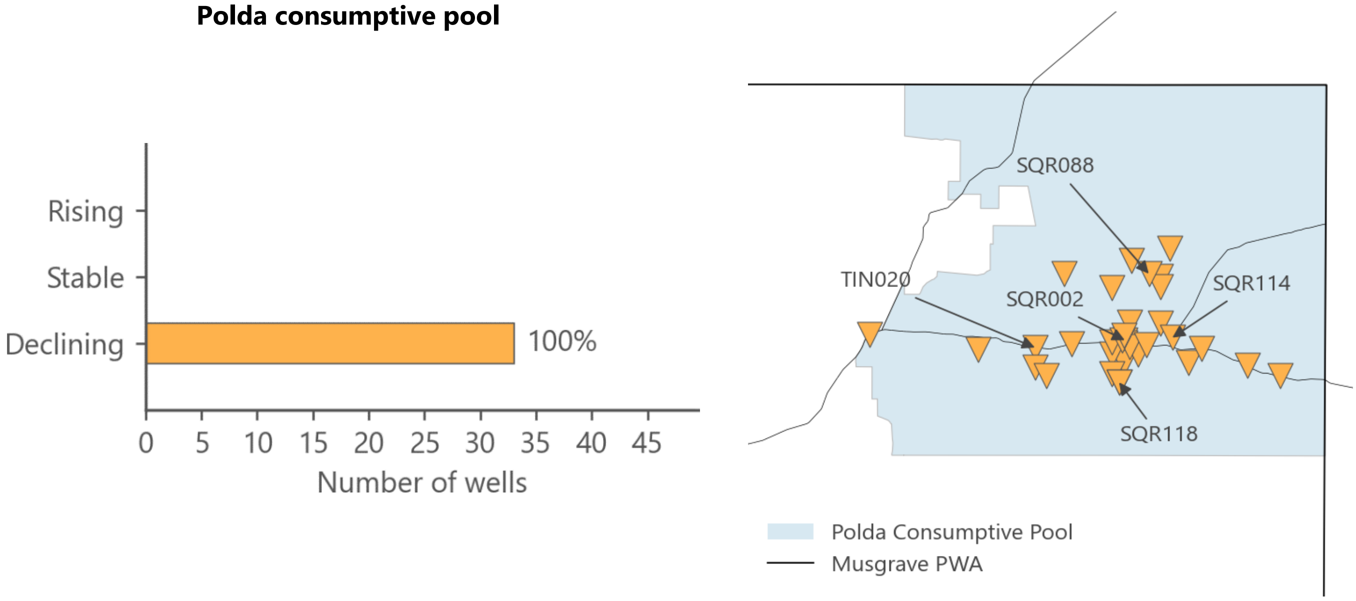


Figure 4.8. 2016–20 trend in winter-recovered water levels for wells in the Quaternary Limestone aquifer in the Polda consumptive pool

Almost all Quaternary Limestone aquifer wells in the Polda consumptive pool reached their lowest level on record towards the end of the Millennium Drought in 2009 (e.g. see representative wells below; Figure 4.9). Widespread recovery in water levels between 2010–17 correspond with above-average rainfall in five of seven years (2010–16) at Terrah Winds (BoM Station 18165; Figure 3.4).

Water levels have declined for all wells throughout 2018 to 2020 despite good winter rainfall in 2018. SQR088 is located toward the northern extent of the monitoring network and shows its lowest level on record since monitoring began in 1963.

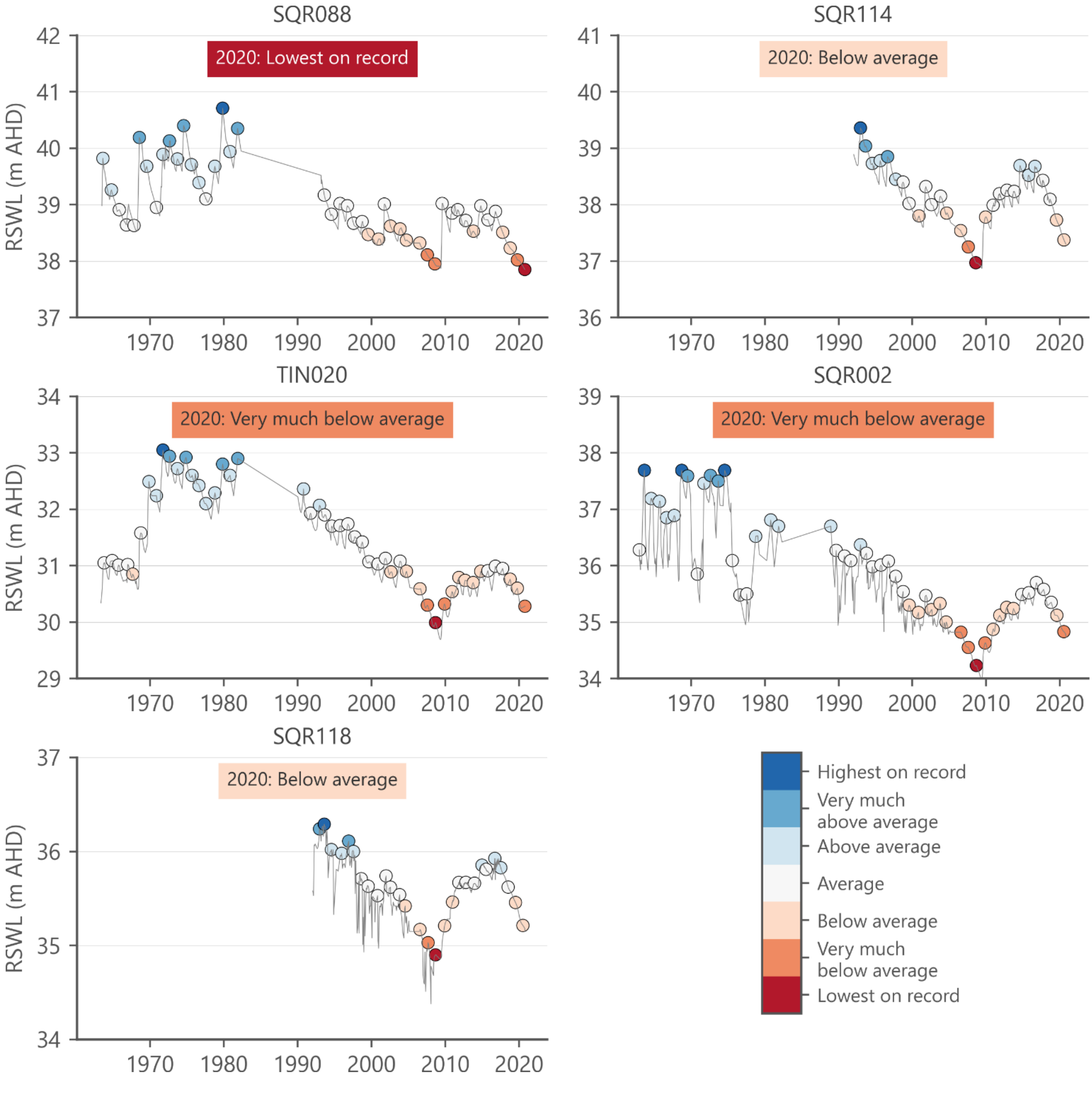


Figure 4.9. Selected hydrographs for wells in the Quaternary Limestone aquifer in the Polda consumptive pool

4.3.4 Polda consumptive pool – salinity

In 2020, groundwater salinity ranged between 498–3392 mg/L (Figure 4.10) (median of 887 mg/L).

In the ten years to 2020, greater than half of wells show an increase in groundwater salinity (Section 2.2.2). Trends in salinity vary from a decrease of 5.70% per year to an increase of 2.15% per year, with a median rate of 0.30% increase per year (Figure 4.11).

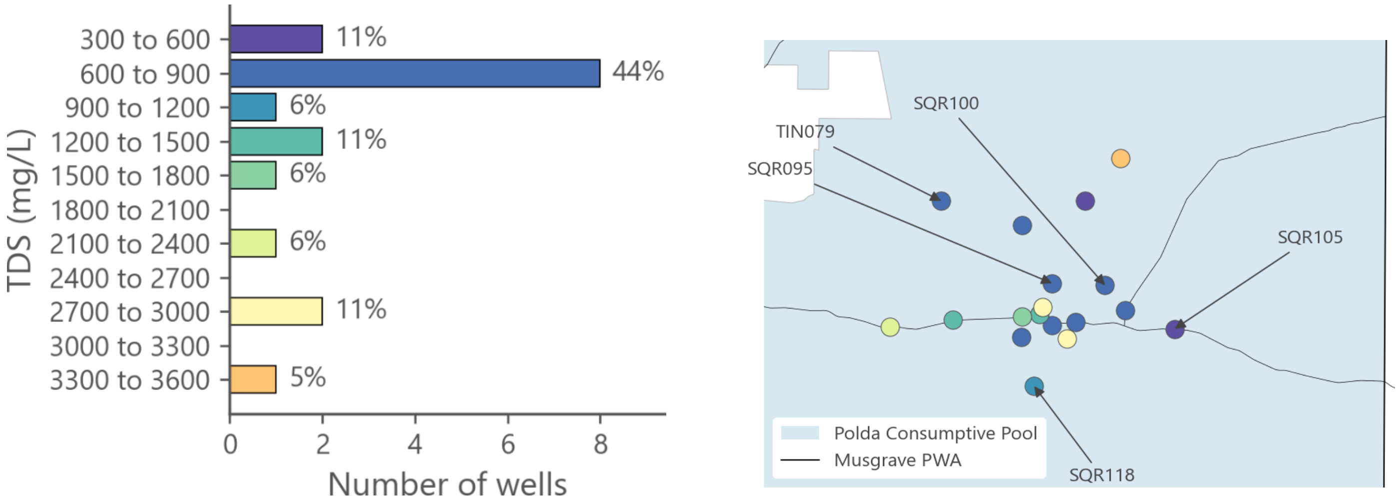


Figure 4.10. 2020 salinity observations from wells in the Quaternary Limestone aquifer in the Polda consumptive pool

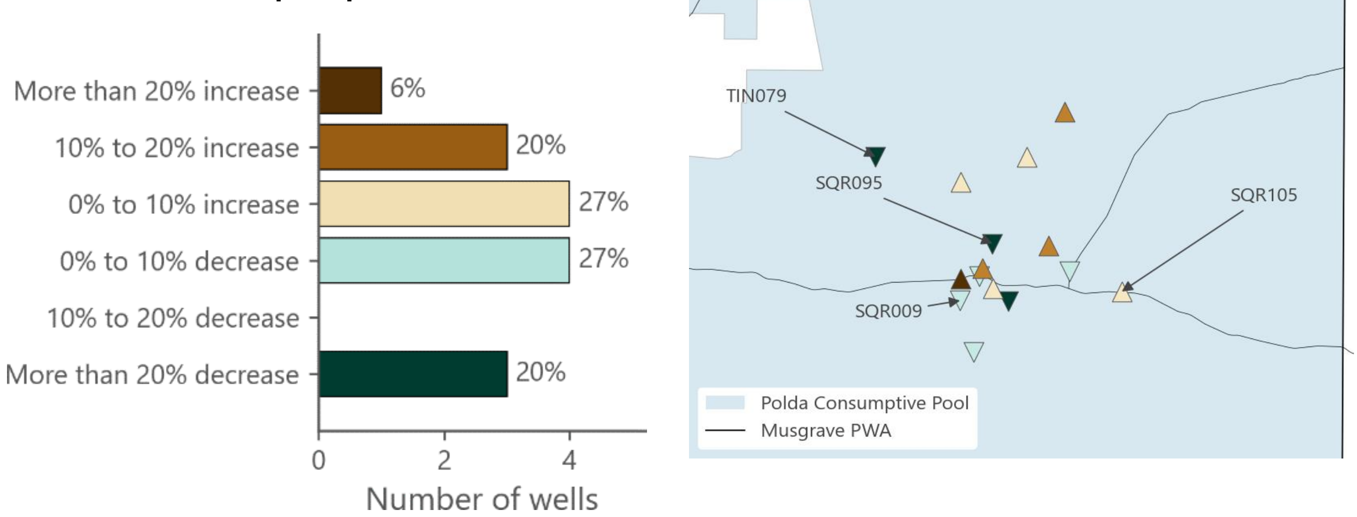


Figure 4.11. Salinity trend in the 10 years to 2020 for wells in the Quaternary Limestone aquifer in the Polda consumptive pool

Salinity measured from Quaternary Limestone aquifer monitoring wells in the Polda consumptive pool are generally low. Observation wells SQR009 and SQR105 show stable salinity over the past 10 years. TIN079 and SQR095 show aquifer freshening following above-average rainfall during 2010–16, following the Millennium Drought that concluded in 2009.

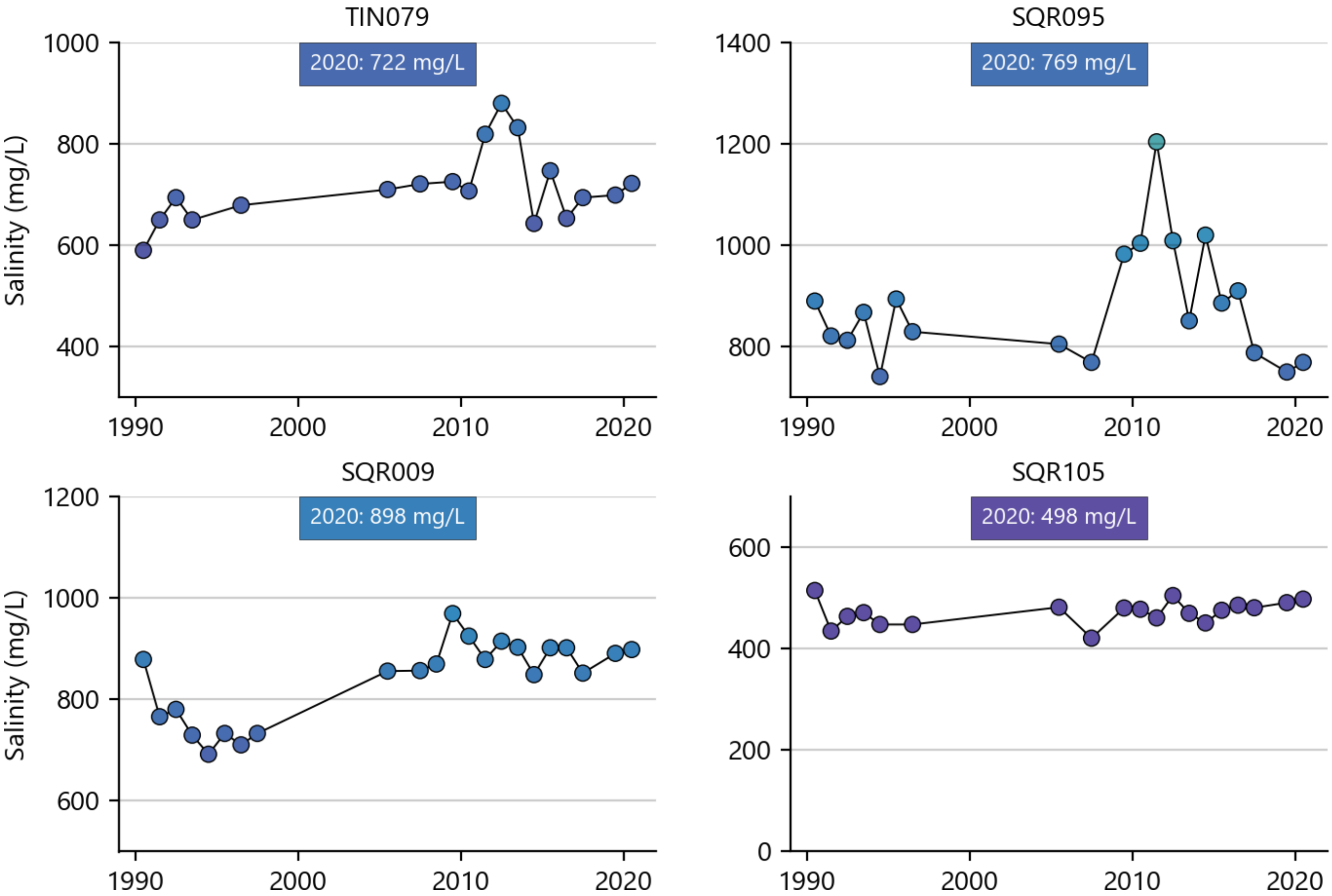


Figure 4.12. Selected salinity graphs for wells in the Quaternary Limestone aquifer in the Polda consumptive pool

4.4 Southern Basins PWA

4.4.1 Coffin Bay consumptive pool – water level

In 2020, six out of seven Quaternary Limestone aquifer monitoring wells are classified 'Below average' (Section 2.2.1) when compared to their respective historical record (Figure 4.13). Water levels in two wells are classified 'Below average' while one well is classified 'Very much below average'.

Over the past thirty years, water levels have declined in all wells by 0.10–0.24 m (median of 0.15 m).

Five-year trends also show declining water levels for all wells (Figure 4.14). Rates of decline range between 0.01–0.03 m/y, with a median of 0.02 m decline per year.

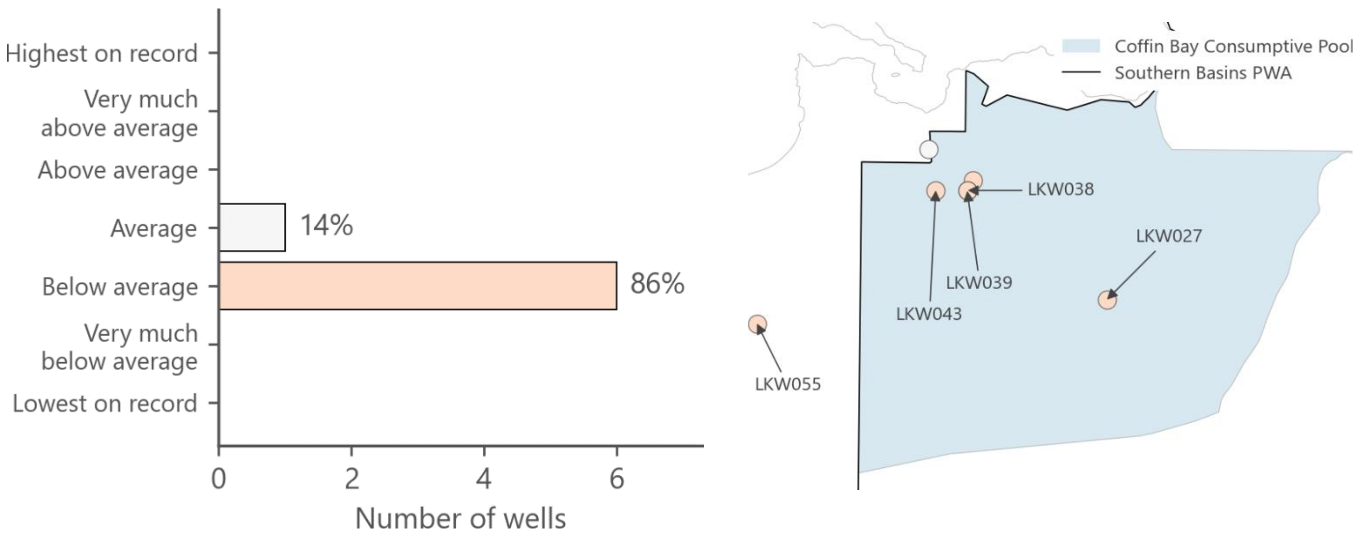


Figure 4.13. 2020 winter-recovered water levels for wells in the Quaternary Limestone aquifer for the Coffin Bay consumptive pool

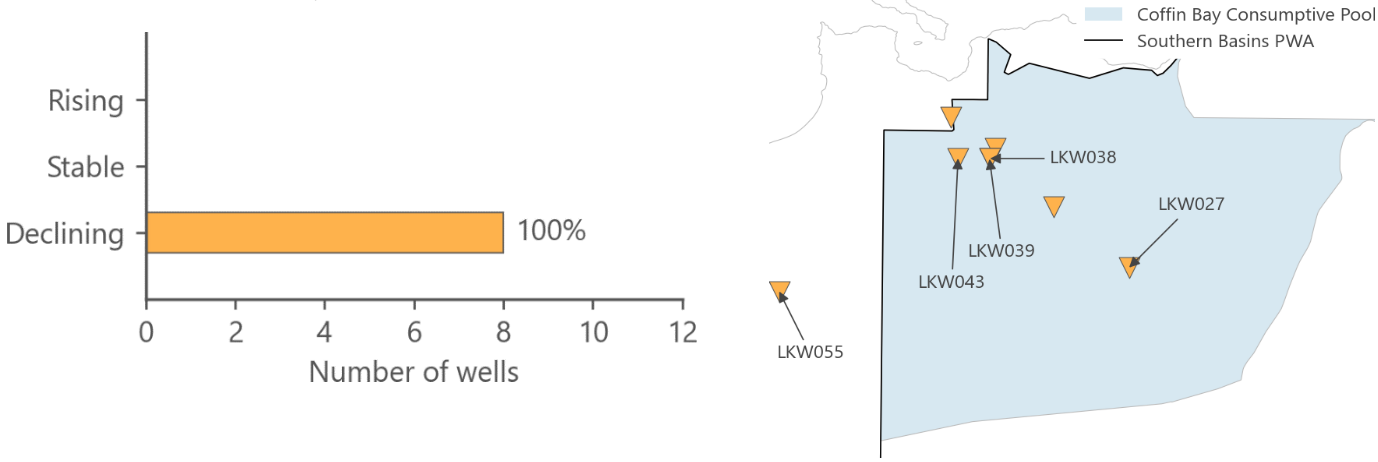


Figure 4.14. 2016–20 trend in winter-recovered water levels for wells in the Quaternary Limestone aquifer for the Coffin Bay consumptive pool

Representative Quaternary Limestone aquifer monitoring wells for the Coffin Bay consumptive pool (Figure 4.15) include LKW038 and LKW039, which are located within the wellfield that supplies public water supply to the township of Coffin Bay. Water levels in both wells are stable over the past thirty years. Water levels that are classified 'Lowest on record' for both wells in 2007 coincide with below-average rainfall recorded in 2006–07.

LKW043 and LKW055 are located in the western part of the Coffin Bay area (Figure 4.14) and also show generally stable water levels. LKW027 is located at a higher elevation to the south-east., where the direction of groundwater flow is generally to the north-west. Water levels were typically classified 'Above average' or greater prior to 1992, but have subsequently declined to 'Average' or 'Below average'.

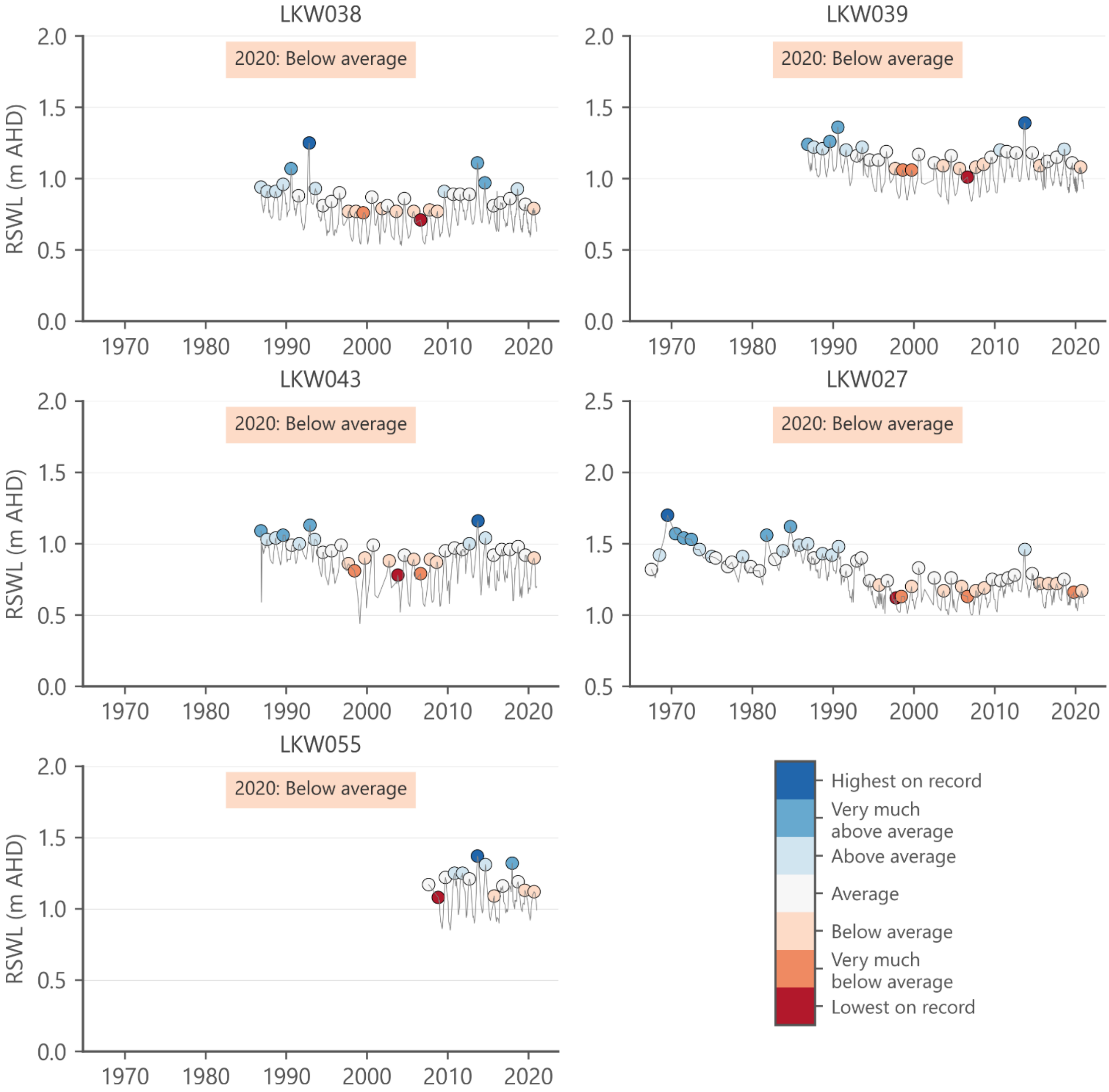


Figure 4.15. Selected hydrographs for wells in the Quaternary Limestone aquifer in the Coffin Bay consumptive pool

4.4.2 Coffin Bay consumptive pool – salinity

In 2020, groundwater salinity in the Coffin Bay consumptive pool ranges from 348 mg/L to 1076 mg/L, with a median of 422 mg/L. Eight out of nine wells (89%) show salinity below 1000 mg/L (Figure 4.16). The majority of salinity monitoring wells are located within the Coffin Bay public water supply wellfield.

In the ten years to 2020, the majority of wells show an increase in groundwater salinity. Trends in groundwater salinity vary from a decrease of 0.24% per year to an increase of 0.50% per year, with a median rate of 0.36% increase per year (Figure 4.17).

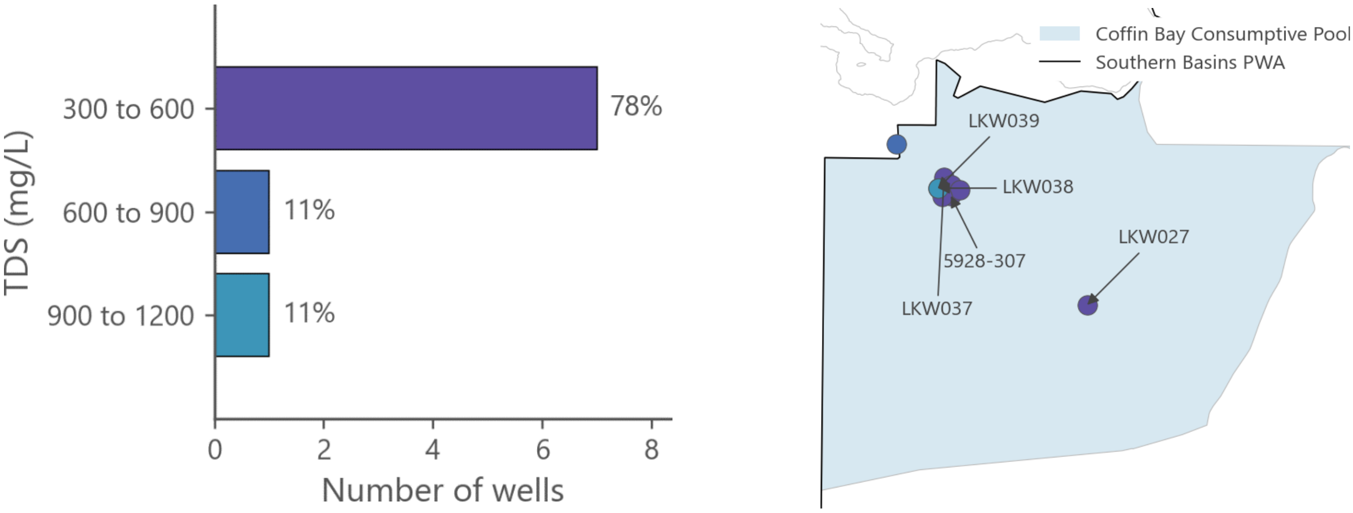


Figure 4.16. 2020 salinity observations from wells in the Quaternary Limestone aquifer in the Coffin Bay consumptive pool

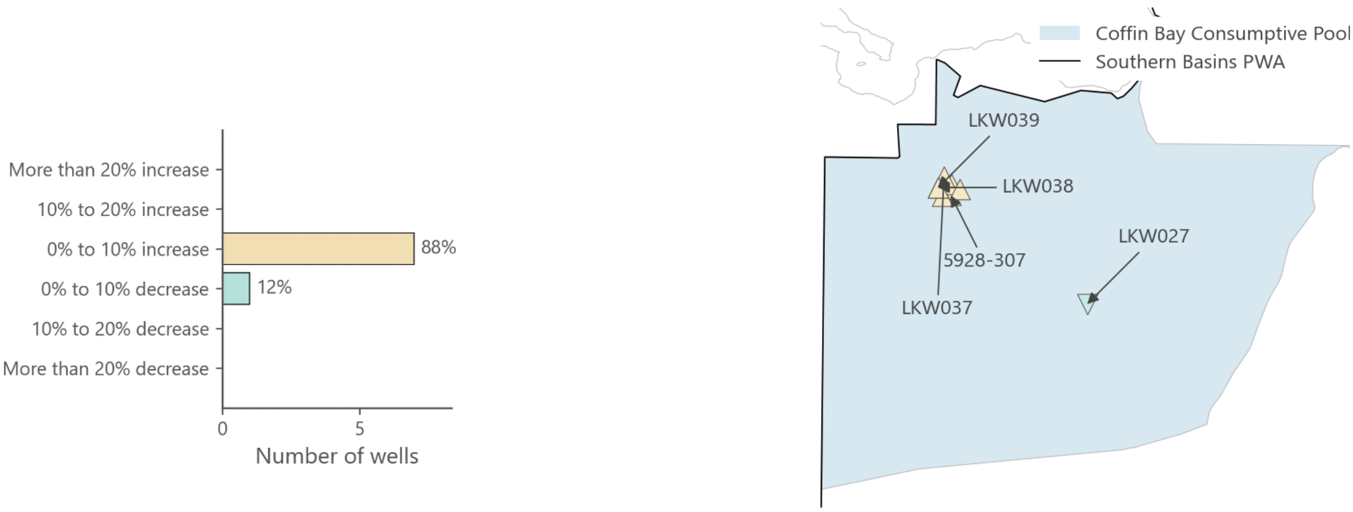


Figure 4.17. Salinity trend in the 10 years to 2020 for wells in the Quaternary Limestone aquifer in the Coffin Bay consumptive pool

Representative Quaternary Limestone aquifer monitoring wells in the Coffin Bay area (Figure 4.18) show generally stable groundwater salinity over the past 30 years.

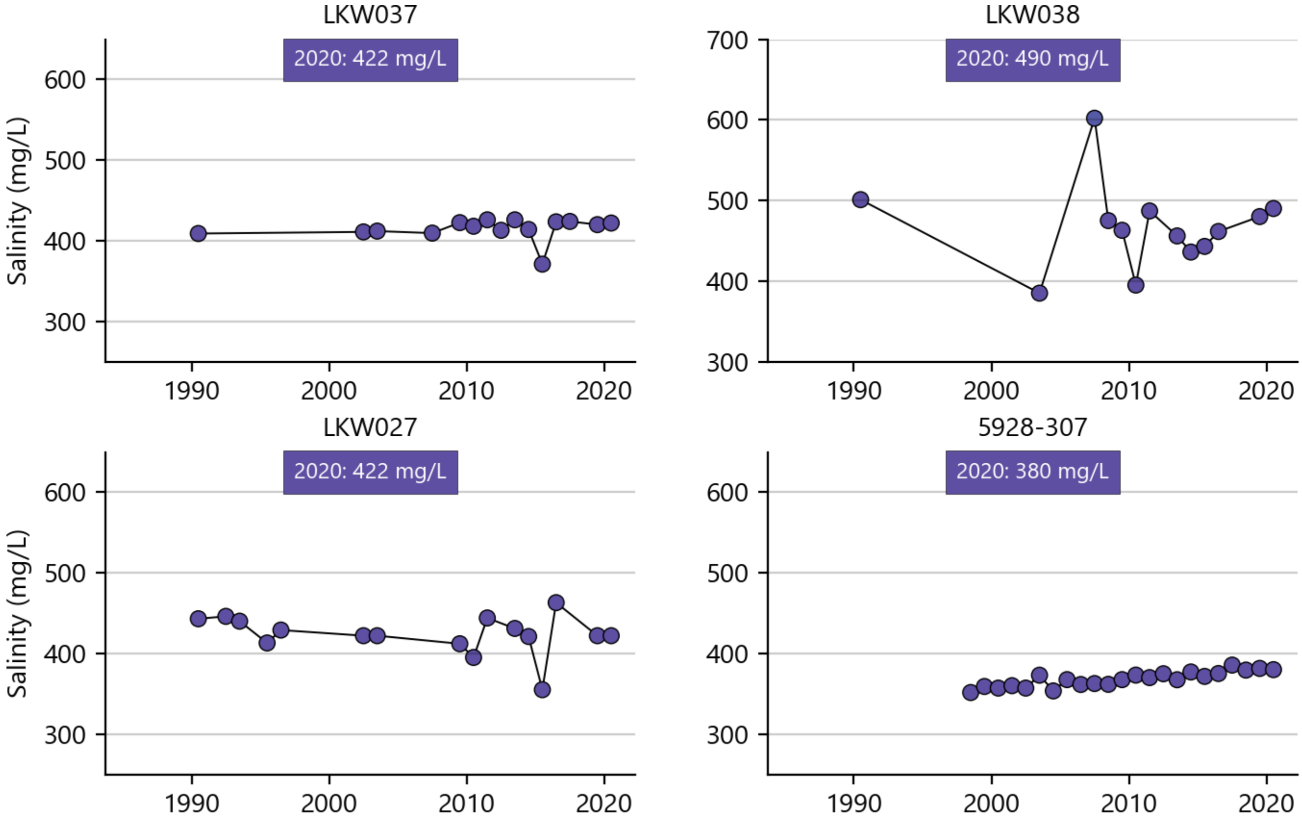


Figure 4.18. Selected salinity graphs for wells in the Quaternary Limestone aquifer in the Coffin Bay consumptive pool

4.4.3 Uley South PWS consumptive pool – water level

In 2020, winter-recovered water levels in 16 of 39 monitoring wells (41%) are classified 'Below average' (Figure 4.19), compared to their respective historical record (Section 2.2.1). Water levels in seven wells are classified 'Very much below average' and six wells are classified 'Lowest on record'.

Over the past 30 years, water levels have declined in all wells. Declines range from 0.05 m to 1.88 m, with a median of 1.27 m. Over the past 20 years, 18% of wells have shown a rise in water level; changes in levels range from a decline of 0.84 m to a rise of 0.72 m (median is a decline of 0.23 m).

Five-year trends in show declining water levels in all wells (Figure 4.20). Rates of decline range between 0.02-0.19 m/y (median of 0.07 m/y).

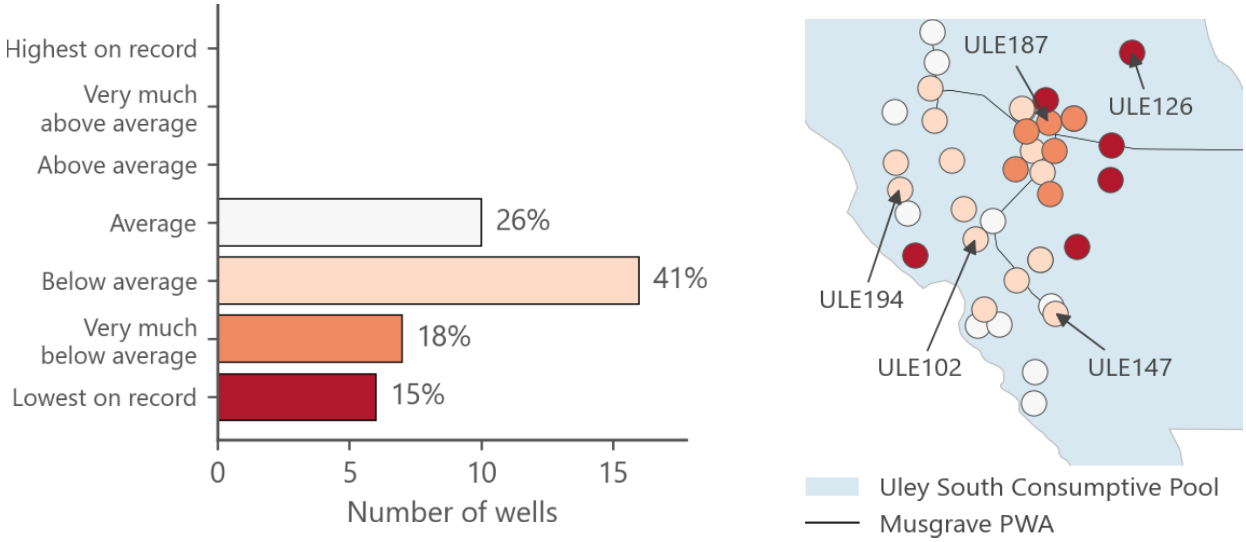


Figure 4.19. 2020 winter-recovered water levels for wells in the Quaternary Limestone aquifer in the Uley South PWS consumptive pool

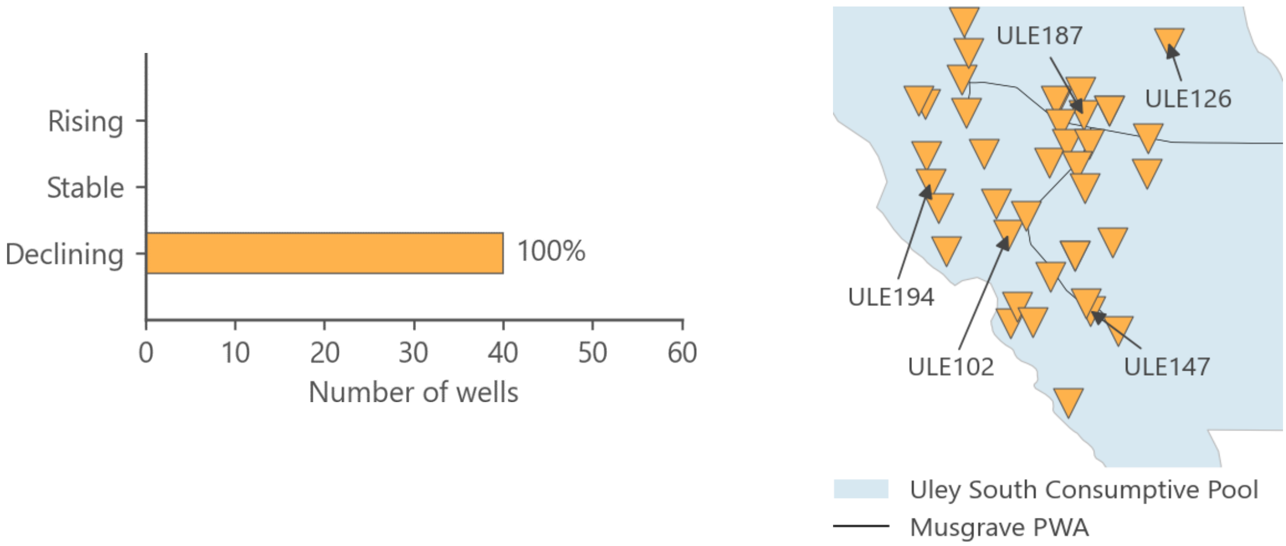


Figure 4.20. 2016–20 trend in winter-recovered water levels for wells in the Quaternary Limestone aquifer in the Uley South PWS consumptive pool

Representative monitoring wells illustrate common or important trends in the Uley South PWS consumptive pool (Figure 4.21). Groundwater extraction from the Uley South lens began in 1977 (Figure 5.6). During the period 1969–76, before extraction from Uley South lens commenced, rainfall was above average yet water levels declined by around 2 m (EP NRM Board, 2016). Recovery in water levels was observed during 1977–86, despite the commencement of extraction at rates in excess of 5 GL/y (e.g. ULE102, ULE147). Between 1986–2000, water levels declined; however, annual rainfall totals and rates of extraction were both variable over this period.

During the Millennium drought (2001–09), water levels in most wells stabilised. This period corresponds with an expansion of the PWS borefield that enabled extraction to be spread across the lens, and a reduction in the rate of pumping from a peak of around 7 GL/y (circa 1999–2005) down to around 5 GL/y (circa 2010–present), which was result of demand management. Over the period 2010–15, water levels generally increased while rates of extraction were stable at around 5 GL/y and rainfall was generally above average.

Water levels have been declining since 2015 in almost all wells, which corresponds with a period of generally below-average rainfall while extraction remains stable at around 5 GL/y.

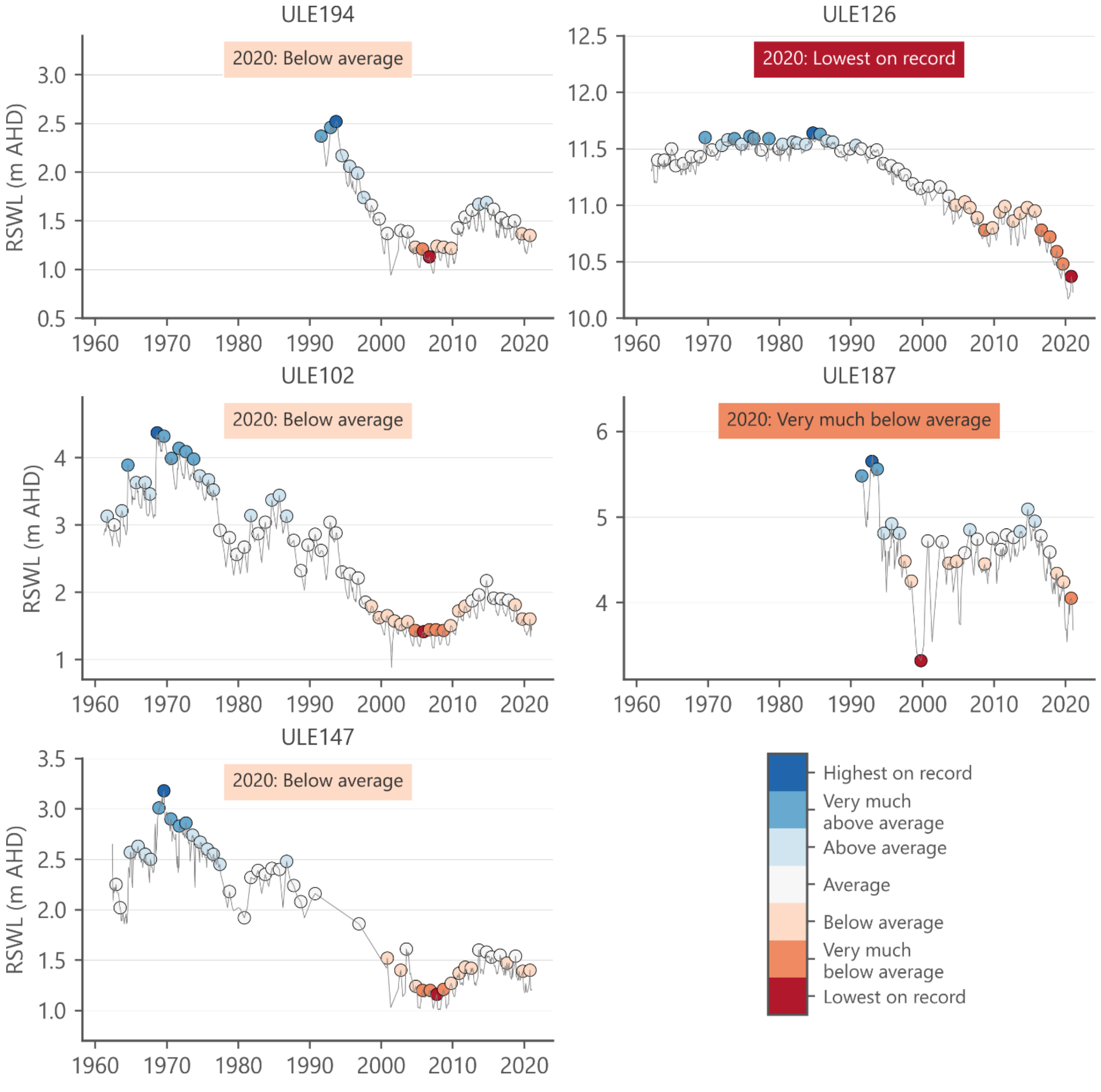


Figure 4.21. Selected hydrographs for wells in the Quaternary Limestone aquifer in the Uley South PWS consumptive pool

4.4.4 Uley South PWS consumptive pool – salinity

In 2020, groundwater salinity in 23 wells ranges between 444–702 mg/L, with a median of 520 mg/L. Salinity samples are obtained from a combination of PWS production bores (15 wells) and DEW monitoring wells (8 wells).

In the ten years to 2020, the majority of wells (67%) show an increase in groundwater salinity (Section 2.2.2). Trends in salinity vary from a decrease of 2.24% per year to an increase of 0.96% per year, with a median rate of 0.21% increase per year (Figure 4.23).

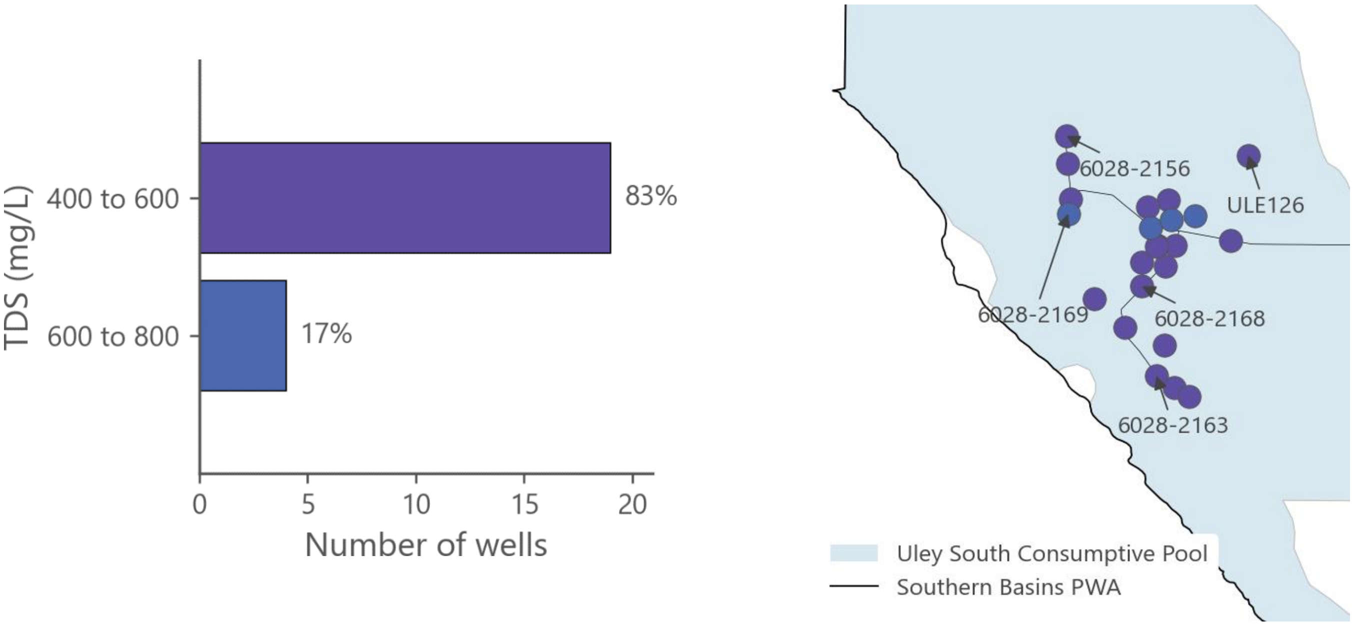


Figure 4.22. 2020 salinity observations from wells in the Quaternary Limestone aquifer in the Uley South PWS consumptive pool

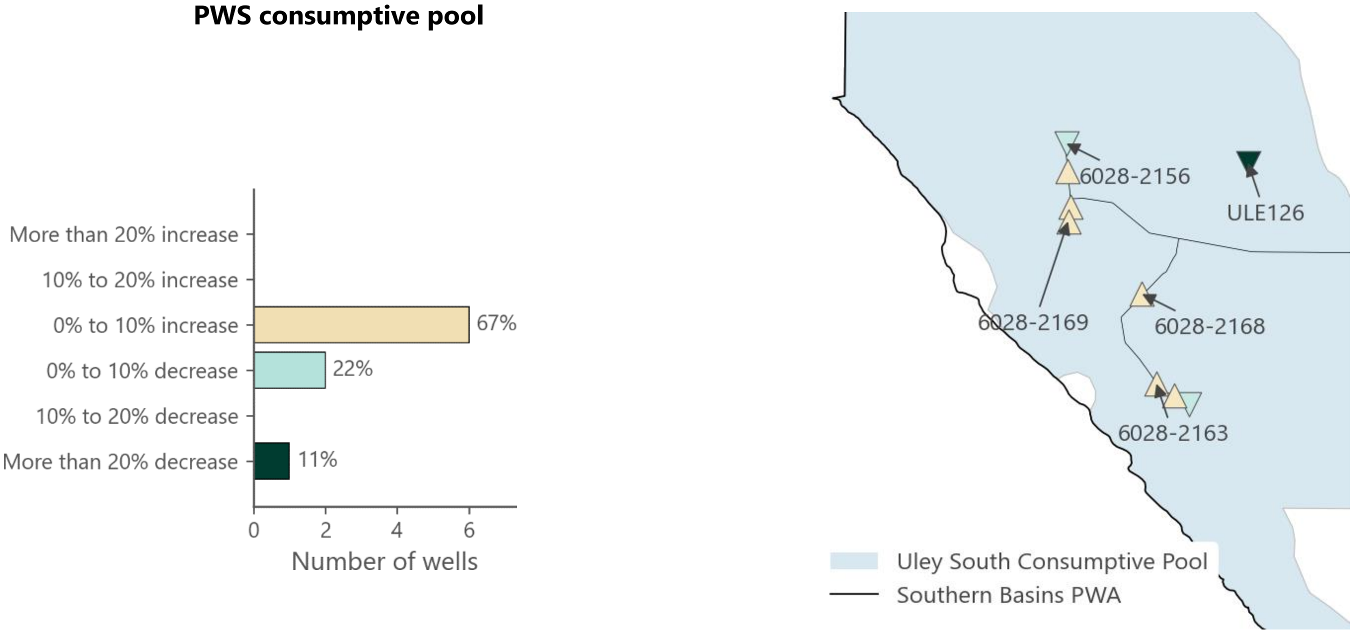


Figure 4.23. Salinity trend in the 10 years to 2020 for wells in the Quaternary Limestone aquifer in the Uley South PWS consumptive pool

Representative monitoring wells illustrate common or important trends in the Uley South PWS consumptive pool (Figure 4.24). In all wells, salinity is low and generally stable over the long term. Some variation in salinity has been measured at the observation well ULE126. The remaining wells are PWS production bores and are generally the most reliable measure of aquifer salinity due to the volume of groundwater each bore extracts. Production bore 6028-2169 shows gradually increasing salinity over the past 20 years at a rate of around 5 mg/L per year, although salinity is still very low at 622 mg/L.

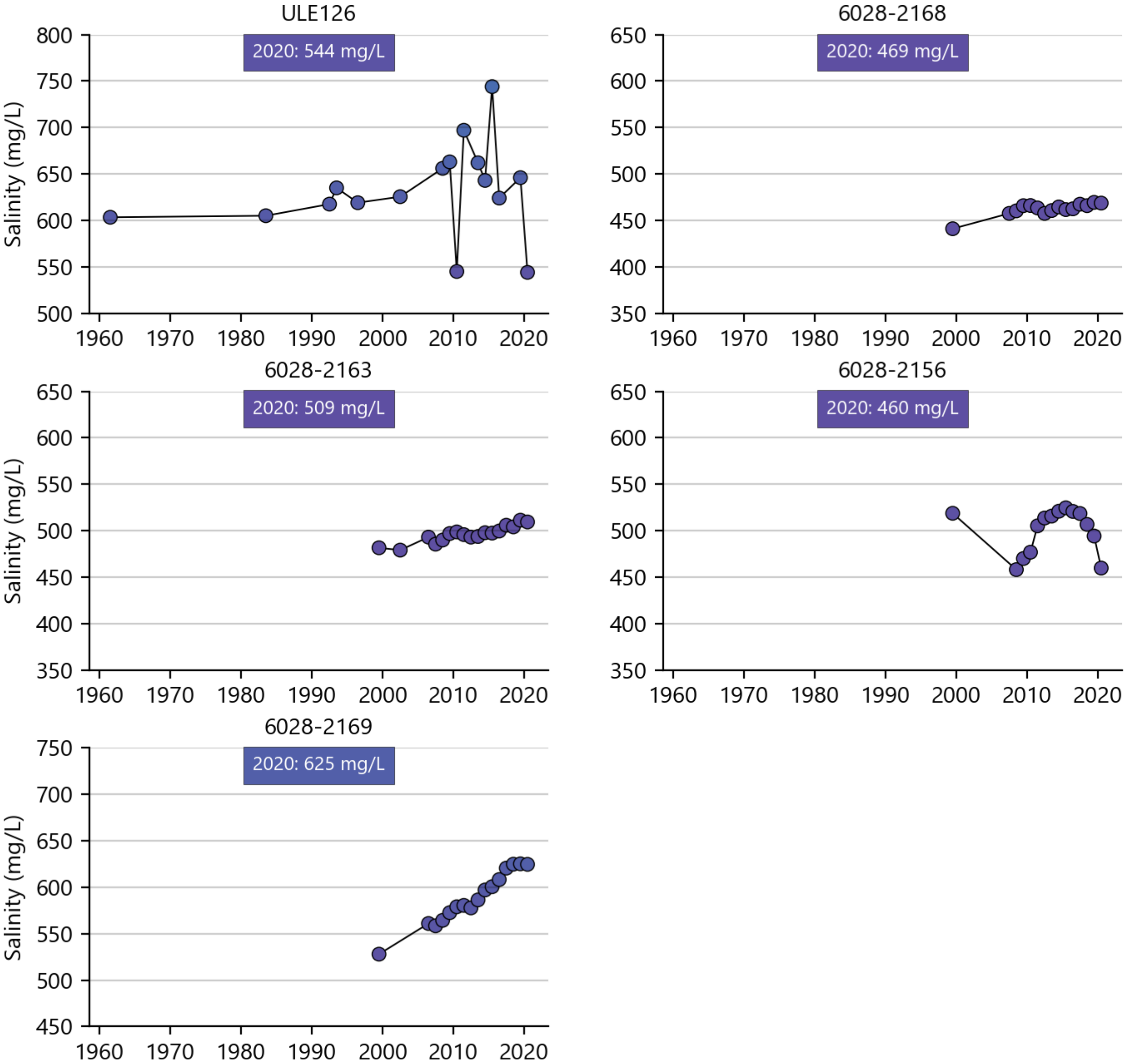


Figure 4.24. Selected salinity graphs for wells in the Quaternary Limestone aquifer in the Uley South PWS consumptive pool

4.4.5 Uley Wanilla PWS consumptive pool – water level

For the Uley Wanilla PWS consumptive pool in 2020, water levels in the majority of Quaternary Limestone aquifer monitoring wells (74%) are classified 'Lowest on record', compared to their respective historical record (Section 2.2.1; Figure 4.25), while water levels in four wells (26%) are classified 'Below average' or 'Very much below average'.

Over the past 30 years, water levels have declined in all wells, with declines ranging between 0.95–4.63 m, with a median decline of 2.49 m.

Five-year trends show water level are declining in all wells with rates of decline ranging from 0.04 m/y to 0.40 m/y (the median rate of decline is 0.16 m/y) (Figure 4.26).

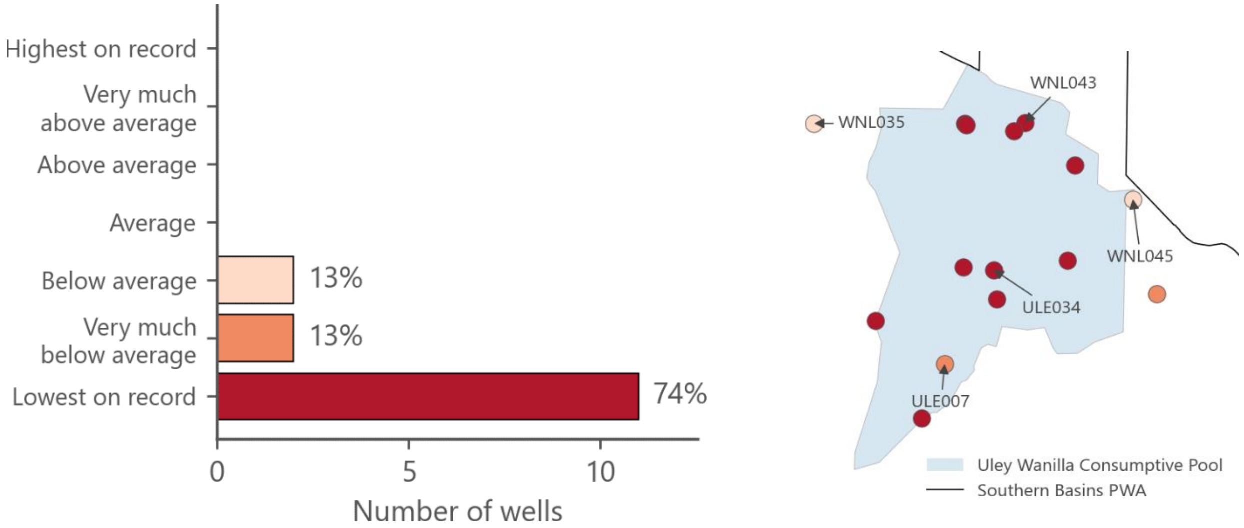


Figure 4.25. 2020 winter-recovered water levels for wells in the Quaternary Limestone aquifer in the Uley Wanilla PWS consumptive pool

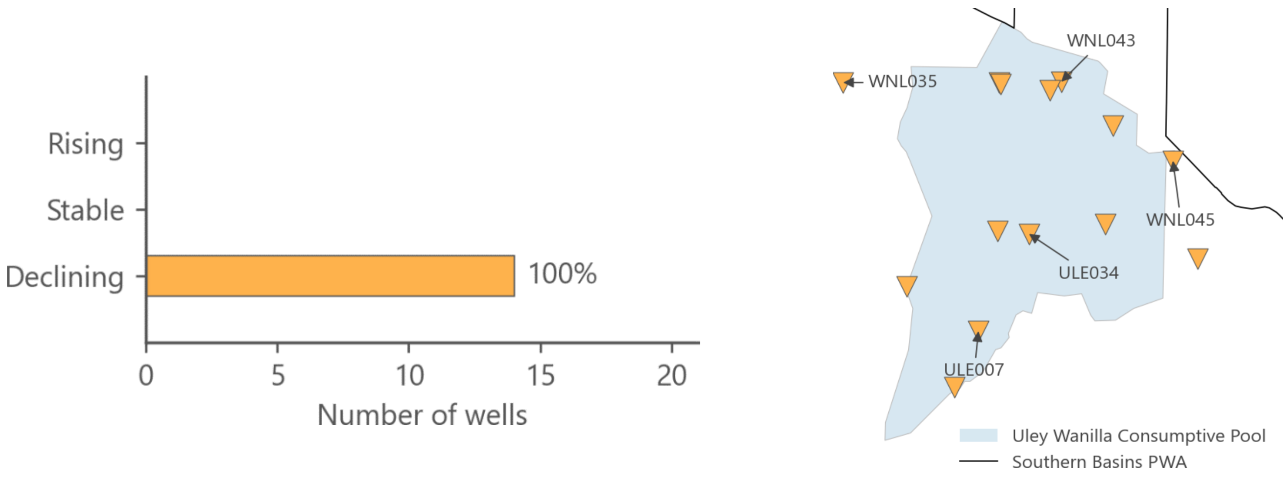


Figure 4.26. 2016–20 trend in winter-recovered water levels for wells in the Quaternary Limestone aquifer in the Uley Wanilla PWS consumptive pool

Representative monitoring wells illustrate common or important trends in the Uley Wanilla PWS consumptive pool (Figure 4.27). Water levels are influenced by perturbations to the basin's water balance, namely changes in: (1) rainfall recharge, (2) rates of extraction, (3) changes in land use (i.e. revegetation) and/or (4) steep watertable gradients that promote lateral groundwater discharge to the south.

Determining the dominant driver of groundwater levels is uncertain – e.g. ULE007 shows a large rise in levels between 1968–72 that coincides with above-average rainfall and large increases in extraction; whereas a slower decline in levels between 1973–78 corresponds with a large increase in extraction with rainfall commensurate with the long-term average.

Since 2010, rates of extraction have been very low (Figure 5.3). Between 2010–16, which was a period of mostly above-average rainfall, water levels have recovered. Since 2016 annual rainfall totals have been very low and most levels have been declining sharply, with the majority of wells currently classified 'Lowest on record' (Figure 4.25).

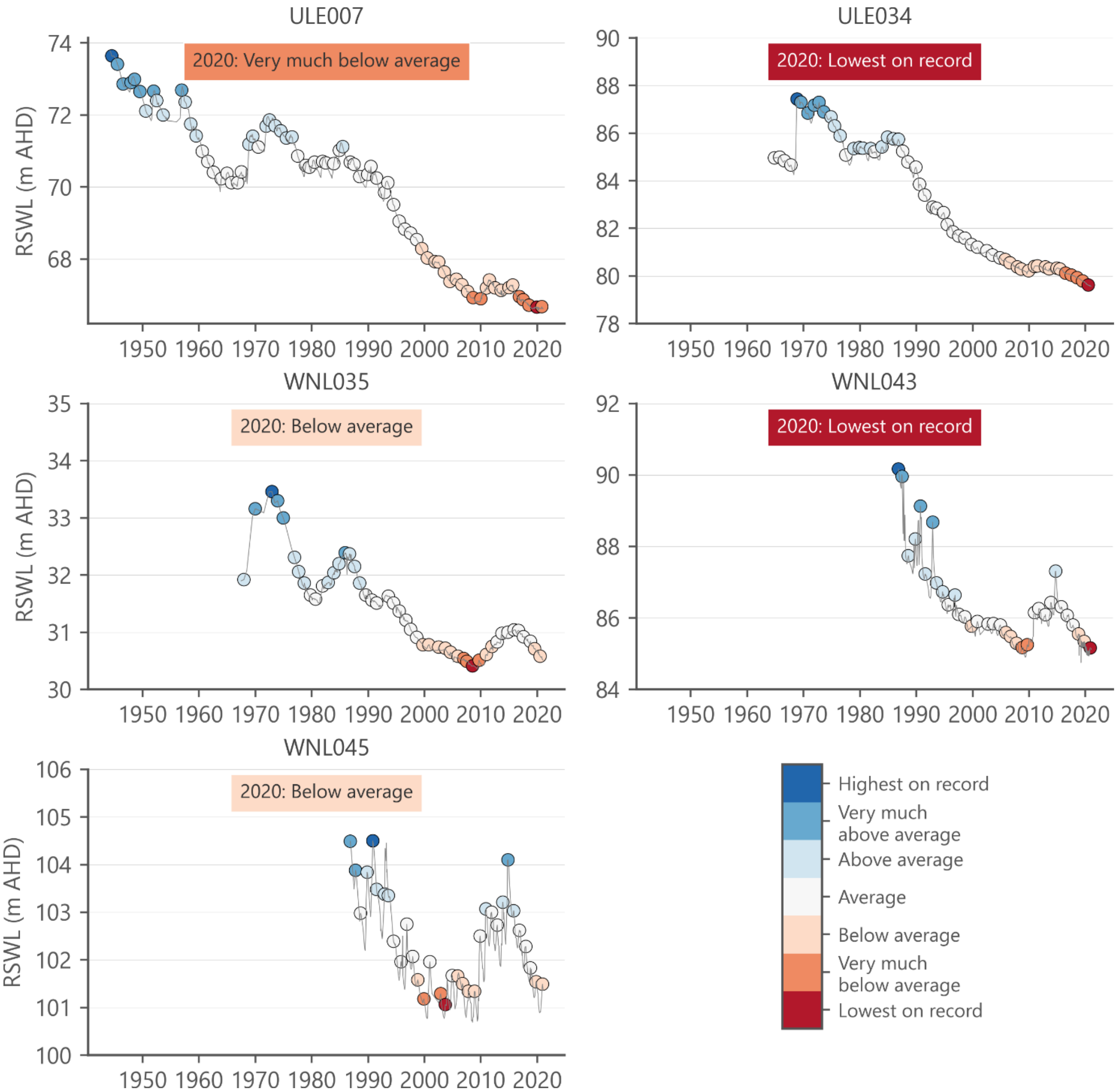


Figure 4.27. Selected hydrographs for wells in the Quaternary Limestone aquifer in the Uley Wanilla consumptive pool

4.4.6 Uley Wanilla PWS consumptive pool – salinity

In 2020, groundwater salinity ranges from 490 mg/L to 1110 mg/L, with a median of 563 mg/L. Nine out of ten wells (90%) show salinity below 1000 mg/L. The majority of wells were located within the PWS wellfield (Figure 4.28).

In the ten years to 2020, the majority of wells show an increase in groundwater salinity (67%). Trends in salinity (Section 2.2.2) vary from a decrease of 0.47% per year to an increase of 2.99% per year, with a median rate of 0.70% increase per year (Figure 4.29).

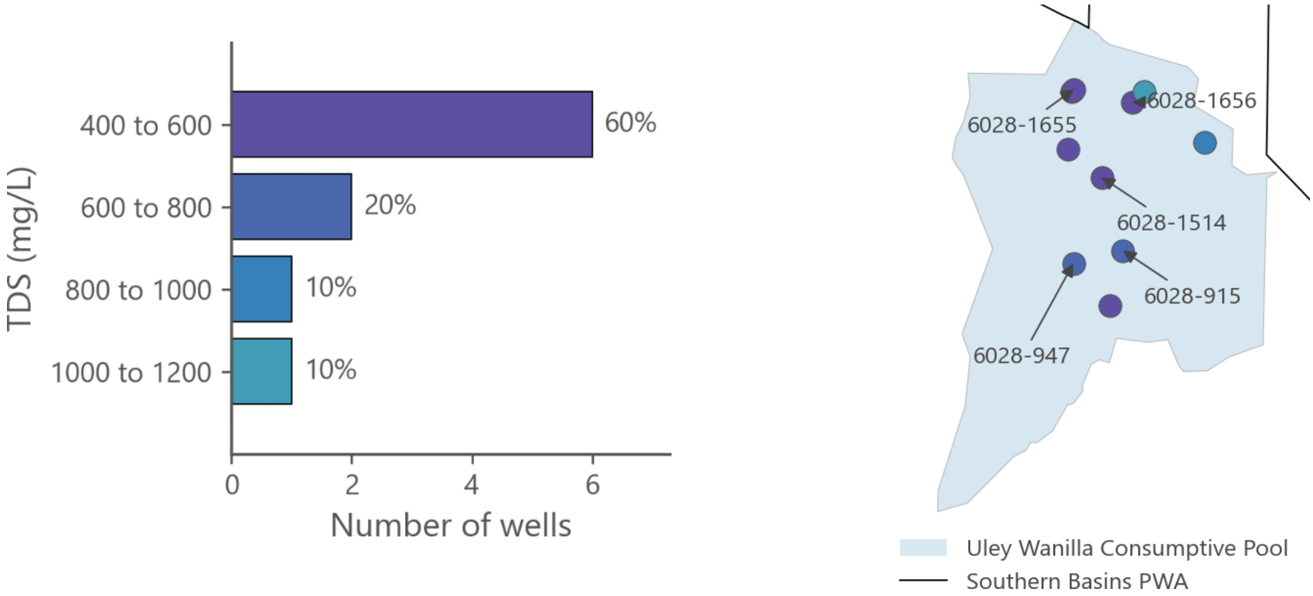


Figure 4.28. 2020 salinity observations from wells in the Quaternary Limestone aquifer in the Uley Wanilla PWS consumptive pool

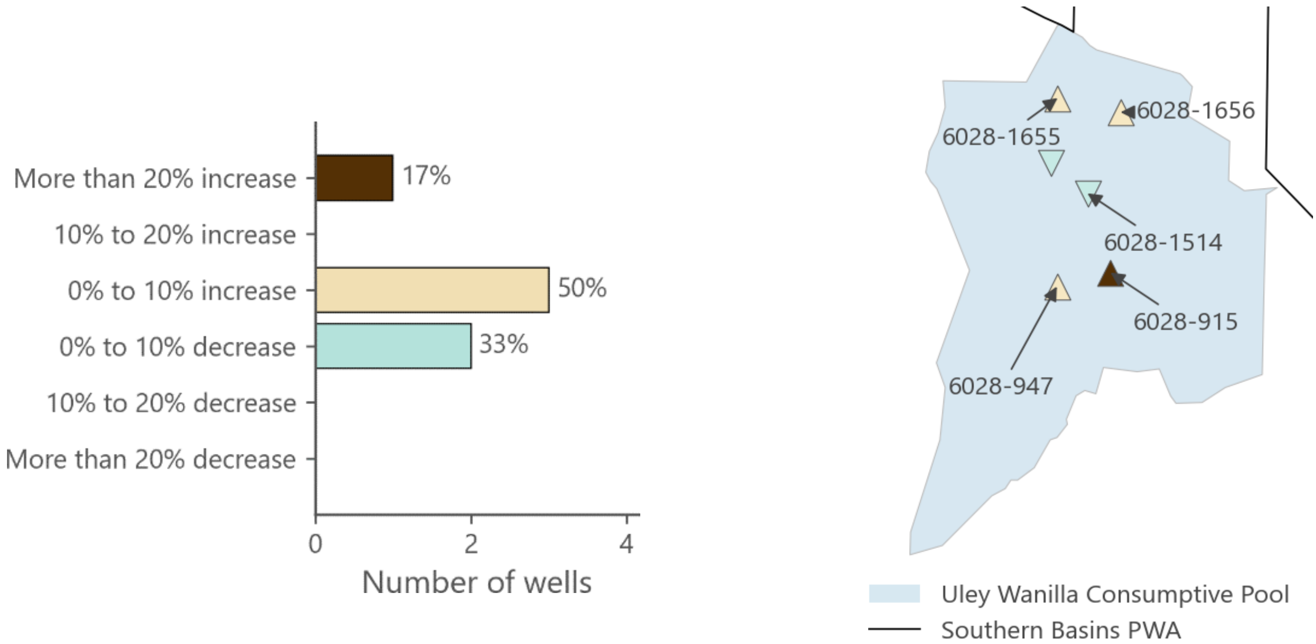


Figure 4.29. Salinity trend in the 10 years to 2020 for wells in the Quaternary Limestone aquifer in the Uley Wanilla PWS consumptive pool

Public water supply production bores in the Uley Wanilla PWS consumptive pool illustrate common or important trends (Figure 4.30). Over the past 30 years, most production bores show stable salinity (e.g. 6028-1656 and 6028-1655). Over the past 40 years, one production bore (6028-1514) shows aquifer freshening while one production bore shows gradually increasing salinity, at a rate of around 5 mg/L per year, although salinity is still low (less than 750 mg/L).

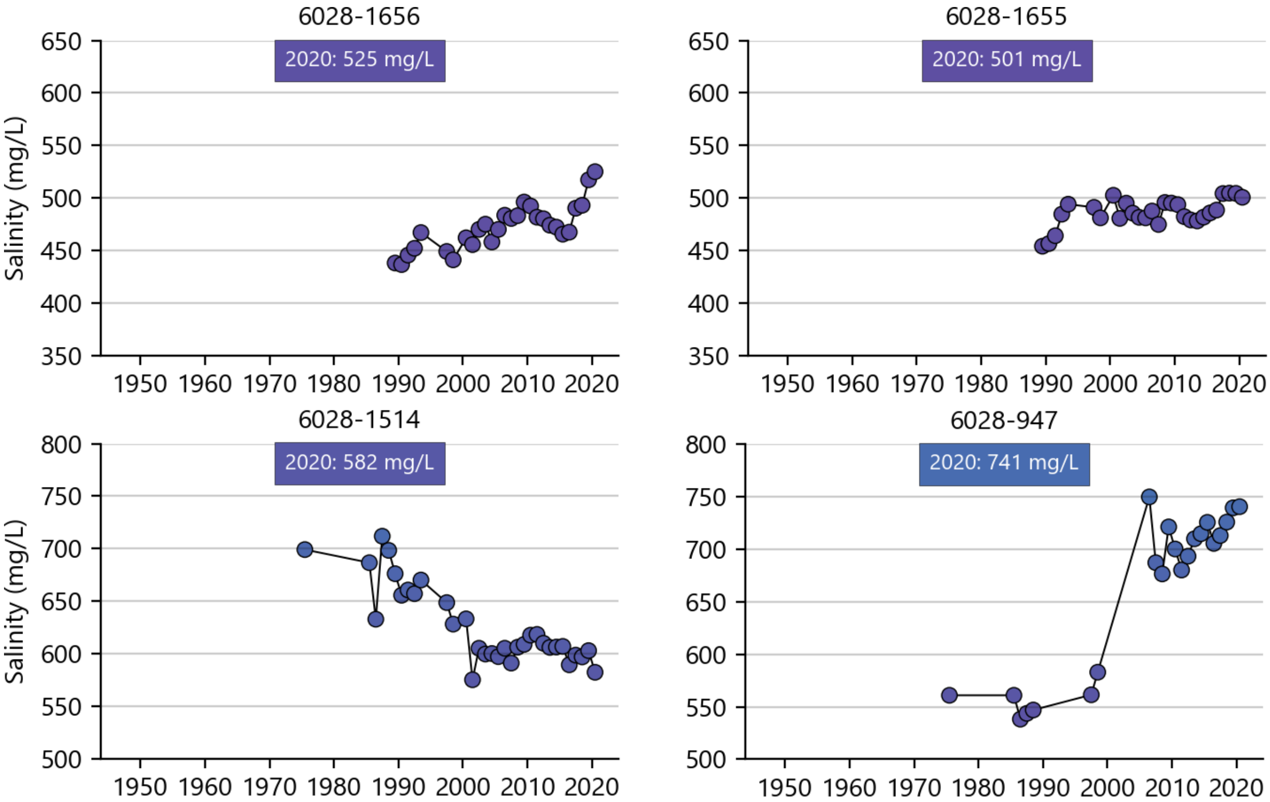


Figure 4.30. Selected salinity graphs for wells in the Quaternary Limestone aquifer in the Uley Wanilla PWS consumptive pool

4.4.7 Lincoln South PWS consumptive pool – water level

In 2020, the majority of water levels in the Quaternary Limestone aquifer (96%) are classified 'Below average' to 'Lowest on record', when compared to their respective historical record (Figure 4.31), while one well is classified 'Average'.

Over the past thirty years, water levels have declined in all wells, with declines ranging from 1.82 to 0.30 m (median of 0.61 m).

Five-year trends show water level are declining in 96% of wells, at rates up to 0.08 m/y (the median rate of decline is 0.04 m/y) (Figure 4.32).

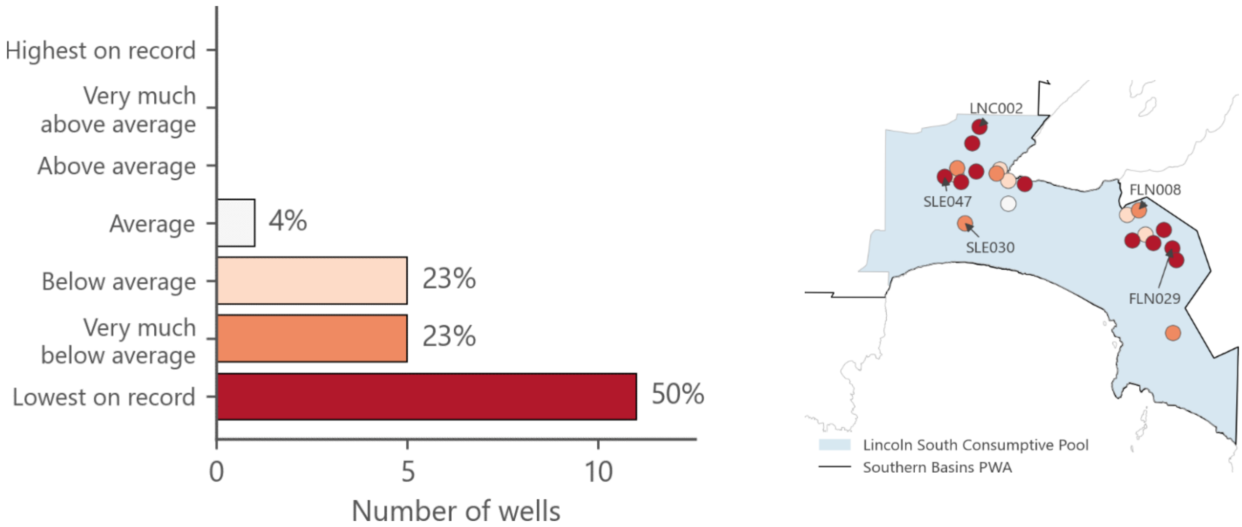


Figure 4.31. 2020 recovered water levels for wells in the Quaternary Limestone aquifer in the Lincoln South PWS consumptive pool

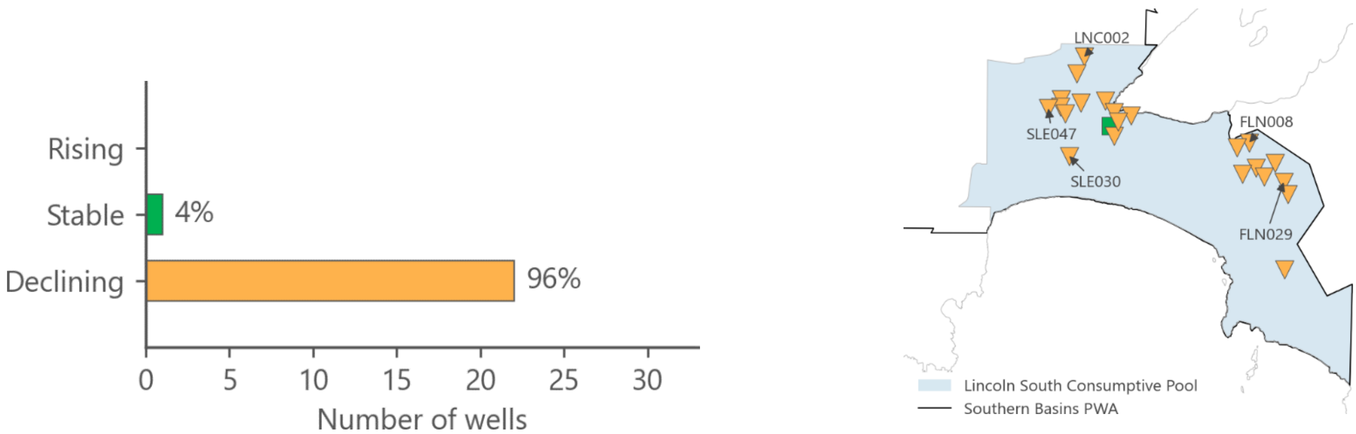


Figure 4.32. 2016–20 trend in recovered water levels for wells in the Quaternary Limestone aquifer in the Lincoln South PWS consumptive pool

Representative monitoring wells illustrate common or important trends in the Lincoln South PWS consumptive pool (Figure 4.33). Since the 1960s, long-term declines in water levels are evident in all wells. While rates of groundwater extraction were high in the 1960s and 1970s (Figure 5.3), rates of extraction have been negligible since 2012–13 (Figure 5.5).

SLE047 and SLE030 are located towards the western margin of the Lincoln South PWS consumptive pool and show a gradual declining trend over the past 50 years with a total decline of 0.93 m and 0.43 m, respectively. Similarly, toward the east of the consumptive pool, FLN029 and FLN008 display a gradual declining trend over the past 50 years with respective total declines of 1.22 m and 0.71 m.

LNC002 is located further inland, to the north-west of the consumptive pool and is also showing a declining trend since 1971 with a total decline of 2.33 m.

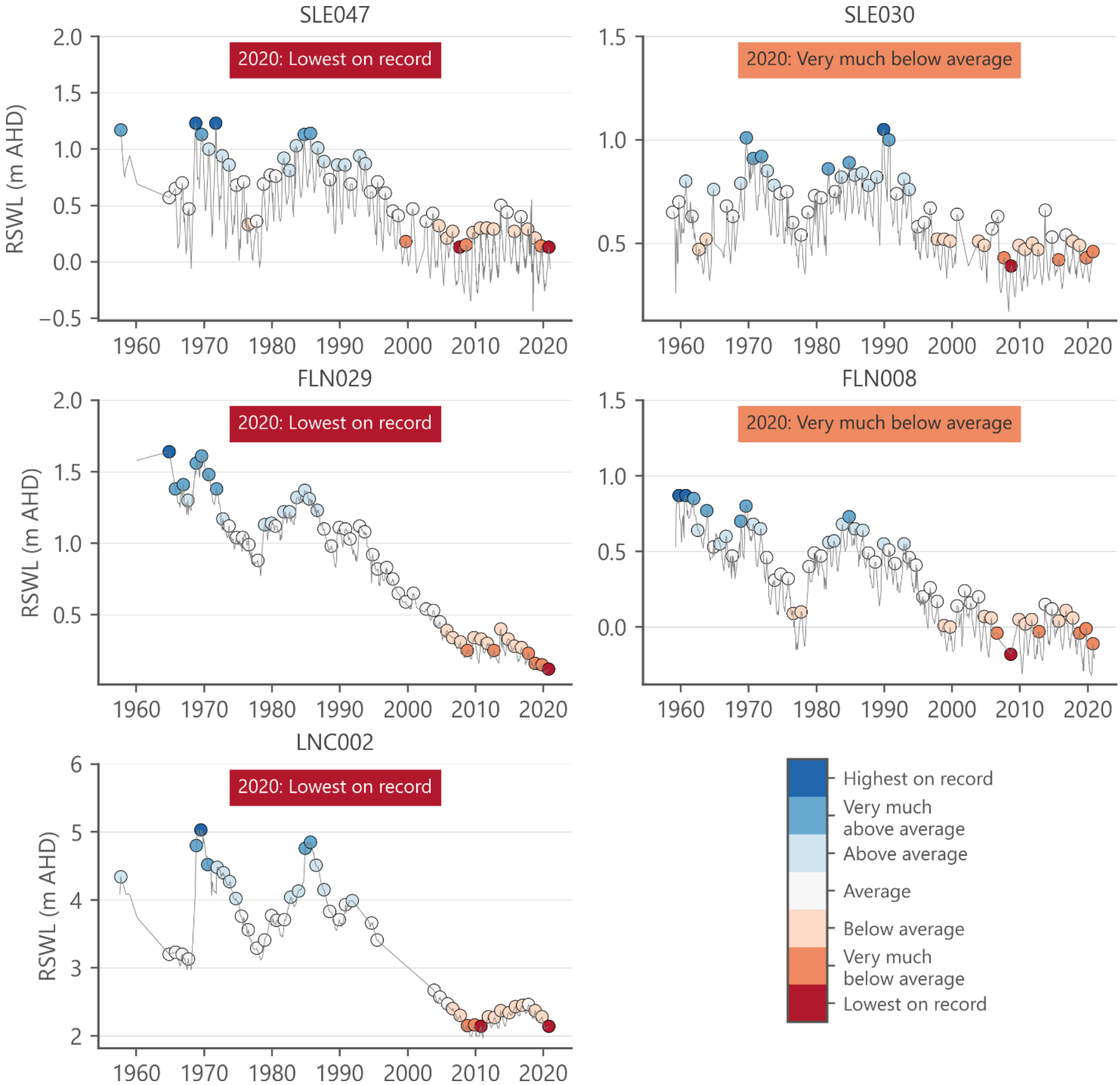


Figure 4.33. Selected hydrographs for wells in the Quaternary Limestone aquifer in the Lincoln South PWS consumptive pool

4.4.8 Lincoln South consumptive pool – salinity

In 2020, groundwater salinity ranged between 620–1552 mg/L, with a median of 1112 mg/L. Four out of 14 wells (43%) show salinities below 1000 mg/L (Figure 4.34).

In the ten years to 2020, the majority of wells (75%) show an increase in groundwater salinity (Section 2.2.2). Trends in salinity over this period vary from a decrease of 0.30% per year to an increase of 0.77% per year, with a median rate of 0.15% increase per year (Figure 4.35).

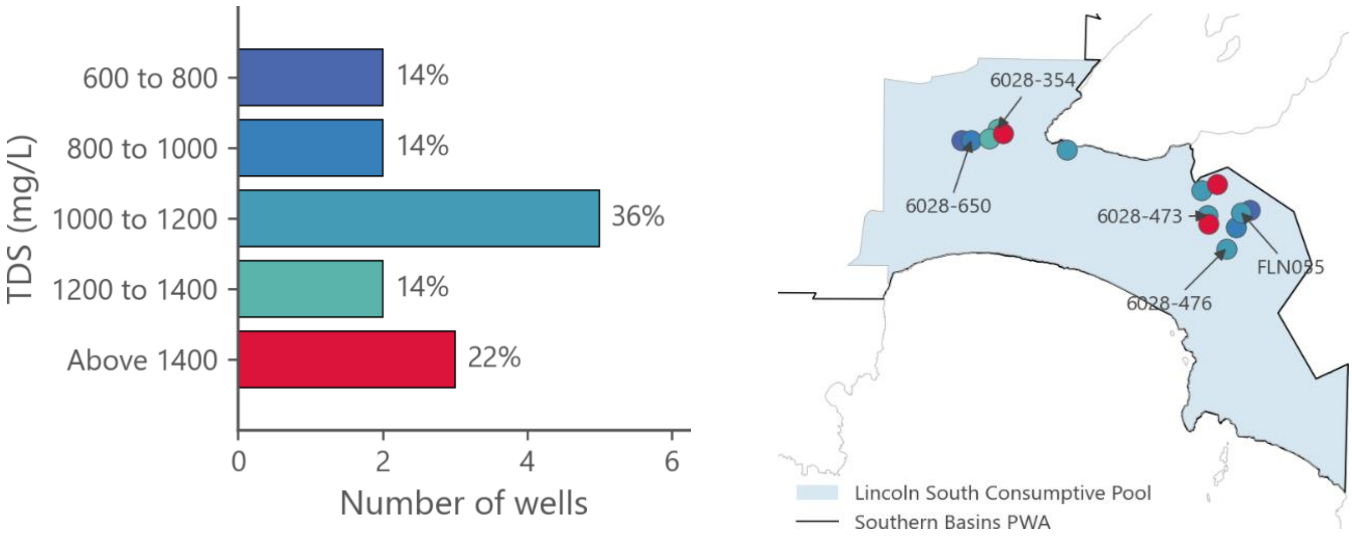


Figure 4.34. 2020 salinity observations from wells in the Quaternary Limestone aquifer in the Lincoln South PWS consumptive pool

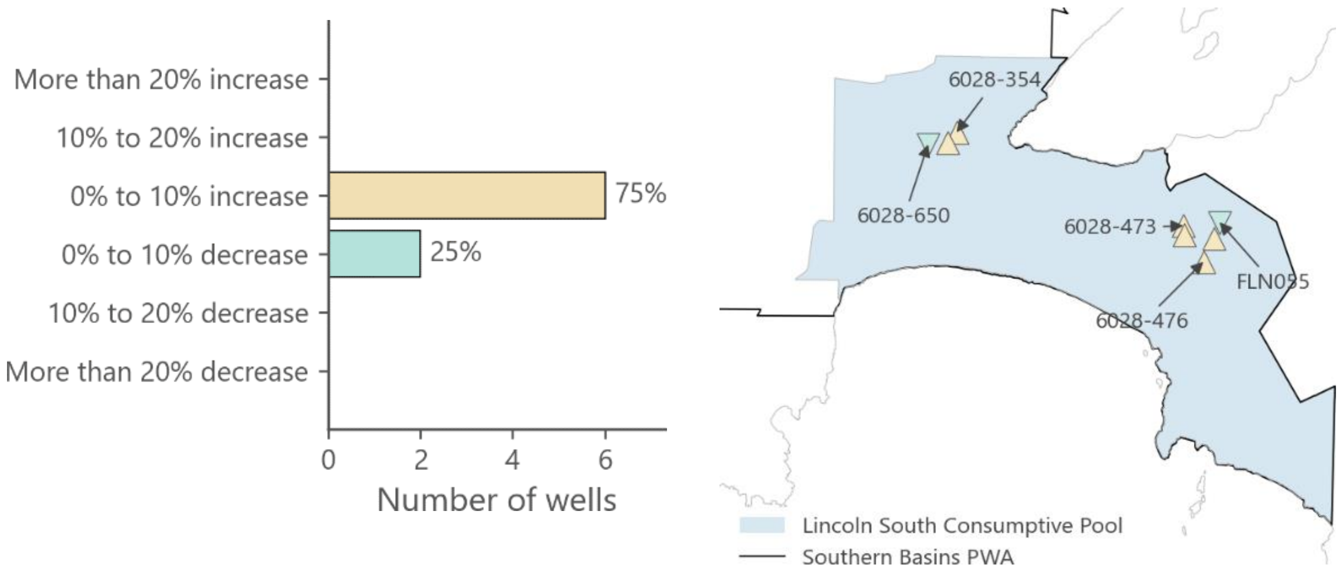


Figure 4.35. Salinity trend in the 10 years to 2020 for wells in the Quaternary Limestone aquifer in the Lincoln South PWS consumptive pool

Representative monitoring wells illustrate common or important trends in the Lincoln South PWS consumptive pool (Figure 4.36). From the late-1970s, all wells show a gradual and continuous decrease in salinity, which coincides with reductions in rates of extraction (Figure 5.3), due to establishment of the Uley South PWS. Groundwater salinity generally increased between mid-1980s and 2010, after which salinity has been stable.

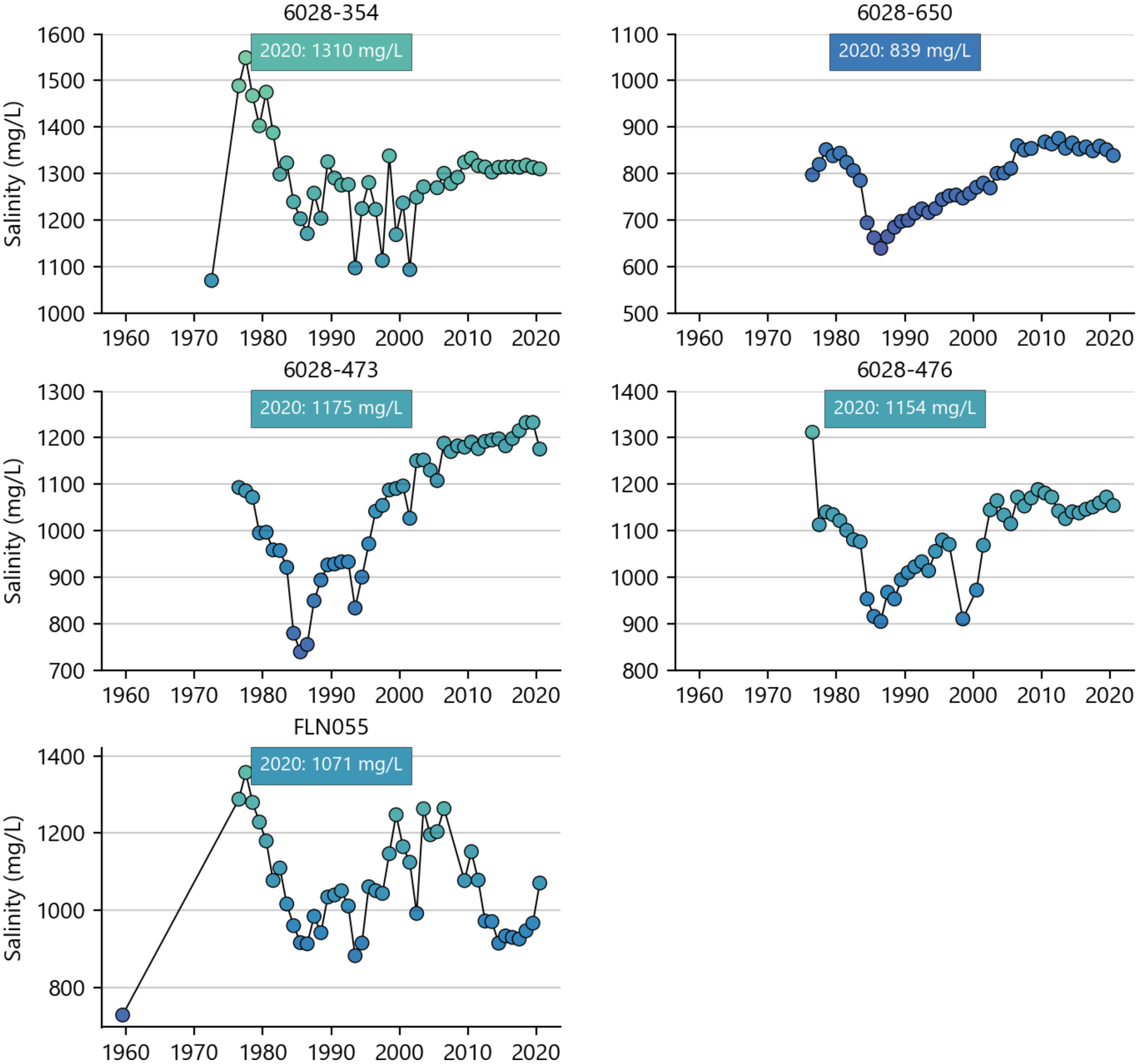


Figure 4.36. Selected salinity graphs for wells in the Quaternary Limestone aquifer in the Lincoln South PWS consumptive pool

5 Water use

In Eyre Peninsula, there are very few surface water resources and there is generally a scarcity of potable groundwater. The fresh groundwater resources in both the Musgrave and Southern Basins PWAs are used for a variety of purposes, but mainly for PWS, stock and domestic use, irrigation of green recreational spaces and industrial purposes.

5.1 Musgrave PWA

Groundwater extraction in the Musgrave PWA began in the 1960s; rates of extraction from Polda have varied considerably over time (Figure 5.1). Total licensed groundwater use in 2019–20 was 70 ML (Figure 5.2), all of which is extracted from the Bramfield consumptive pool (Figure 5.2), which is a decrease of 31% compared to 2018–19. The rate of extraction from Bramfield consumptive pool has been stable at around 70 ML/y since 2002–03.

Extraction from the Polda consumptive pool for PWS ceased in 2008 due to increasing salinity (EP NRM Board, 2016). Between 2008–16, a Notice of Prohibition prevented extraction for all licensed uses from the Polda consumptive pool (Figure 5.2) and in 2015, SA Water voluntarily relinquished their (PWS) license to extract from this resource.

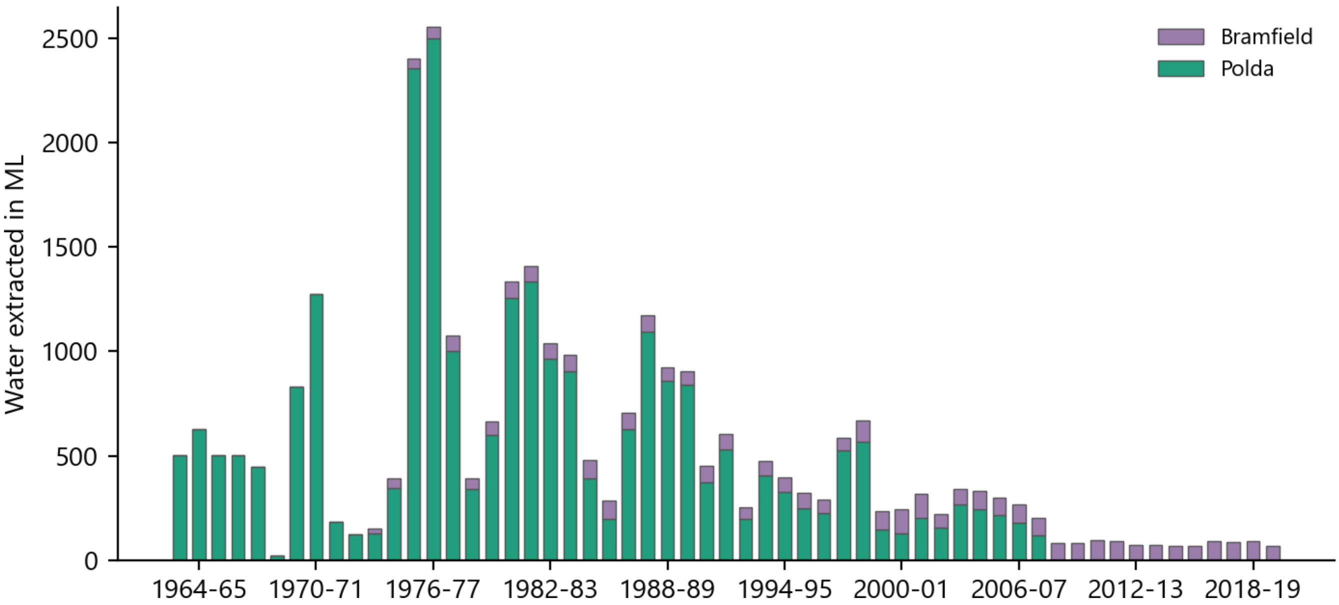


Figure 5.1. Historical groundwater extraction from groundwater resources in the Musgrave PWA

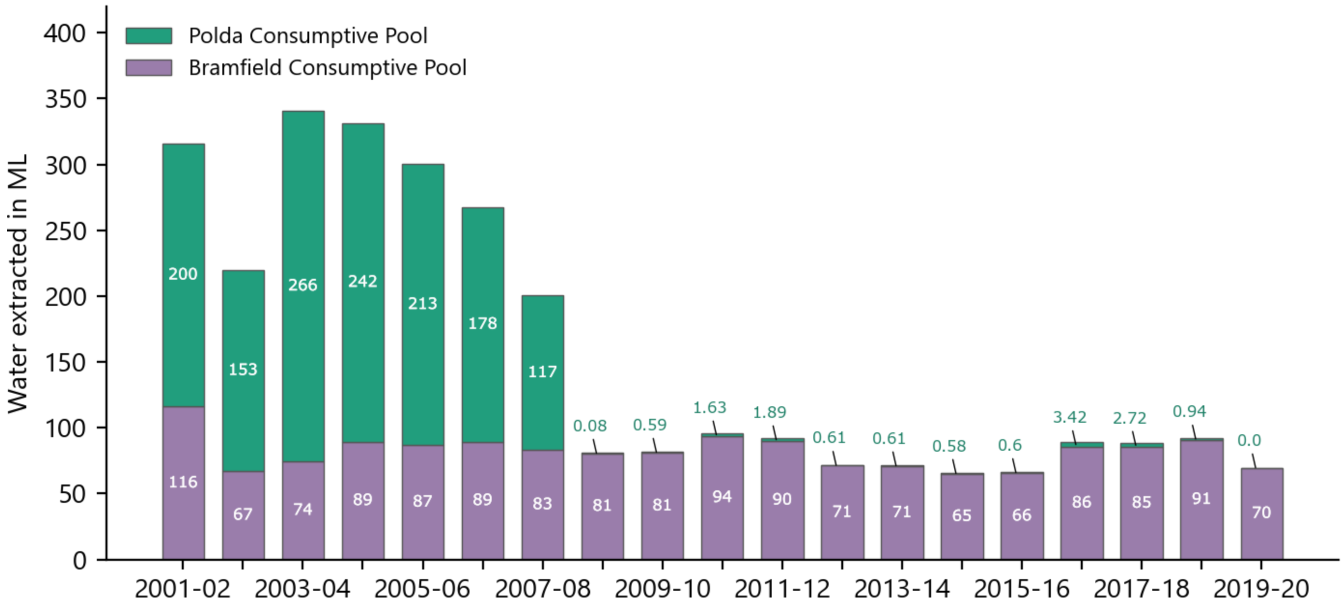


Figure 5.2. Licensed groundwater extraction since 2001–02 in the Musgrave PWA

5.2 Southern Basins PWA

In the Southern Basins PWA, historical patterns of groundwater extraction have varied significantly since groundwater extraction began in the 1950s. Since the late 1970s, the majority of extraction has occurred from the Uley South lens (Figure 5.3). In 2019–20, total licensed groundwater use in the Southern Basins PWA is 5442 ML (Figure 5.4), with 93% of this volume sourced from the Uley South PWS consumptive pool.

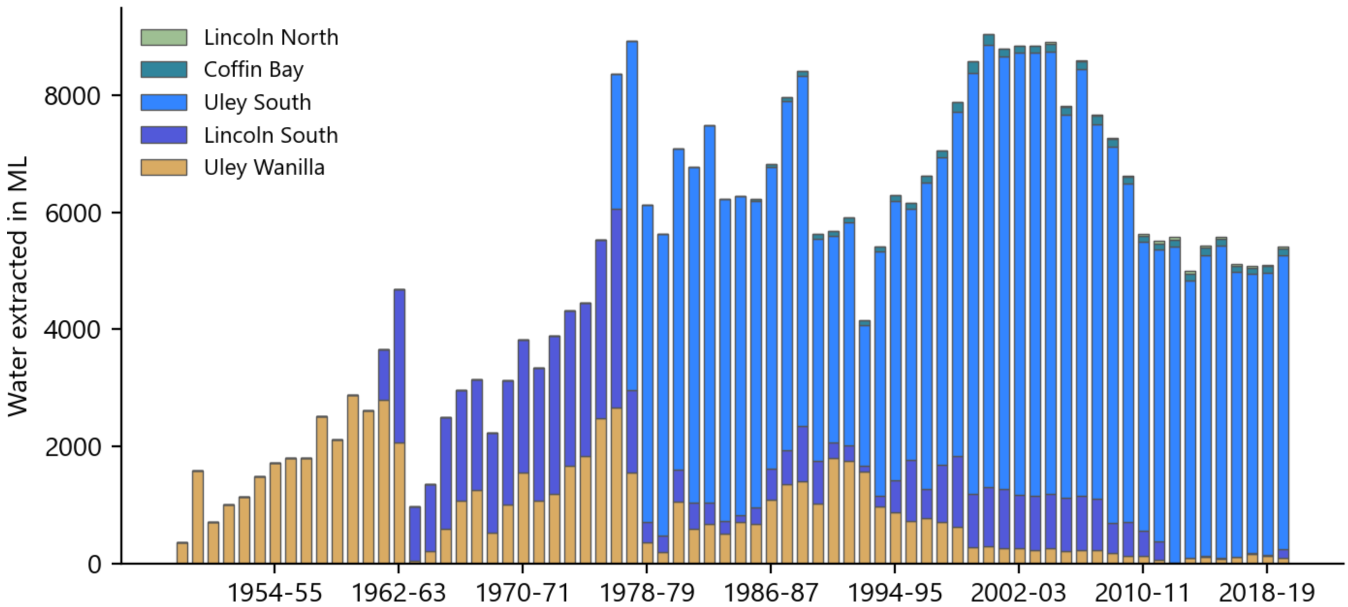


Figure 5.3. Historical groundwater extraction from groundwater resources in the Southern Basins PWA

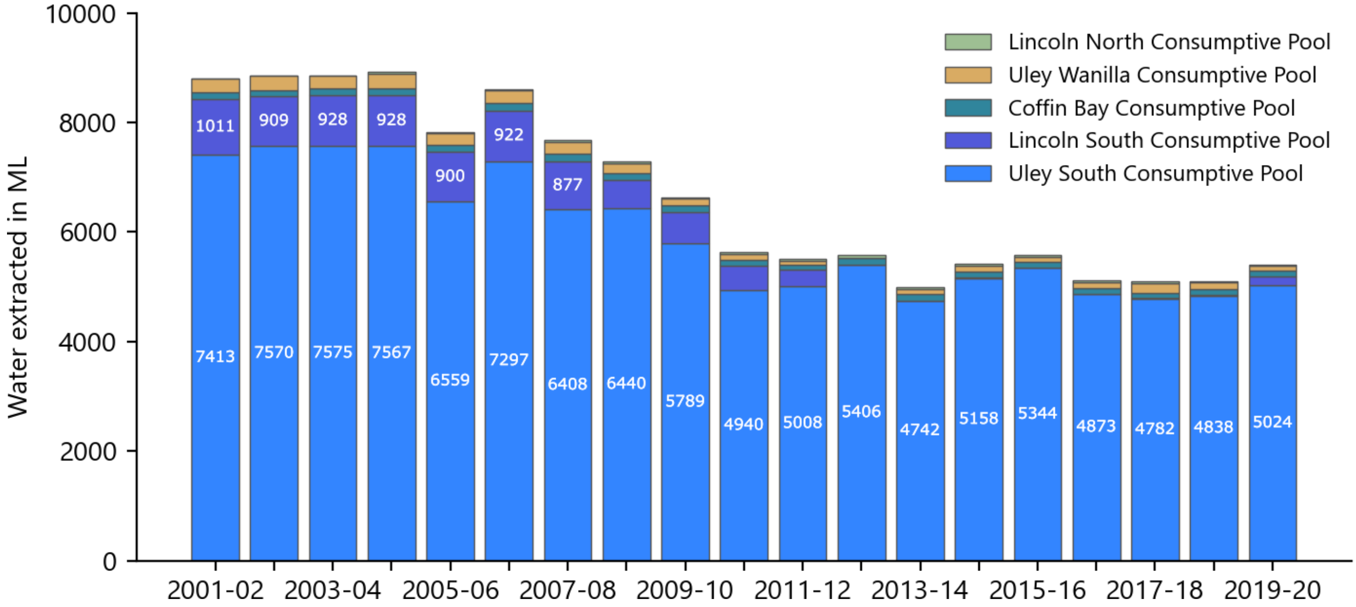


Figure 5.4. Licensed groundwater extraction for 2001–20 in the Southern Basins PWA

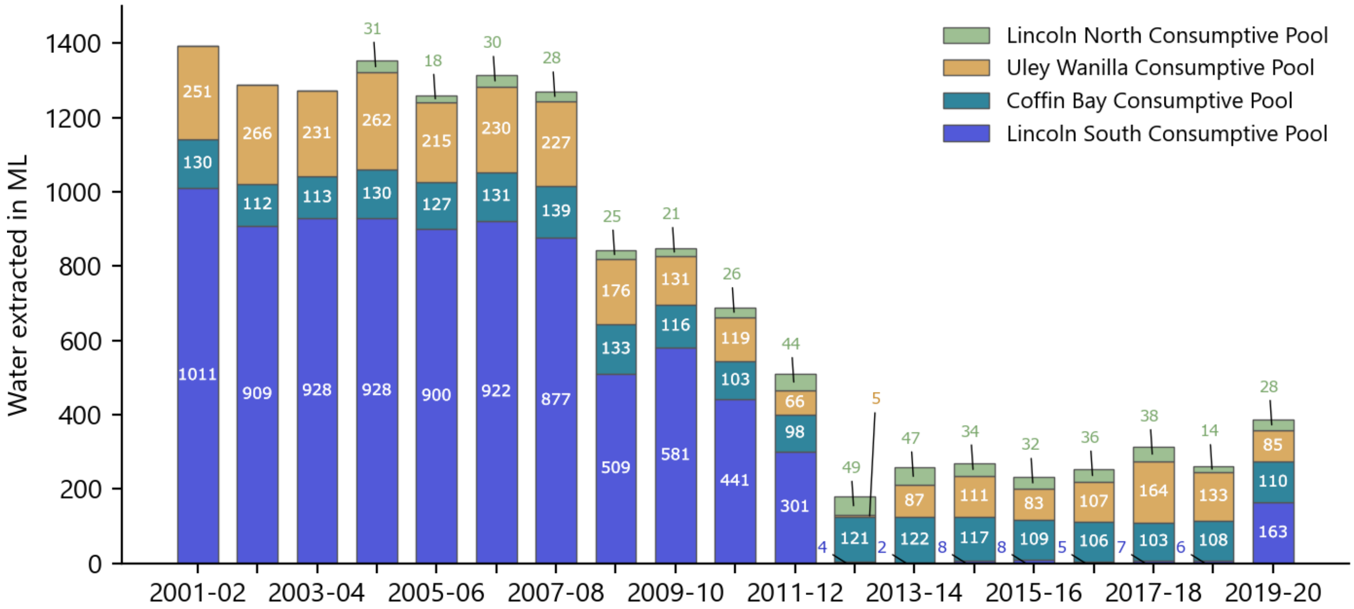


Figure 5.5. Licensed groundwater extraction for 2001–20 in the Southern Basins PWA for the Lincoln North, Uley Wanilla PWS, Coffin Bay, and Lincoln South PWS consumptive pools.

5.2.1 Uley South PWS consumptive pool

Licensed extractions in 2019–20 from the Uley South PWS consumptive pool were 5024 ML, an increase of 4% (186 ML) compared to 2018–19. The rate of extraction has remained stable since 2010–11, after gradually reducing from approximately 7500 ML/y prior to 2006–07 (Figure 5.4 and Figure 5.6).

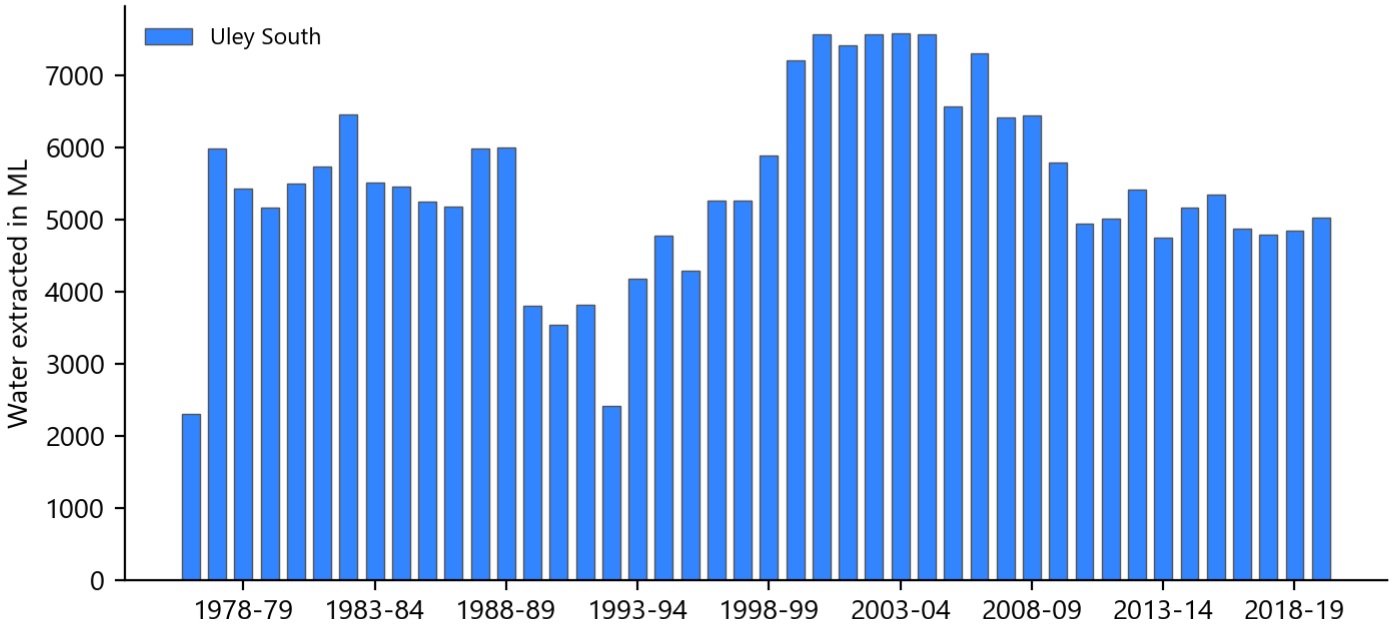


Figure 5.6. Historical groundwater extraction from the Uley South groundwater resource

5.2.2 Uley Wanilla PWS consumptive pool

The Uley Wanilla basin was the first groundwater basin to be developed in 1949, after recognition that the Tod River Reservoir was insufficient to supply the region's growing demand for water. Extractions from Uley Wanilla have been decreasing steadily since 1993 (Figure 5.3), with marked reductions from 2008 (Figure 5.5). Extraction in 2019–20 is 85 ML, a reduction of 36% (48 ML) compared to 2018–19, and less than 40% of the annual volumes extracted prior to 2007–08.

5.2.3 Lincoln South PWS consumptive pool

Groundwater extraction from the Lincoln South basin commenced in 1961 (Figure 5.3). From the late 1990s, rates of extraction varied between around 900–1000 ML/y, until reductions began in 2008–09, and decreased further in 2012–13 (Figure 5.5), due to operational constraints resulting from up-coning of underlying high-salinity groundwater. In 2019-20, licensed extractions increased to 163 ML compared to 6 ML in 2018–19.

5.2.1 Coffin Bay consumptive pool

Licensed groundwater extraction from the Coffin Bay consumptive pool in 2019–20 was 110 ML, which is commensurate with 113 ML extracted in 2018–19 (Figure 5.5). Rates of extraction have been stable at 103–110 ML/y over the past five water-use years (Figure 5.7).

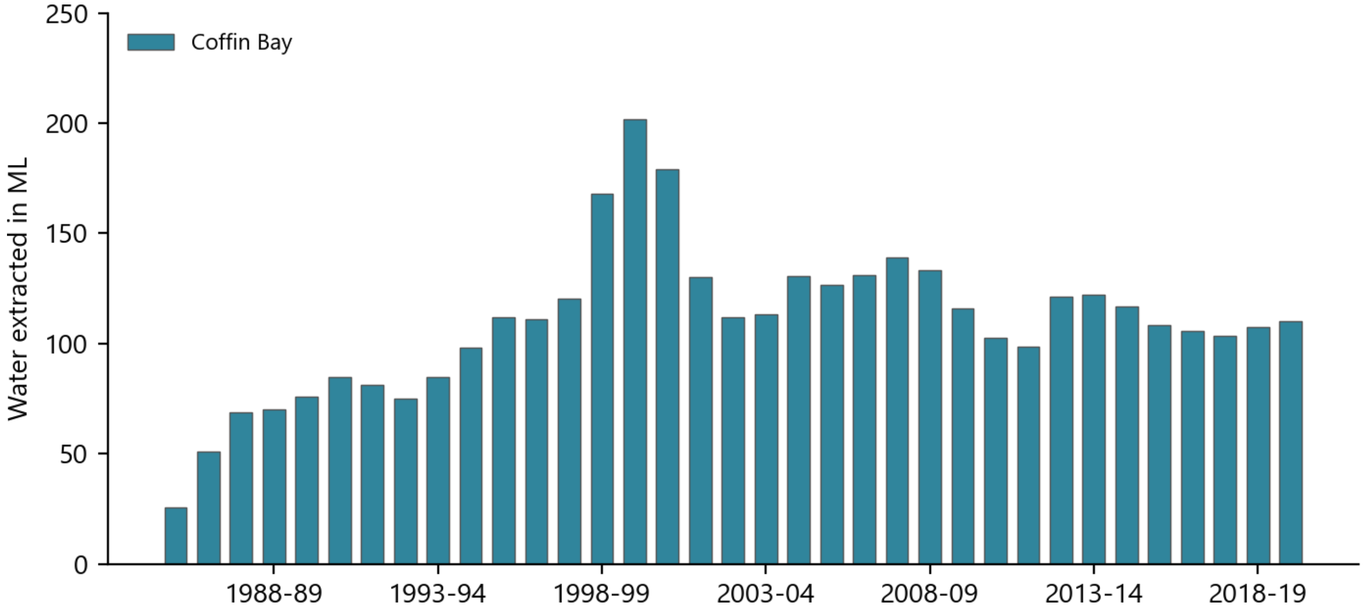


Figure 5.7. Historical rates of groundwater extraction from the Coffin Bay consumptive pool

6 References

DEW (2019a). Musgrave Prescribed Wells Area Bramfield 2018 Groundwater level and salinity status report, Government of South Australia, through Department for Environment and Water, Adelaide.

DEW (2019b). Musgrave Prescribed Wells Area Polda 2018 Groundwater level and salinity status report, Government of South Australia, through Department for Environment and Water, Adelaide.

DEW (2019c). Southern Basins Prescribed Wells Area Coffin Bay 2018 Groundwater level and salinity status report, Government of South Australia, through Department for Environment and Water, Adelaide.

DEW (2019d). Southern Basins Prescribed Wells Area Lincoln South 2018 Groundwater level and salinity status report, Government of South Australia, through Department for Environment and Water, Adelaide.

DEW (2019e). Southern Basins Prescribed Wells Area Uley South 2018 Groundwater level and salinity status report, Government of South Australia, through Department for Environment and Water, Adelaide.

DEW (2019f). Southern Basins Prescribed Wells Area Uley Wanilla 2018 Groundwater level and salinity status report, Government of South Australia, through Department for Environment and Water, Adelaide.

DEW (2020). Musgrave and Southern Basins Prescribed Wells Area 2018–19 water resources assessment, DEW Technical report 2020/32, Government of South Australia, Department for Environment and Water, Adelaide.

DFW (2010a). Musgrave PWA Groundwater level and salinity status report 2009-10, Government of South Australia, through Department for Water, Adelaide.

DFW (2010b). Southern Basins PWA Groundwater level and salinity status report 2009-10, Government of South Australia, through Department for Water, Adelaide.

EP NRM Board (2016). Water Allocation Plan for the Southern Basins and Musgrave Prescribed Wells Areas, Government of South Australia, through Eyre Peninsula Natural Resources Management Board.

Stewart S (2013). Additional Science Support for the Eyre Peninsula Water Allocation Plan, DEWNR Technical Report 2013/19, Government of South Australia, through Department of Environment, Water and Natural Resources, Adelaide.

Stewart S (2015). Supporting documentation for the amendment of the Water Allocation Plan for the Southern Basins and Musgrave PWAs, DEWNR Technical Report 2015/18, Government of South Australia, through Department of Environment, Water and Natural Resources, Adelaide.

Stewart S, Alcoe D, Risby L (2012). Science Support for the Musgrave and Southern Basins Prescribed Wells Areas Water Allocation Plan, DFW Technical Report 2012/15, Government of South Australia, through Department for Water, Adelaide.

Government
of South Australia

Department for
Environment and Water