Musgrave and Southern Basins Prescribed Wells Areas 2018-19 water resources assessment

Department for Environment and Water
December, 2020

DEW Technical report 2020/32

Government of South Australia
Department for Environment and Water

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Contents

1 Summary

Rainfall

- In 2018–19, rainfall in the Musgrave Prescribed Wells Area (PWA) at Elliston rainfall station recorded 424 mm, just below the average of 427 mm.
- Recharge to the Quaternary limestone (QL) aquifer in the Musgrave PWA is likely to occur when monthly rainfall above 60 mm occurs between May and October. In August 2018, this occurred at all three rainfall stations, with a very high monthly rainfall ranging from 91 to 114 mm. In 2019, Elliston recorded 89 mm in May and 73 mm in June and Terrah Winds recorded 61 mm in May and 68 mm in September.
- Rainfall in the Southern Basins PWA was also similar to the average; the Big Swamp rainfall station recorded 564 mm, just above the average of 557 mm.
- Recharge to the QL aquifer in the Southern Basins PWA is likely to occur when more than 10 days of 10 mm daily rainfall occur between May and October; this did not occur in 2018 (9 days), but did occur in 2019 (11 days) at Big Swamp.
- Long-term data trends indicate a decline in annual rainfall at all stations.

Groundwater

- Water levels in the QL aquifer in the Musgrave PWA are generally at below average (59% of wells) and very much below average (32% of wells) levels compared to their historic record.
- Water levels in the QL aquifer in the Southern Basins PWA are also at low levels compared to their historic record, with 42% of wells at below average levels and 26% of wells at their lowest level on record.
- The majority of wells (73%) in the Uley Wanilla Consumptive Pool are at their lowest level on record. The median ranked well in the Uley South and Lincoln South Consumptive Pools is at below-average levels compared to historic records, while in Coffin Bay the median ranked well is at average water levels.
- Five-year trends in water level show the majority of wells in the Bramfield (84% of wells) and Polda (100%) lenses in the Musgrave PWA are declining, with similar results in the Southern Basins PWA (90% of wells declining, except for Coffin Bay, where 57% of wells show rising trends).
- Groundwater salinity trends are stable in the majority of wells in both PWAs (80% of wells overall).

Water use

- There is a general absence of reliable surface water and good quality groundwater on the Eyre Peninsula. The available fresh groundwater resources in both the Musgrave and Southern Basins PWAs are therefore used for a variety of purposes, including town water supplies, stock and domestic use, irrigation and mining.
- Metered water extraction in 2018–19 was 92 ML in the Musgrave PWA, which is significantly less than historical patterns due to the cessation of significant extraction for public water supply from the Polda resource in 2007–08. Metered extraction from the Bramfield Consumptive Pool in 2018–19 was 91 ML.
- Metered water extraction in 2018–19 from the Southern Basins PWA was 5099 ML, with the majority of this (95%) taken from the Uley South Consumptive Pool. Volumes taken from the other main consumptive pools in 2018–19 were 133 ML from Uley Wanilla, 6 ML from Lincoln South and 108 ML from Coffin Bay.

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) build on the fact sheets to provide more comprehensive information 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 all resources across all regions in a quick-reference format.

This document is the Technical Note for the Musgrave Prescribed Wells Area (PWA) and Southern Basins PWA for 2018-19 and addresses groundwater data collected up until December 2019, together with water use data up to the end of June 2019.

1.2 Regional context

The Musgrave PWA (Figure 1.1) and Southern Basins PWA (Figure 1.2) are in the southern part of the Eyre Peninsula Landscape Region. This area incorporates undulating topography which is the remnant of ancient dune systems which formed over the last 100 000 years, with thin soils and calcrete across much of the area.

Groundwater is the major water resource on the Eyre Peninsula and is used for town water supply, stock and domestic uses, irrigation, recreational and industrial use. There are at least four aquifer systems located in the region: the uppermost unconfined aquifer in Quaternary limestone deposits, an unconfined to confined aquifer in underlying Tertiary sediments, an aquifer in Jurassic sedimentary rocks in the Musgrave PWA and a fractured rock aquifer occurring in basement rocks.

The water resources are managed under rules in the Water Allocation Plan (WAP) for the Southern Basins and Musgrave Prescribed Wells Areas (EP NRM Board, 2016), which was adopted in 2016.

The largest and most reliable supplies of low-salinity groundwater are found in the Quaternary limestone, which is widely used in both the Musgrave and Southern Basins PWAs. Groundwater resources in the Quaternary limestone are separated into spatially distinct areas of low-salinity groundwater which are often referred to as groundwater lenses. The spatial separation can be caused by the surface topography, variations in the elevation of the underlying basement rock and the location of recharge and discharge areas. These lenses or basins are also reflected in the consumptive pools outlined in the WAP and are used to delineate groundwater resources for discussion in this Technical Note.

The relevant resources in the Musgrave PWA are shown in Figure 1.1:

- The Bramfield lens, which extends to the north-east of the township of Elliston;
- The Polda lens, which is located around 50 km inland from Elliston, in the north-eastern part of the Musgrave PWA.

The relevant lenses in the Southern Basins PWA are shown in Figure 1.2:

- The Coffin Bay lens, located immediately inland of the township of Coffin Bay;
- The Uley South lens, located inland from coastal cliffs, around 30 km to the west of Port Lincoln;

- The Uley Wanilla lens, located inland about 15 km east of Coffin Bay;
- The Lincoln South lenses, located between Port Lincoln and Sleaford Bay.

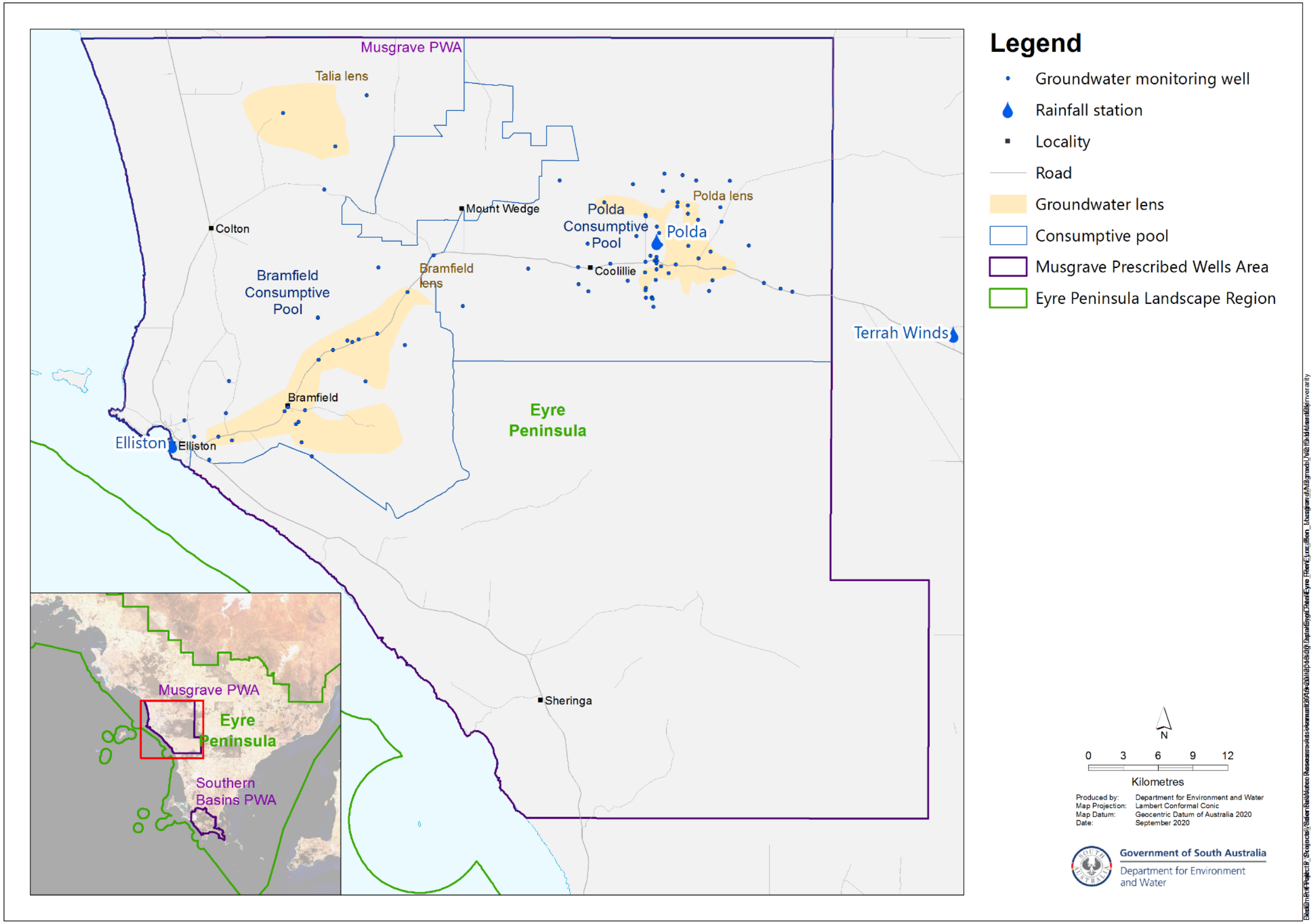

Figure 1.1. Location of Musgrave PWA

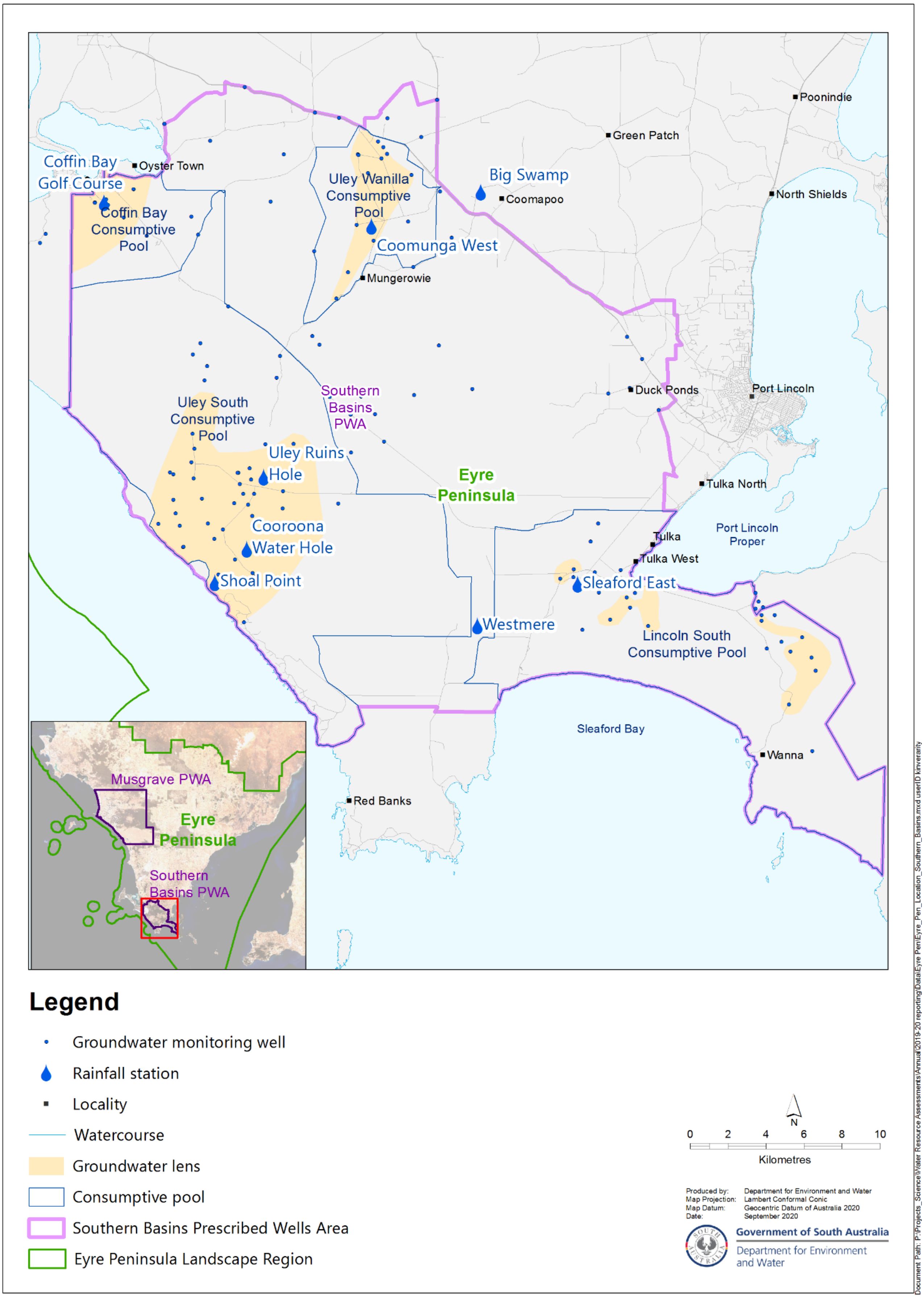

Figure 1.2. Location of Southern Basins PWA

2 Methods and data

This section describes the source of rainfall, surface water, groundwater and water use data presented in this report and the methods used to analyse and present this 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).

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 observations. 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 (for example see Figure 4.1). Hydrographs are shown for a selection of wells to illustrate common or important trends (for example see Figure 4.3).

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[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 were 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 (for example see 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. 1989–1991) 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 (for example see Figure 4.4).

Five-year salinity trends are calculated where there are at least five 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:

$$\text{Percentage change in salinity (\%)} = \frac{\text{Slope of linear trend line (mg/L/y)} * 5}{\text{Value of trend line at start of period (mg/L)}} * 100$$

If the percentage change is greater than 10% then the well is given a status of 'increasing' or 'decreasing' depending on how the salinity is changing, while if the absolute percentage change is less than 10% it is given a status of 'stable'. The latter is intended to reflect the fact that salinity measurements based on the measurement of the

[3] Bureau of Meteorology Annual climate statement 2019

electrical conductivity of a water sample are often subject to small instrument errors. The number of increasing, decreasing and stable wells are then summarized in for each resource (e.g. Figure 4.5).

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);
- 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

Annual rainfall on the lower Eyre Peninsula varies from approximately 550 mm on average in the Southern Basins PWA to 400 mm on average in the north-west in the Musgrave PWA. In general rainfall totals are higher in coastal areas than in inland areas. The spatial distribution of rainfall in 2018–19 was generally similar to the 1986–2016 average distribution, with a band of higher rainfall occurring in coastal parts of the Musgrave PWA and slightly lower totals occurring in the south-eastern part of the Southern Basins PWA, around the Lincoln South lens (Figure 3.1)[4].

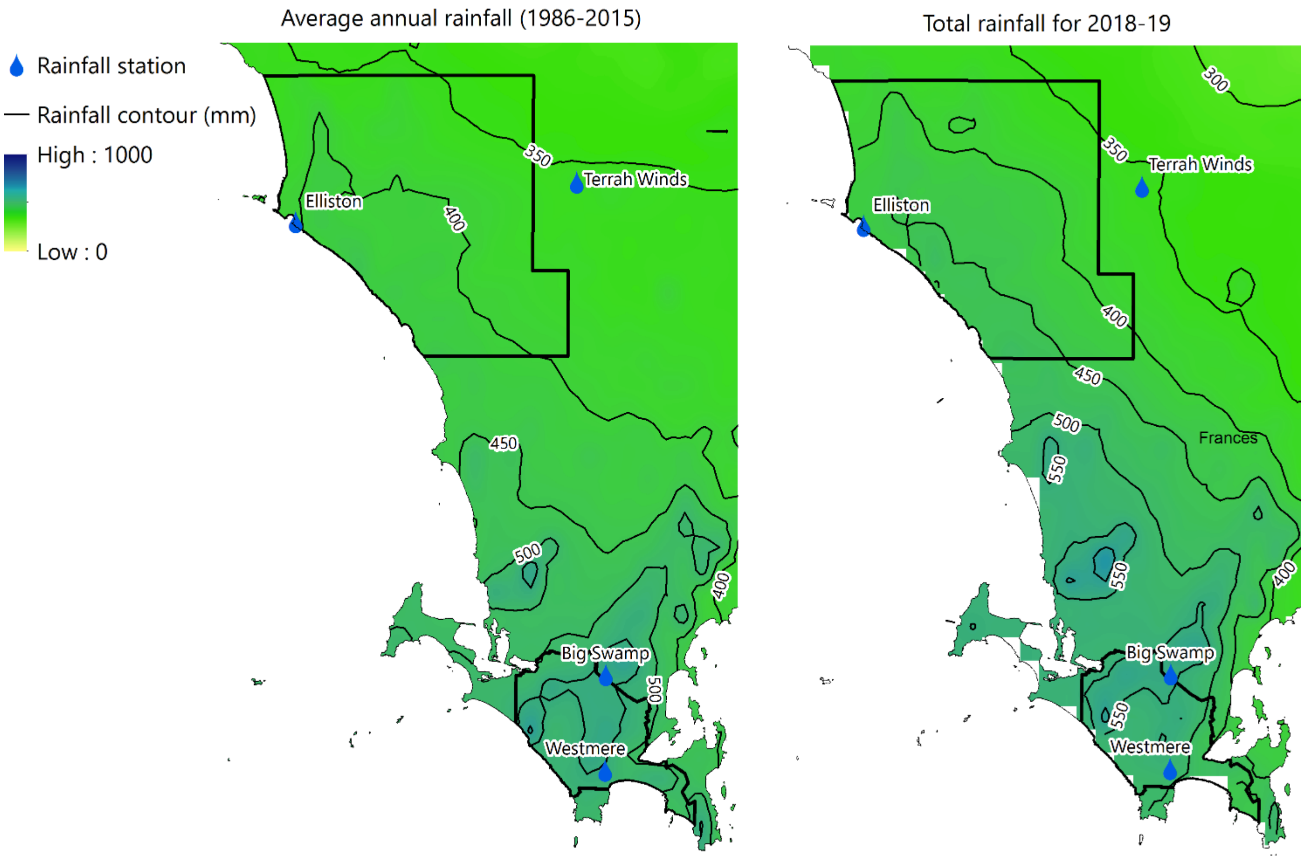

Figure 3.1. Rainfall in the Musgrave PWA and Southern Basins PWA for 2018–19 compared to the 30-year average (1986–2015). Rainfall stations operated by DEW are not shown.

The past forty years of annual and monthly rainfall are shown below for rainfall stations operated by the BOM:

- Elliston, in the coastal part of the Musgrave PWA (Figure 3.2 and Figure 3.3);
- Terrah Winds, inland from Elliston, about 25 km east of the Polda groundwater lens (Figure 3.4 and Figure 3.5);
- Big Swamp, located halfway between Coffin Bay and Port Lincoln, representing rainfall in the inland part of the Southern Basins PWA (Figure 3.9 and Figure 3.10);

[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 and further detail is provided in Section 2.1.

- Westmere, located near Sleaford Bay, southwest of Port Lincoln, representing rainfall in the coastal parts of the Southern Basins PWA (Figure 3.12 and Figure 3.13).

In addition, this section also shows the past ten years of annual and monthly rainfall for rainfall sites operated by DEW within selected groundwater lenses:

- Polda rainfall station, in the Polda groundwater lens, within the Musgrave PWA (Figure 3.6 and Figure 3.7);
- Coffin Bay Golf Course rainfall station, in the Coffin Bay groundwater lens, within the Southern Basins PWA (Figure 3.15 and Figure 3.16);
- Shoal Point rainfall station, on the coastal cliffs in the Uley South groundwater lens, within the Southern Basins PWA (Figure 3.18 and Figure 3.19).

Rainfall data are also available since 2010 for two additional DEW-operated sites at the Uley South lens (Cooroona Water Hole station and Uley Ruins Hole station) and since 2016 for DEW-operated sites in the Lincoln South lens (Sleaford East rainfall station) and in the Uley Wanilla lens (Coomunga West rainfall station).

3.1 Musgrave PWA

Rainfall stations operated by the BoM are used as representative rainfall stations for long-term averages and changes in rainfall. DEW also operate a rainfall station at Polda (DEW station A0211001), within the Polda lens, with records going back to 2010.

The Elliston station (BoM station 18069) is located on the coast at the south-western end of the Bramfield groundwater lens. The annual total recorded here in 2018–19 was 424 mm (Figure 3.2), which is 1% below the average annual rainfall of 427 mm (1970–71 to 2018–19).

The Terrah Winds station (BoM station 18165) is located 25 km east of the Polda lens, just outside the eastern edge of the Musgrave PWA. It generally records drier inland rainfall conditions. The annual total recorded here in 2018–19 was 366 mm (Figure 3.4). This was 1% below the average annual rainfall of 370 mm (1970–71 to 2018–19).

The DEW-operated Polda rainfall station (A0211001) is located in the centre of the Polda lens. The annual total recorded here in 2018–19 was 329 mm (Figure 3.3), which is 12% below the average annual rainfall of 372 mm (2010–11 to 2018–19). This is well below the nearby Terrah Winds rainfall station total for 2018–19 (see above).

Well-above-average monthly rainfall was recorded in August and November 2018 and May 2019, at all three stations, and well-below-average monthly rainfall was recorded during summer (December 2018 to March 2019) at all three stations (Figure 3.8).

The long-term trend (1970–71 to 2018–19) is declining at both long-term BoM stations, with a greater rate of decline at Elliston. The trend at Polda from 2010–11 to 2018–19 is also declining.

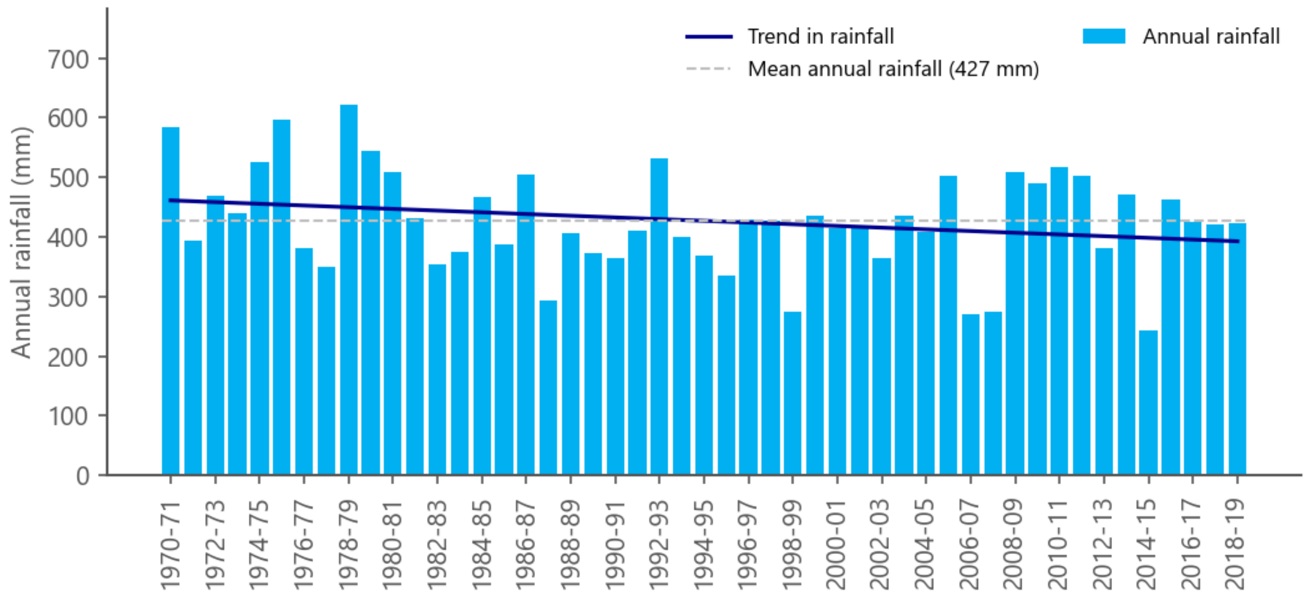

Figure 3.2. **Annual rainfall for 1970–71 to 2018–19 at the Elliston rainfall station (BoM station 18069)**

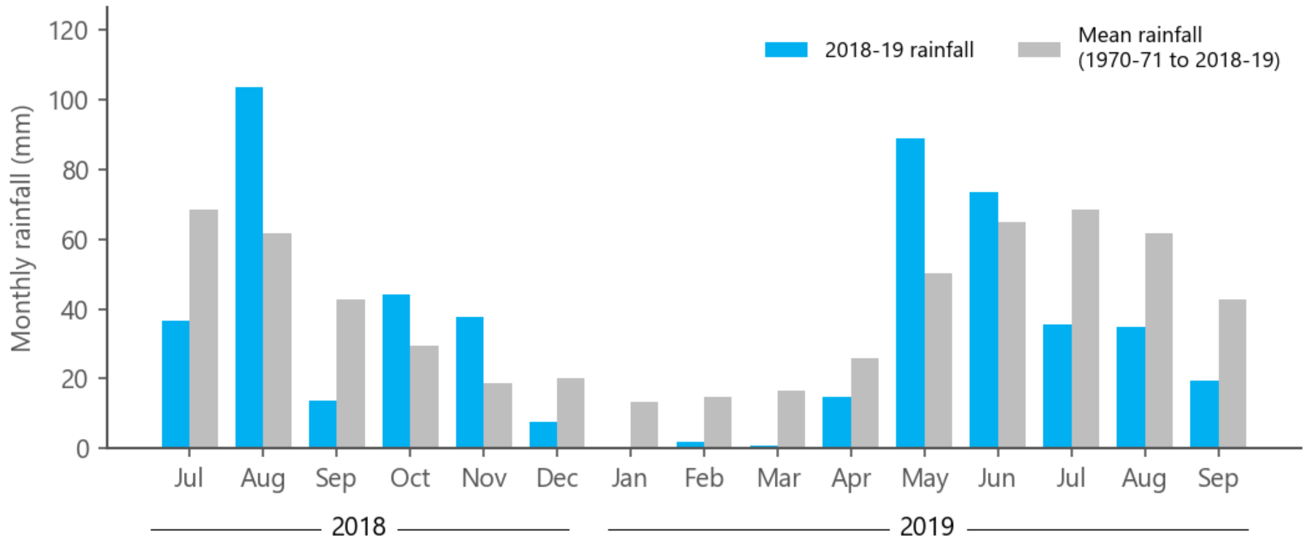

Figure 3.3. **Monthly rainfall between July 2018 and September 2019 at the Elliston rainfall station (BoM station 18069)**

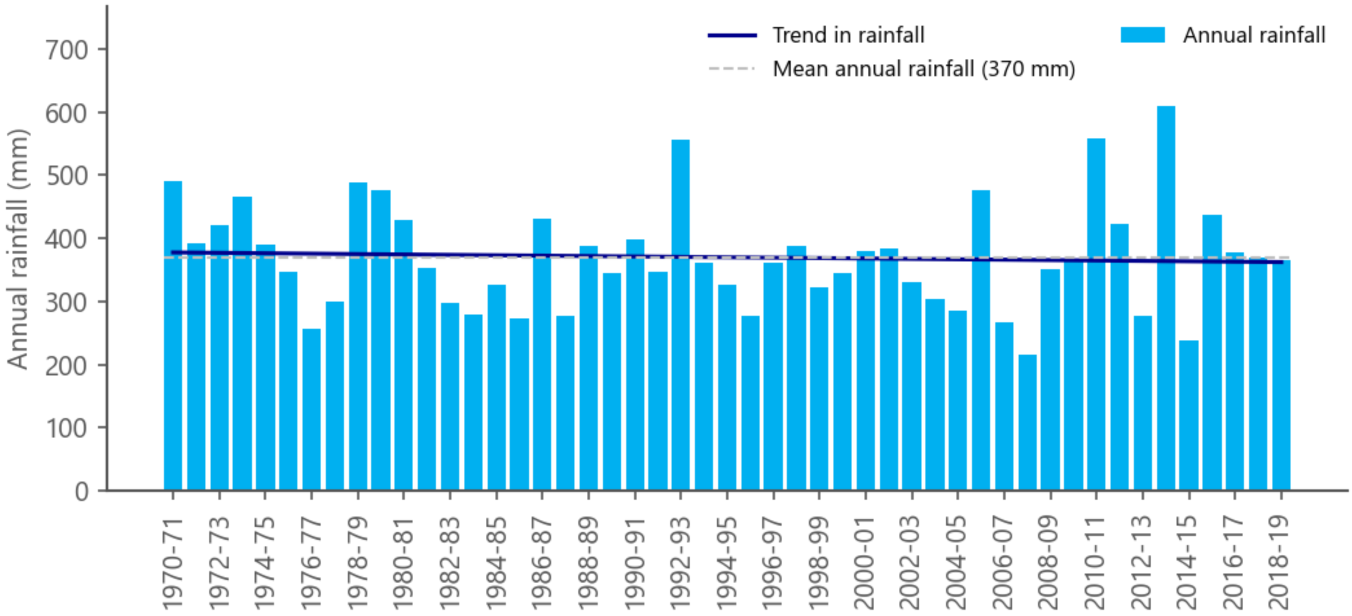

Figure 3.4. Annual rainfall for 1970–71 to 2018–19 at the Terrah Winds rainfall station (BoM station 18165)

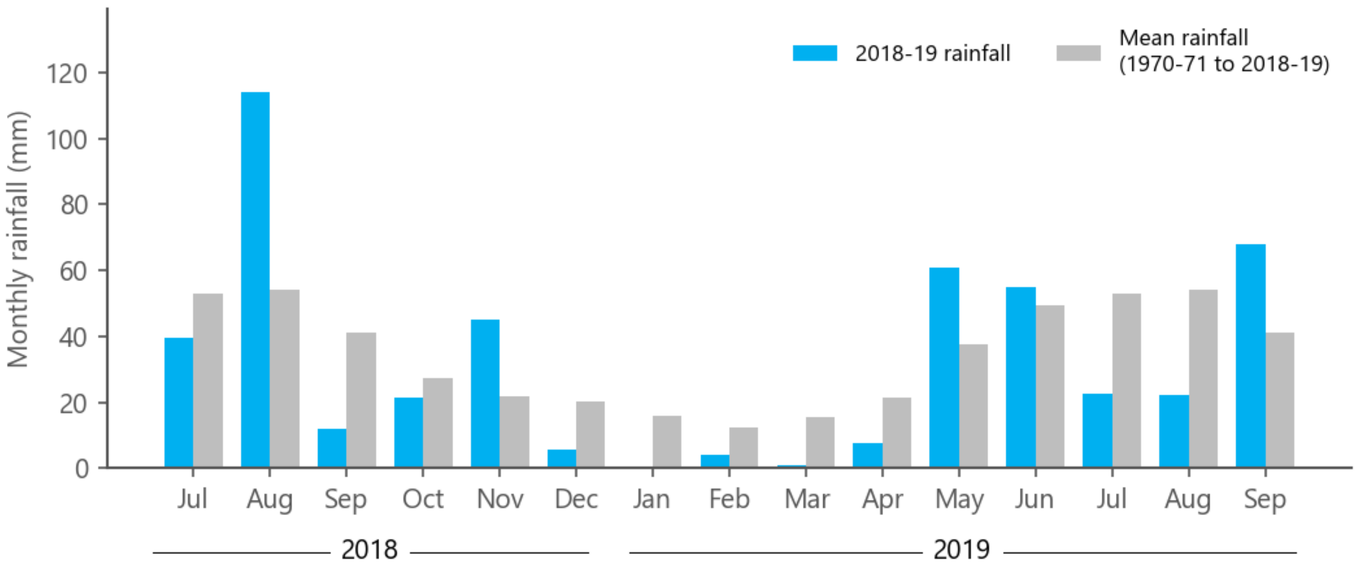

Figure 3.5. Monthly rainfall between July 2018 and September 2019 at the Terrah Winds rainfall station (BoM station 18165)

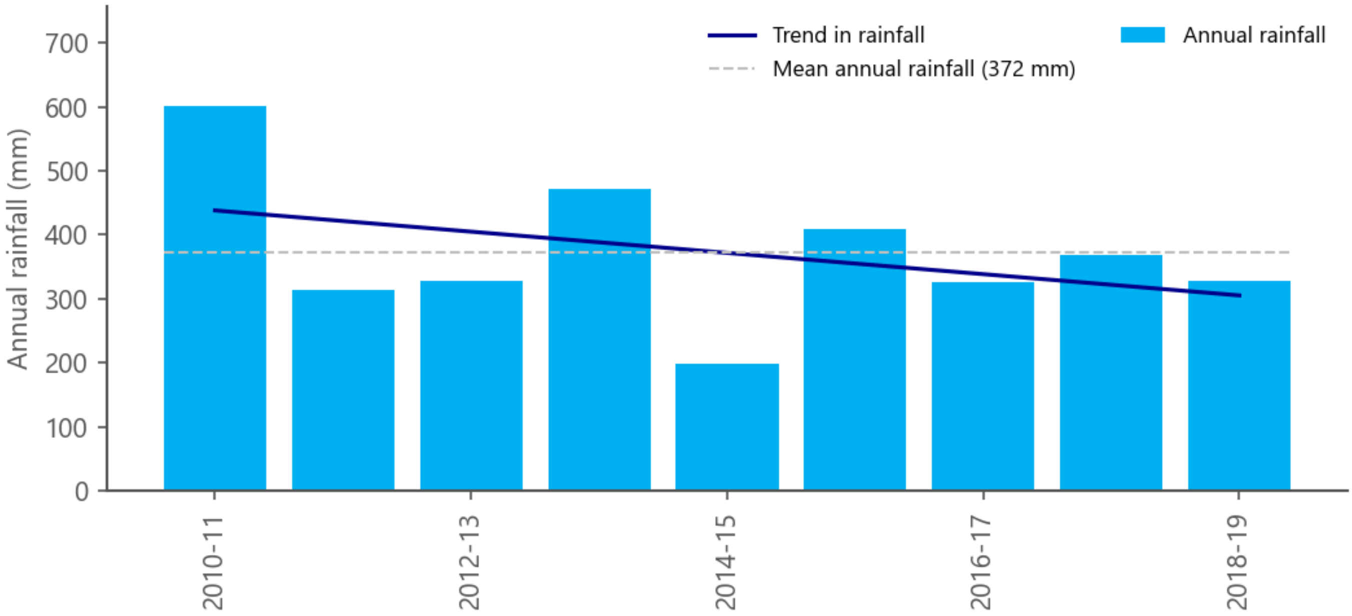

Figure 3.6. **Annual rainfall for 2010–11 to 2018–19 at the Polda rainfall station (DEW station A0211001)**

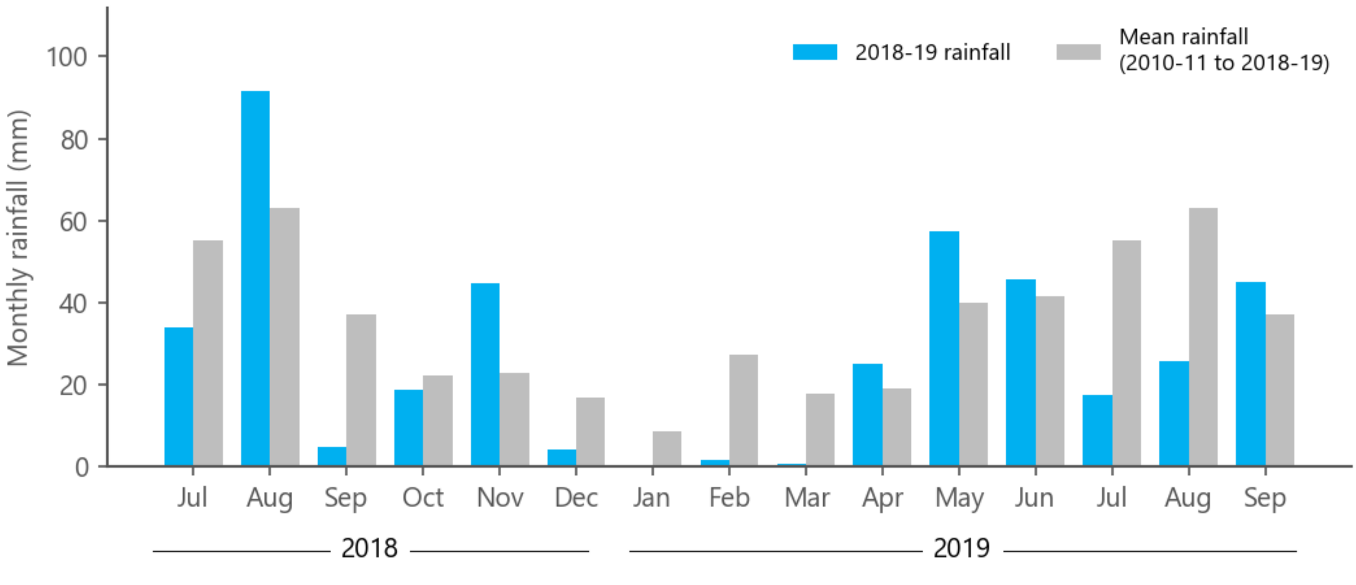

Figure 3.7. **Monthly rainfall between July 2018 and September 2019 at the Polda rainfall station (DEW station A0211001)**

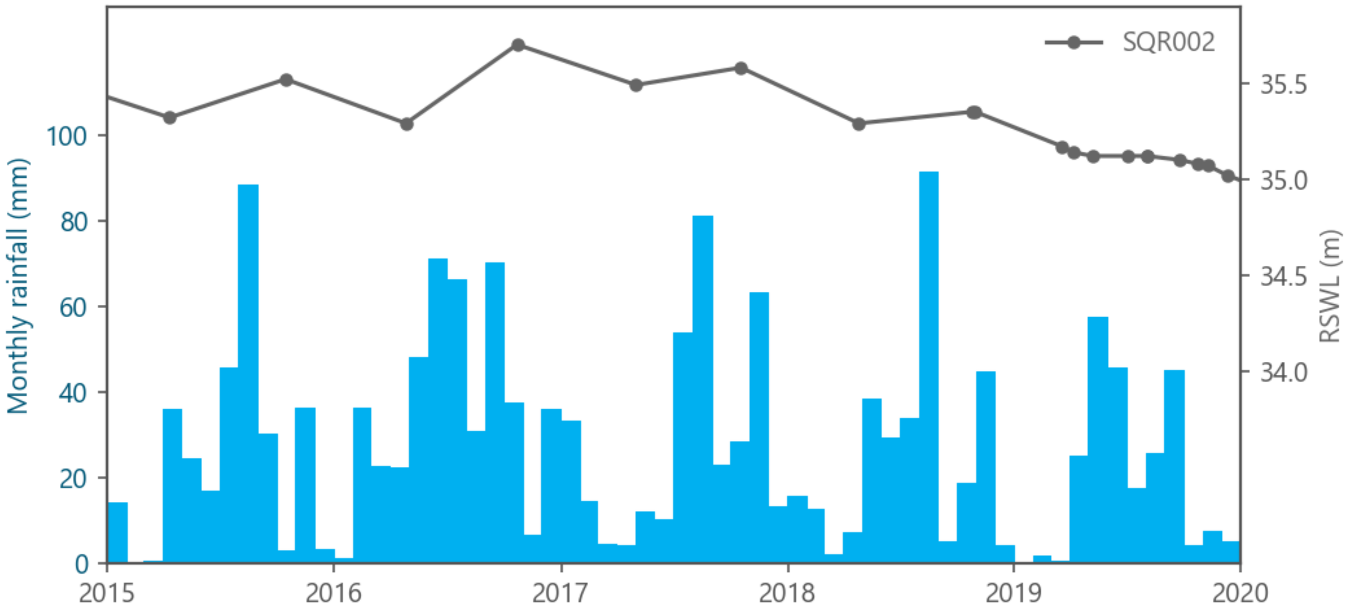

Figure 3.8. Monthly rainfall between 2015 and 2020 at Polda rainfall station (DEW station A0211001) compared to nearby Quaternary limestone groundwater levels from SQR002.

3.2 Southern Basins PWA

Rainfall stations operated by the BoM are used as representative rainfall stations for long-term averages and changes in rainfall, while DEW has also operated a number of rainfall stations since 2010 and 2016. The latter stations are used to monitor localised changes in the spatial distribution of rainfall totals and rainfall intensity. Previous studies have indicated that recharge to the Quaternary limestone aquifer is likely to occur when there are more than 10 days of rainfall of more than 10 mm between the months of May and October (Stewart et al., 2012). In 2018, this occurred at three of eight stations (Westmere, Shoal Point and Coomunga West) and in 2019 this occurred at two of eight stations (Big Swamp and Westmere).

The Big Swamp station (BoM station 18017) is located on the northern side of the Southern Basins PWA, near the Uley Wanilla lens. The annual total recorded here in 2018–19 was 564 mm (Figure 3.9) which is 1% above the average annual rainfall of 557 mm (1970–71 to 2018–19). Above-average monthly rainfall occurred in August, October and November 2018, and also May 2019. Daily rainfall above 10 mm occurred on 9 days between May and October 2018, and on 11 days between May and October 2019 (Figure 3.11).

The Westmere station (BoM station 18137) is located in the central part of the Southern Basins PWA, near the Lincoln South lens. The annual total recorded here in 2018–19 was 536 mm (Figure 3.12), which is 4% below the average annual rainfall of 558 mm (1970–71 to 2018-19). Above-average monthly rainfall occurred in August, October and November 2018 and May 2019. Daily rainfall above 10 mm occurred on 14 days between May and October 2018, and on 10 days between May and October 2019 (Figure 3.14).

Monthly rainfall at these two long-term monitoring sites was well-above-average for August 2018 and May 2019, while rainfall was well-below-average in particular for September 2018 and between January and April 2019.

For the rainfall stations operated by DEW since 2010 and 2016:

- Coffin Bay Golf Course (DEW station A5121002) recorded an annual total in 2018–19 of 508 mm (Figure 3.15), which was 3% above the average annual rainfall of 494 mm (2010–11 to 2018–19). Daily rainfall above 10 mm occurred on 9 days between May and October 2018, and on 7 days between May and October 2019 (Figure 3.17).
- Shoal Point (located in the Uley South lens; DEW station A5121003) recorded an annual total in 2018–19 of 505 mm (Figure 3.18), which was 10% above the average annual rainfall of 460 mm (2010–11 to 2018–19). Daily rainfall above 10 mm occurred on 10 days between May and October 2018, and on 7 days between May and October 2019 (Figure 3.20).
- Cooroona Water Hole (located in the Uley South lens; DEW station A5121004) recorded an annual total in 2018–19 of 512 mm, which was 11% above the average annual rainfall of 461 mm (2010–11 to 2018–19). Daily rainfall above 10 mm occurred on 13 days between May and October 2018, and on 4 days between May and October 2019.
- Uley Ruins Hole (located in the Uley South lens; DEW station A5121005) recorded an annual total in 2018–19 of 503 mm, which was 8% above the average annual rainfall of 464 mm (2010–11 to 2018–19). Daily rainfall above 10 mm occurred on 9 days between May and October 2018, and on 4 days between May and October 2019.
- Coomunga West (located in the Uley Wanilla lens; DEW station A5121007) recorded an annual total in 2018–19 of 561 mm. Daily rainfall above 10 mm occurred on 10 days between May and October 2018, and on 7 days between May and October 2019.
- Sleaford East (located in the Lincoln South lens; DEW station A5121008) recorded an annual total in 2018–19 of 486 mm. Daily rainfall above 10 mm occurred on 8 days between May and October 2018, and on 4 days between May and October 2019.

Comparisons to annual averages are not shown for Coomunga West and Sleaford East, as these stations only have data back to 2016.

The long-term trend (1970–71 to 2018–19) is declining at both the long-term BoM stations, and also declining at the DEW stations operating since 2010.

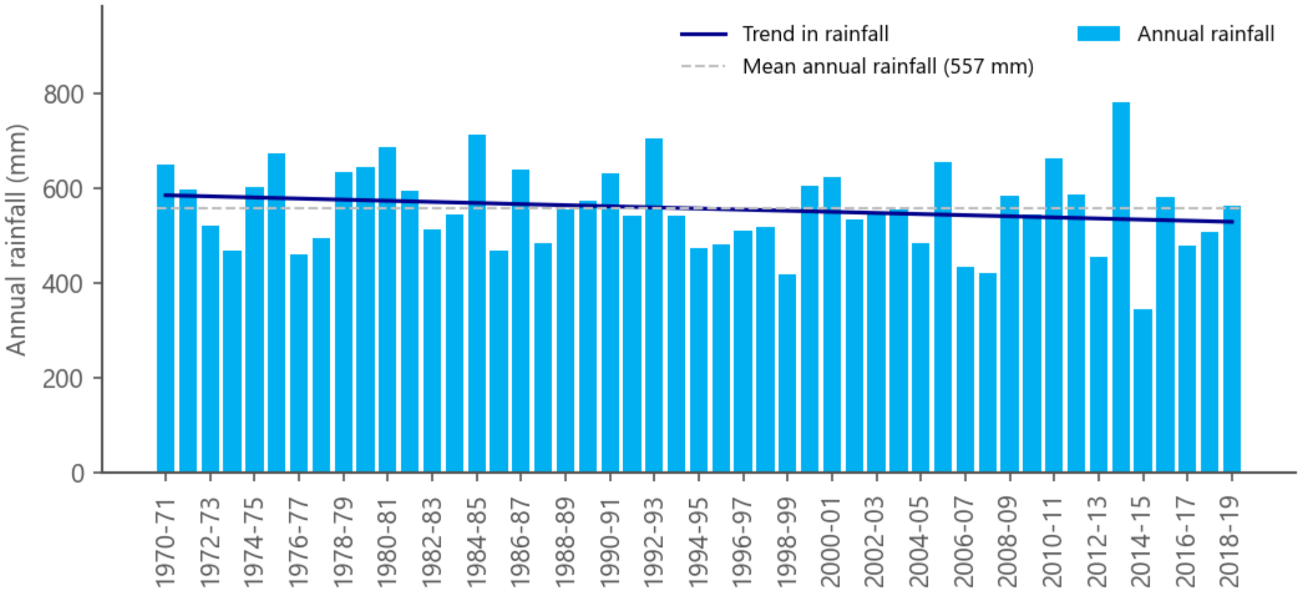

Figure 3.9. Annual rainfall for 1970–71 to 2018–19 at the Big Swamp rainfall station (BoM station 18017)

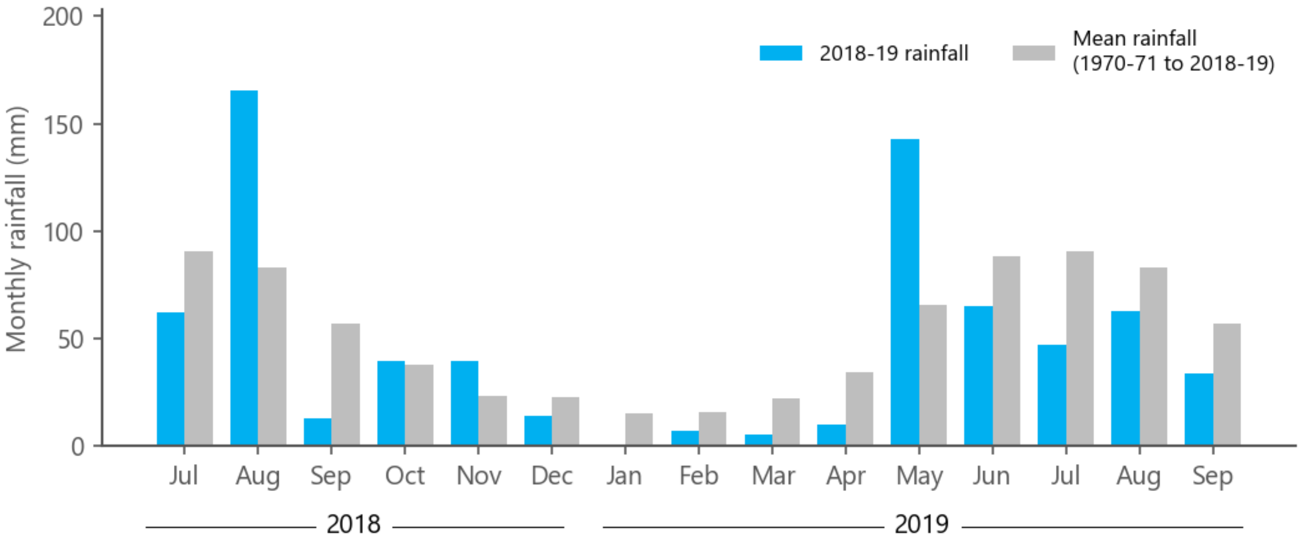

Figure 3.10. Monthly rainfall between July 2018 and September 2019 at the Big Swamp rainfall station (BoM station 18017)

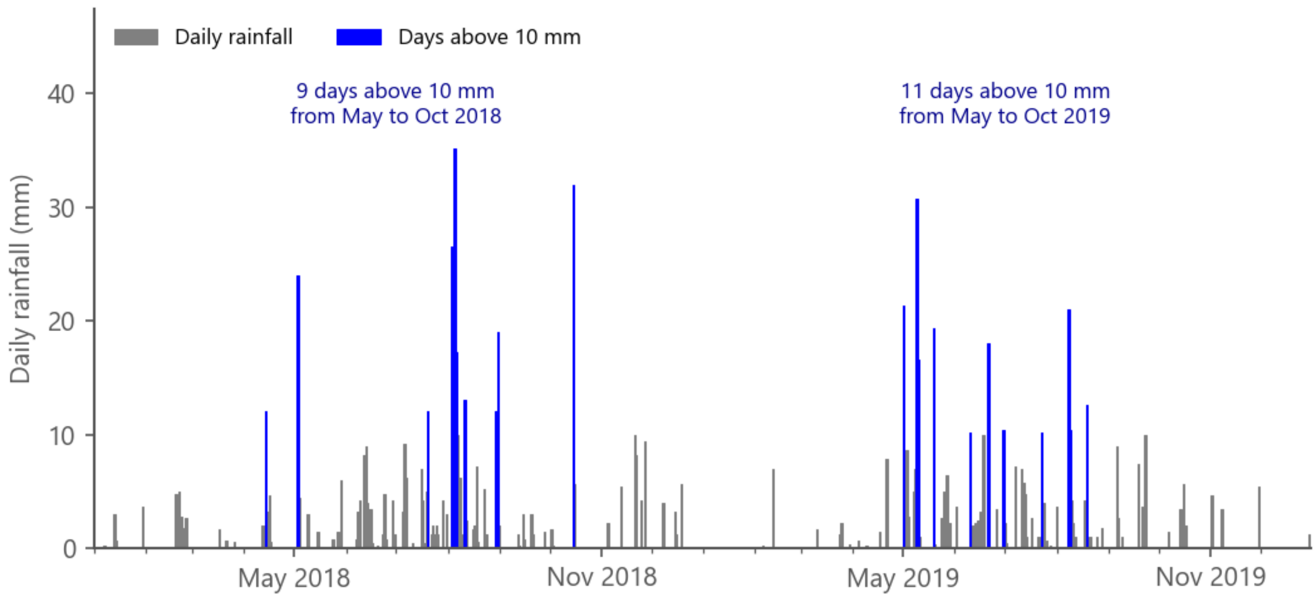

Figure 3.11. **Daily rainfall in 2018 and 2019 at the Big Swamp rainfall station (BoM station 18017)**

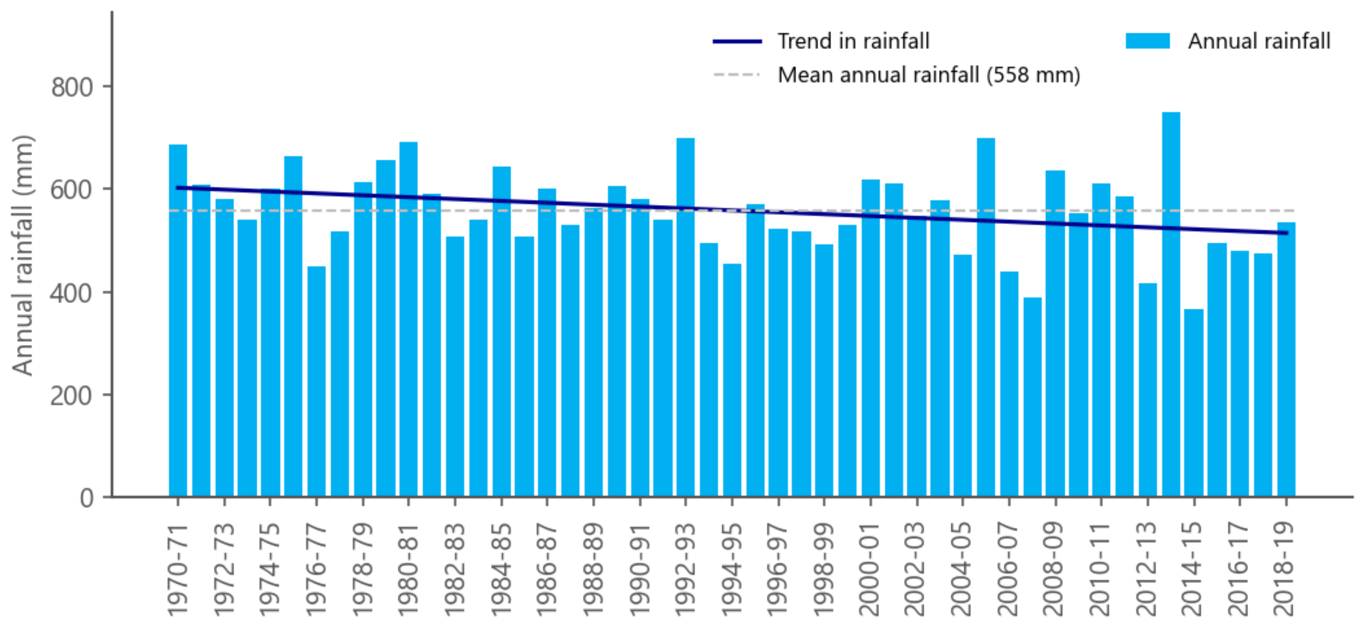

Figure 3.12. **Annual rainfall for 1970–71 to 2018–19 at the Westmere rainfall station (BoM station 18137)**

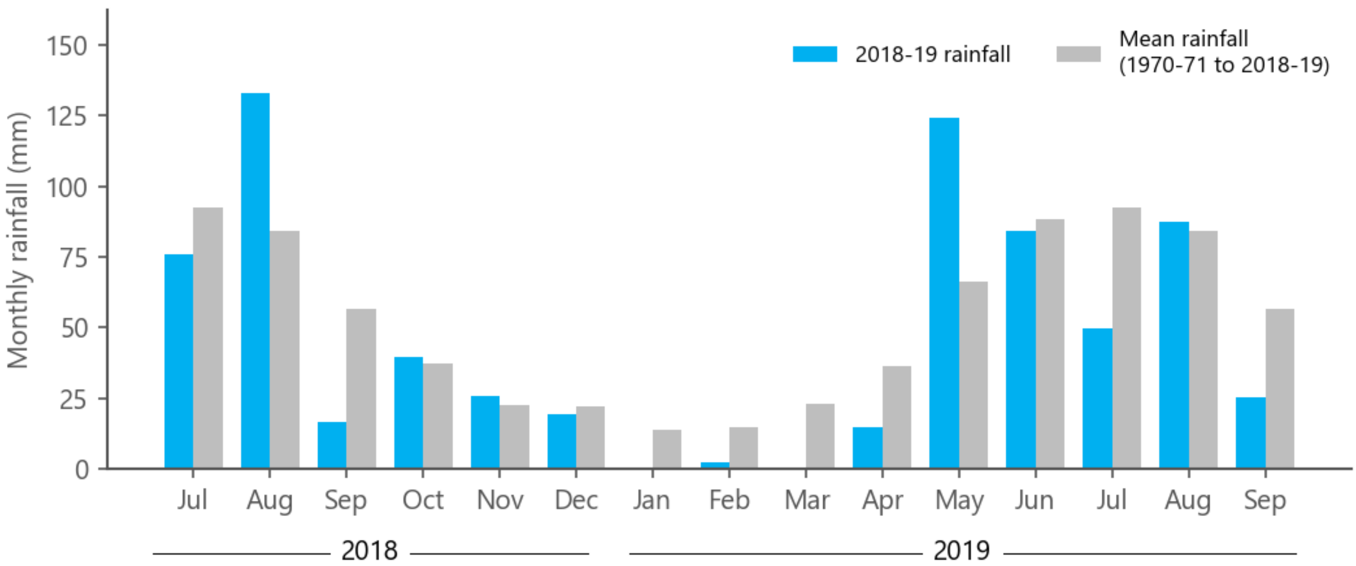

Figure 3.13. Monthly rainfall between July 2018 and September 2019 at the Westmere rainfall station (BoM station 18137)

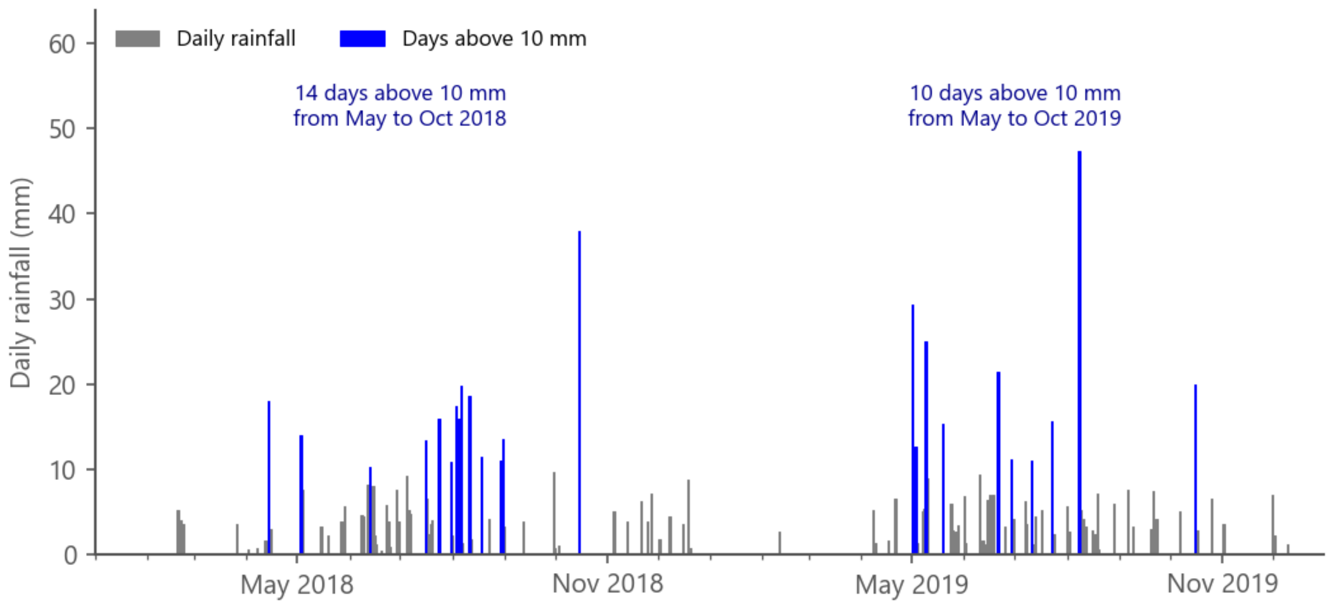

Figure 3.14. Daily rainfall in 2018 and 2019 at the Westmere rainfall station (BoM station 18137)

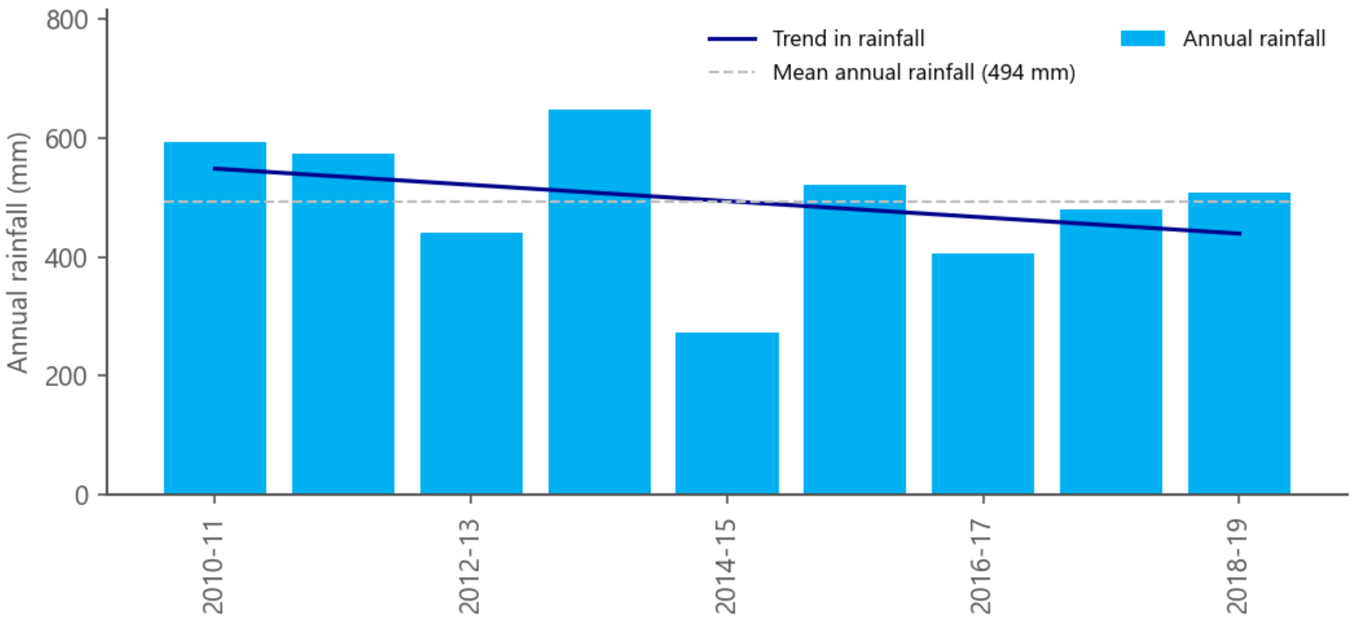

Figure 3.15. Annual rainfall for 2010–11 to 2018–19 at the Coffin Bay Golf Course rainfall station (DEW station A5121002)

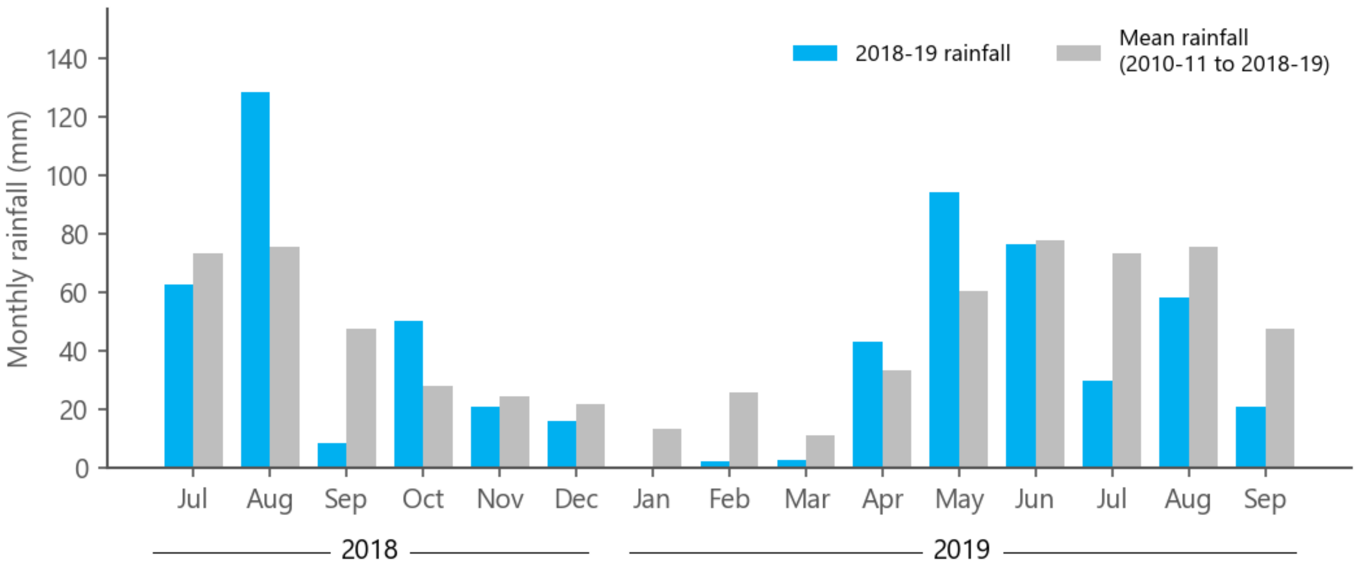

Figure 3.16. Monthly rainfall between July 2018 and September 2019 at the Coffin Bay Golf Course rainfall station (DEW station A5121002)

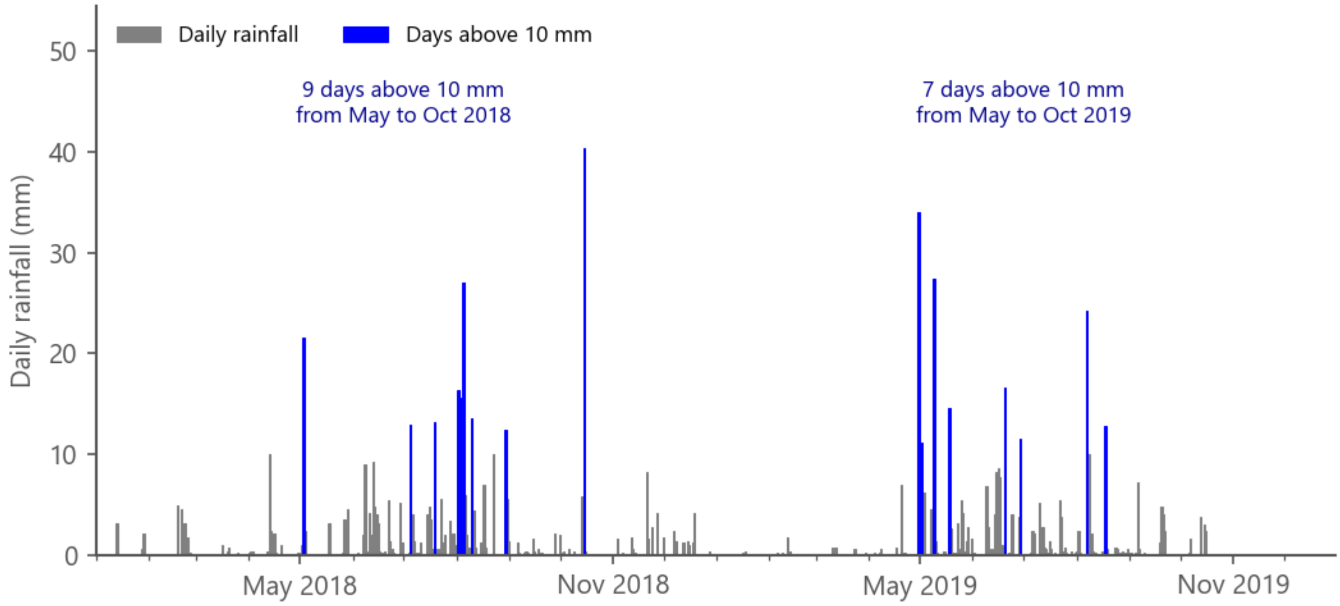

Figure 3.17. Daily rainfall in 2018 and 2019 at the Coffin Bay Golf Course rainfall station (DEW station A5121002)

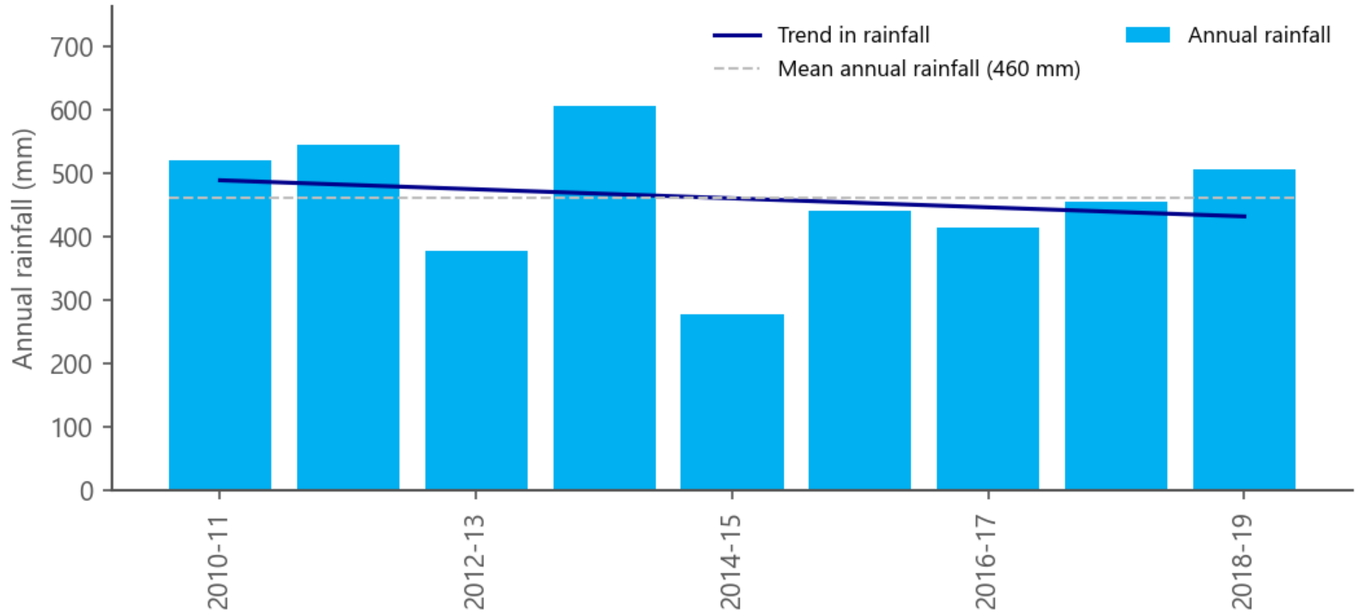

Figure 3.18. Annual rainfall for 2010–11 to 2018–19 at the Shoal Point rainfall station (DEW station A5121003)

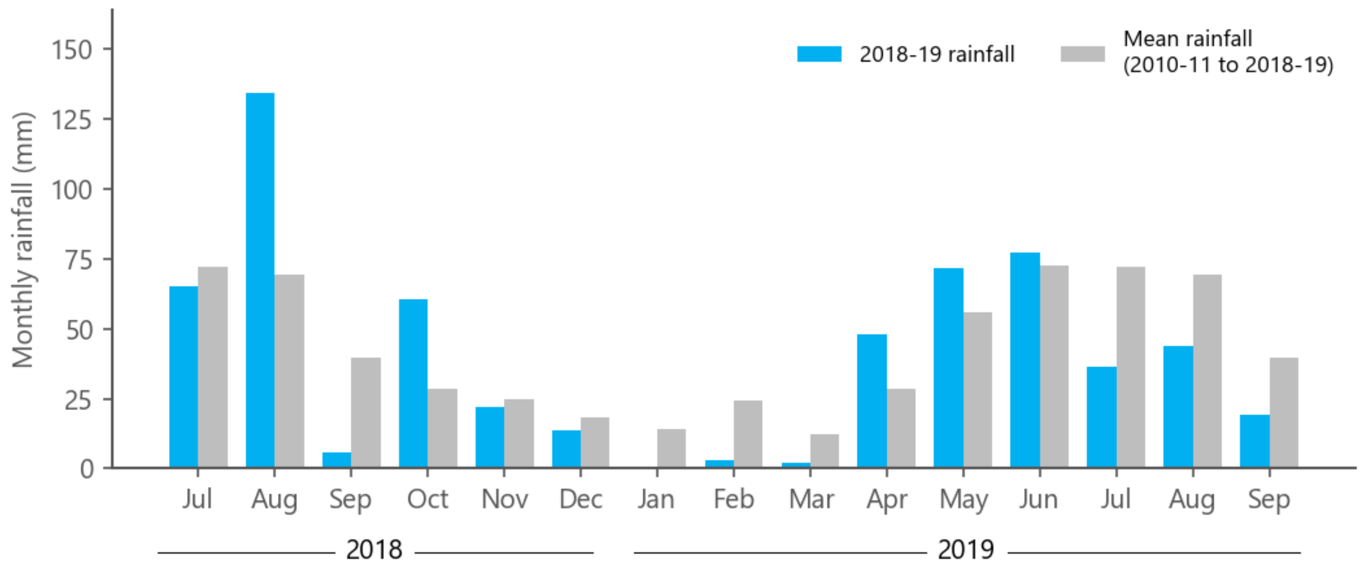

Figure 3.19. Monthly rainfall between July 2018 and September 2019 at the Shoal Point rainfall station (DEW station A5121003)

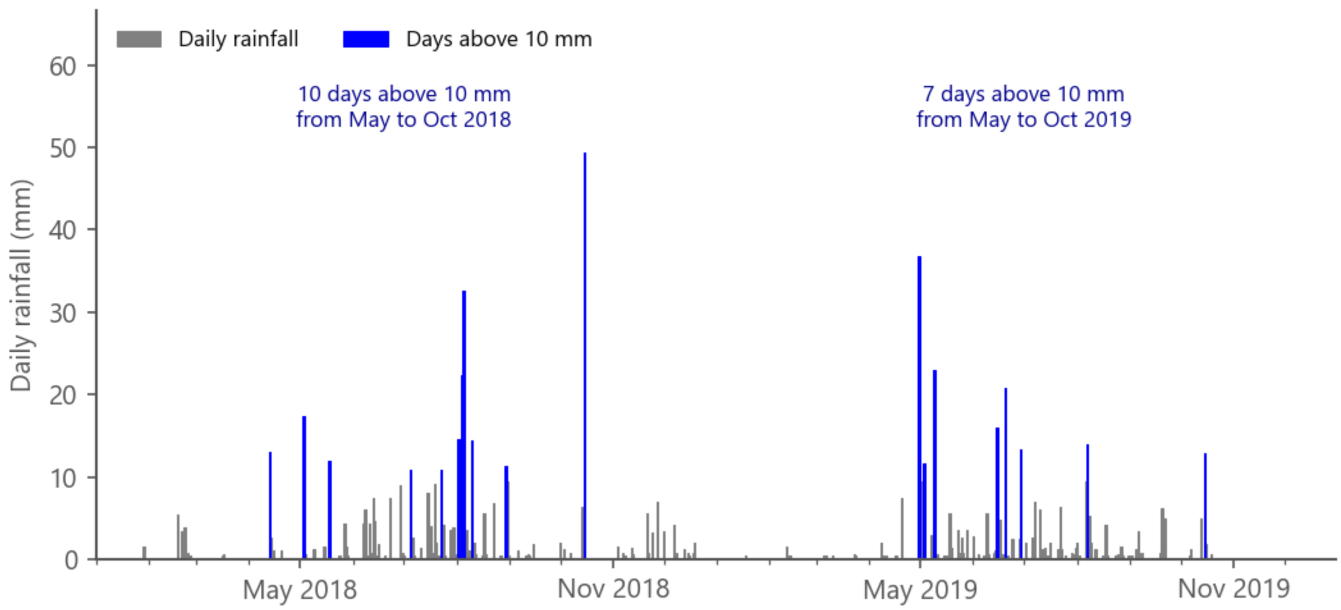

Figure 3.20. Daily rainfall in 2018 and 2019 at the Shoal Point rainfall station (DEW station A5121003)

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 in the Musgrave PWA, which 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 (QL) aquifer. The groundwater resources in the QL aquifer are referred to as lenses and are separated by areas where the aquifer is thinner or dry. The water allocation plan defines consumptive pools which extend beyond the physical boundary of the lens. This report uses the consumptive pools to divide the QL aquifer resources for discussion. There are also underlying low-yielding aquifers containing higher salinity groundwater: the Tertiary Sand (TS) aquifer and fractured rock aquifers, neither of which are widely utilized.

Groundwater levels and salinities in both PWAs are highly responsive to recharge from rainfall and trends in groundwater level or 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 both elements can cause the groundwater levels to decline and salinities to 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 QL 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 form a thin aquitard and the underlying TS aquifer. Generally, the TS aquifer is of higher salinity than the QL aquifer and also presents well development and yield problems due to fine-grained flowing sediments. It is therefore not widely used. The thin layer of Tertiary clay which separates the two aquifers is ubiquitous across the PWA.

The largest and most utilized QL aquifer 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 area used primarily for stock and domestic purposes. The main source of recharge to the Quaternary limestone aquifer is the direct infiltration of local rainfall, while the direction of groundwater flow is predominantly to the west and south-west.

4.2 Southern Basins PWA

In the Southern Basins PWA, the QL aquifer generally comprises aeolianite sediments of the Bridgewater Formation, similar to 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 QL and TS aquifers, but it is not present in all locations.

The largest and most utilized QL aquifer resources in the Southern Basins PWA are the Uley South, Coffin Bay, Uley Wanilla and Lincoln South lenses.

The main source of recharge to the Quaternary limestone aquifer is the direct infiltration of rainfall. Groundwater flow is predominantly in a westerly to southwesterly direction toward the Southern Ocean.

4.3 Musgrave PWA

4.3.1 Bramfield Consumptive Pool – water level

Observed recovered water levels in 2019 were below-average (3 wells out of 8 total) or very-much-below-average (4 wells) compared to historic levels for almost all of the QL aquifer wells with suitable long-term records in the Bramfield consumptive pool (Figure 4.1). The median well had below-average levels.

The change in water level over the last 10 years has been a decline in all 8 wells; the median change over 10 years has been a decline of 0.56 m, with similar changes over the past 20 years (median change is a decline of 0.90 m) and 30 years (median change is a decline of 2.06 m).

More recently, five-year trends in water level are declining for 84% of wells, with rates overall ranging from a decline of 0.43 m/y to a rise of 0.02 m/y (median rate is a decline of 0.07 m/y; Figure 4.2). All of the wells with long-term records are located around the township of Bramfield or to the north and north-west. All but one of these wells have continued their long-term decline over the past five years, whereas the five wells drilled more recently between Elliston and Bramfield are showing either lower rates of decline, stable, or even slightly increasing trends.

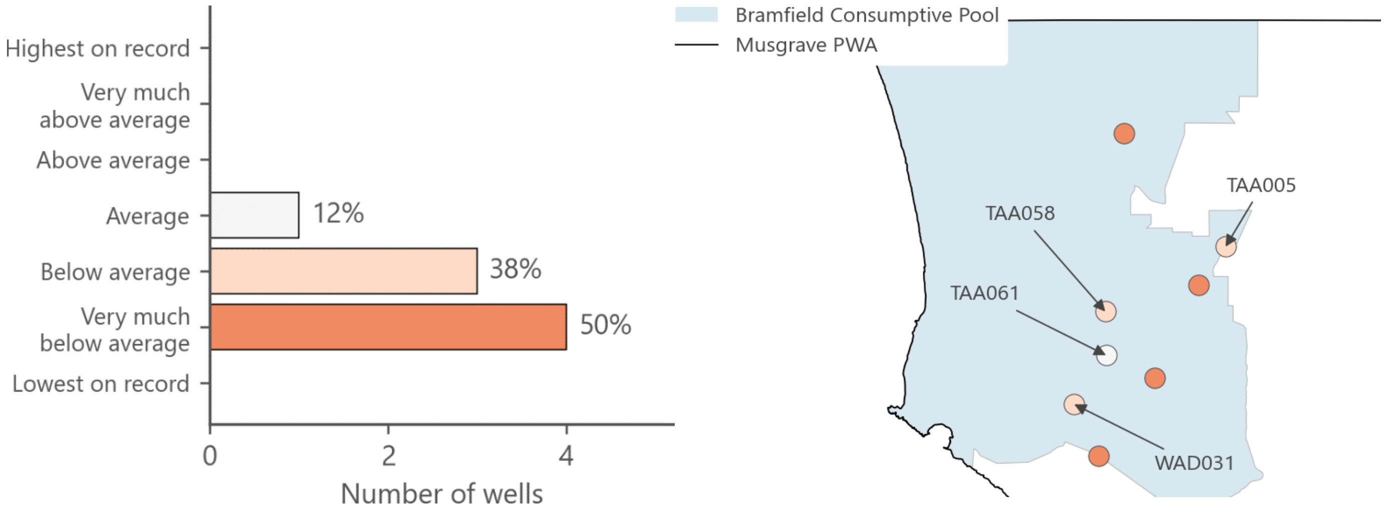

Figure 4.1. 2019 recovered water levels for wells in the QL aquifer in the Bramfield Consumptive Pool

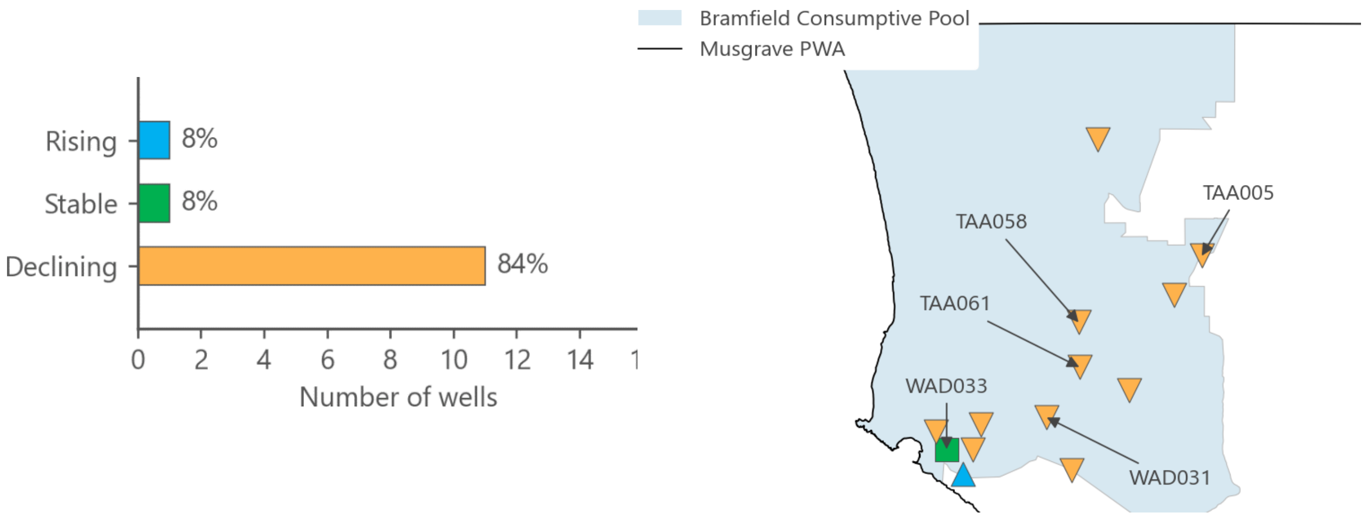

Figure 4.2. 2015-2019 trend in recovered water levels for wells in the QL aquifer in the Bramfield Consumptive Pool

Figure 4.3 shows hydrographs for some representative wells completed in the QL aquifer in the Bramfield area.

Long-term water level declines have occurred since 1990 in all wells, with most reaching their lowest level on record in 2008 during the Millennium Drought, following two consecutive years of very low rainfall. The only exception to this is TAA005, which is located on the western edge of the lens, which has monitoring data from 1963 onwards; in 1966 water levels declined to slightly lower levels than those seen in 2008.

The long-term decline is also observed in for example TAA058, TAA061 and WAD031, the latter being located in the township of Bramfield. In all cases, water levels recovered slightly following generally above-average rainfall years between 2008–09 and 2013–14. 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 in 2018 and 2019 has led to another decline in water levels.

WAD033 is close to the coast at Elliston and has a much shorter monitoring period. It is included here to illustrate more stable trends in recent years, with declines in 2019 less pronounced than other wells.

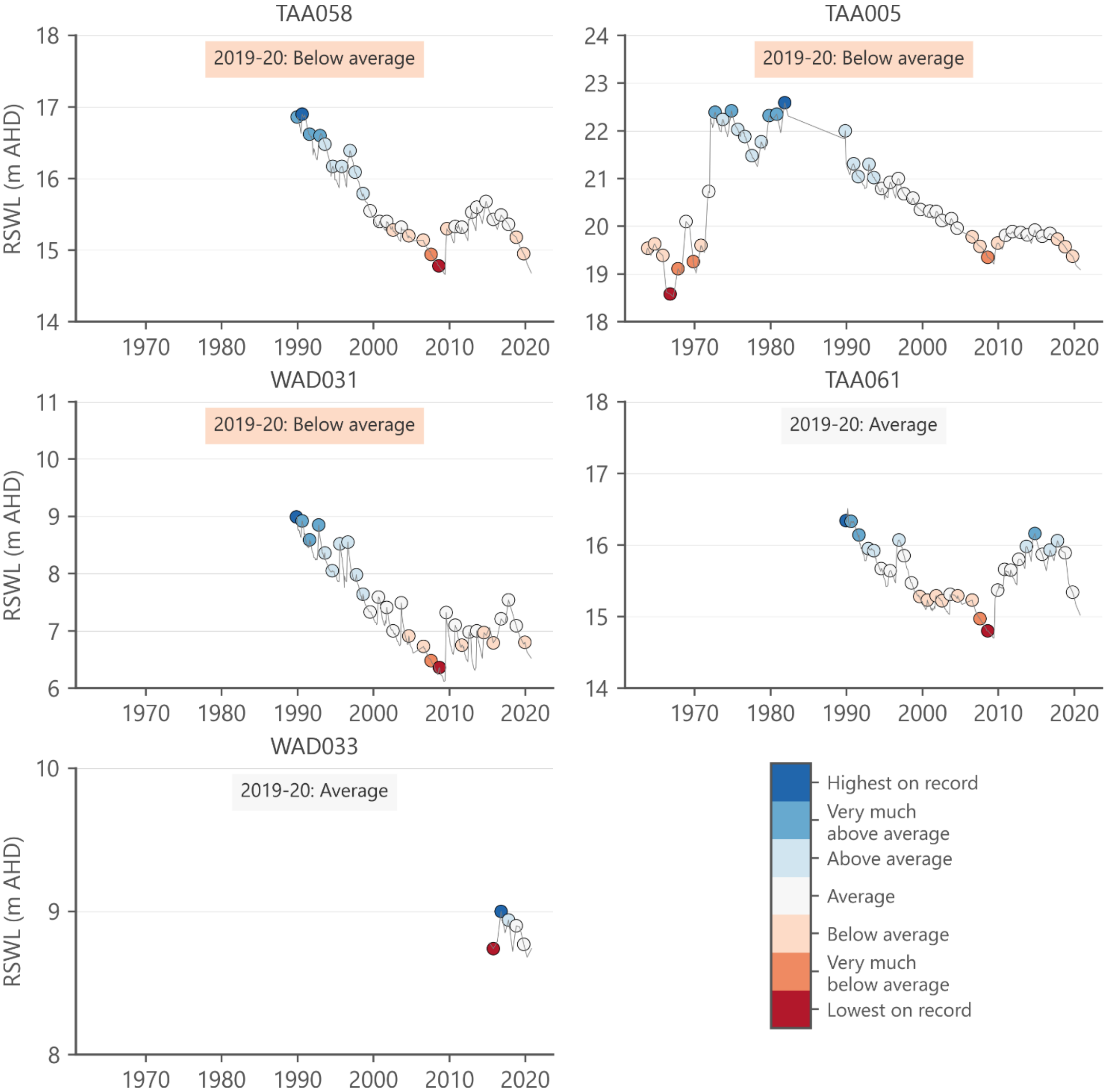

Figure 4.3. Selected hydrographs for wells in the QL aquifer in the Bramfield Consumptive Pool

4.3.2 Bramfield Consumptive Pool – salinity

In 2019, the groundwater salinity in the QL aquifer ranged from 403 mg/L to 1005 mg/L (Figure 4.4). Almost all wells were below 1000 mg/L (90%), with a median salinity of 572 mg/L.

Five-year salinity trends vary across the lens, with generally stable or decreasing salinities observed in the south-western end of the lens (80% of wells; Figure 4.5) and one well with an increasing trend (TAA057) in the north-eastern part of the lens.

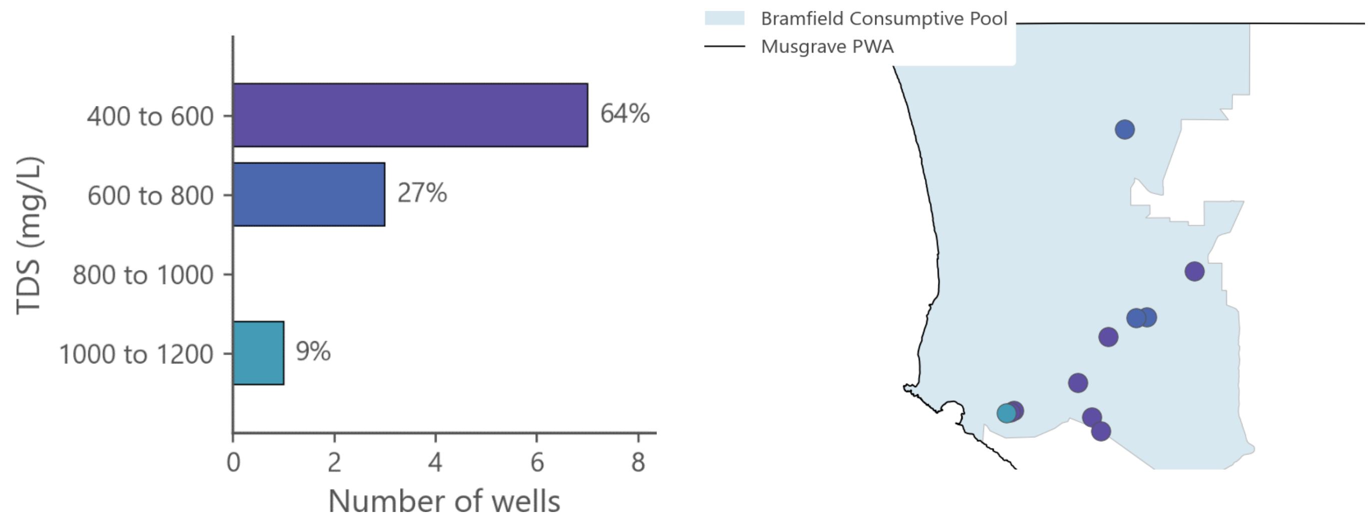

Figure 4.4. 2019 salinity observations from wells in the QL aquifer in the Bramfield Consumptive Pool

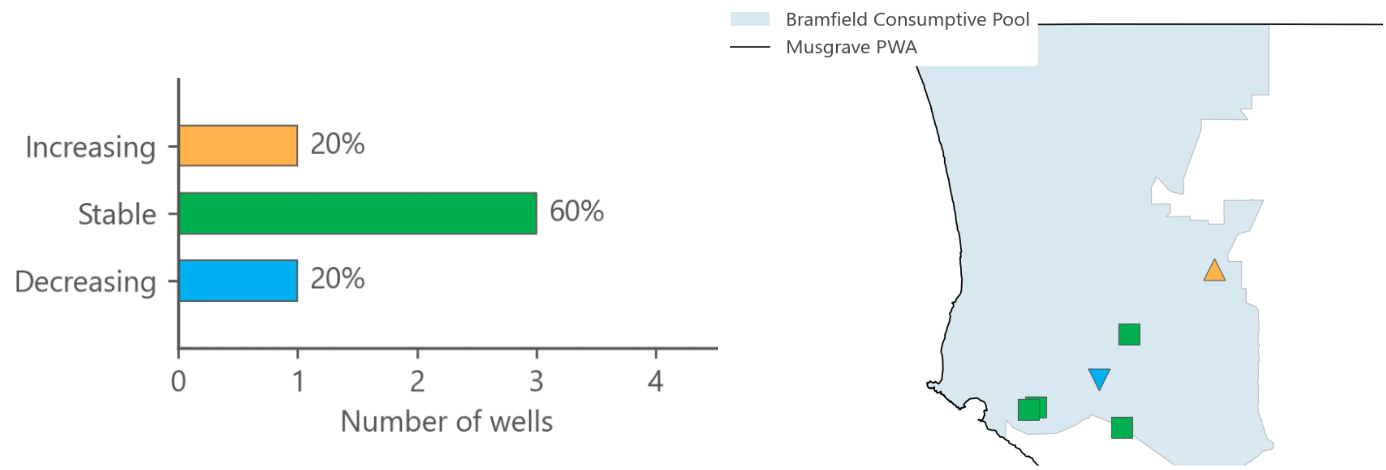

Figure 4.5. 2015-2019 trend in water salinity for wells in the QL aquifer in the Bramfield Consumptive Pool

4.3.3 Polda Consumptive Pool – water level

Observed recovered water levels in 2019 were below-average when compared to historic levels for the majority of QL aquifer wells (64%) in the Polda Consumptive Pool (Figure 4.6). A smaller number of wells, mainly on the northern edge of the Quaternary lens, were at very-much-below-average levels (28%) or at their lowest levels on record (8%).

The change in water level over the last 20 years has been a decline in all wells, with changes ranging from a decline of 1.02 m to a decline of 0.14 m (the median change is a decline of 0.39 m over 20 years).

More recently, five-year trends in water level are declining for all 31 wells, at rates of decline ranging from 0.08 m/y to 0.32 m/y (Figure 4.7). Wells with rates of decline greater than 0.20 m/y are mainly on the northern and western side of the Polda lens, with the majority of below-average wells showing less rapid rates of decline.

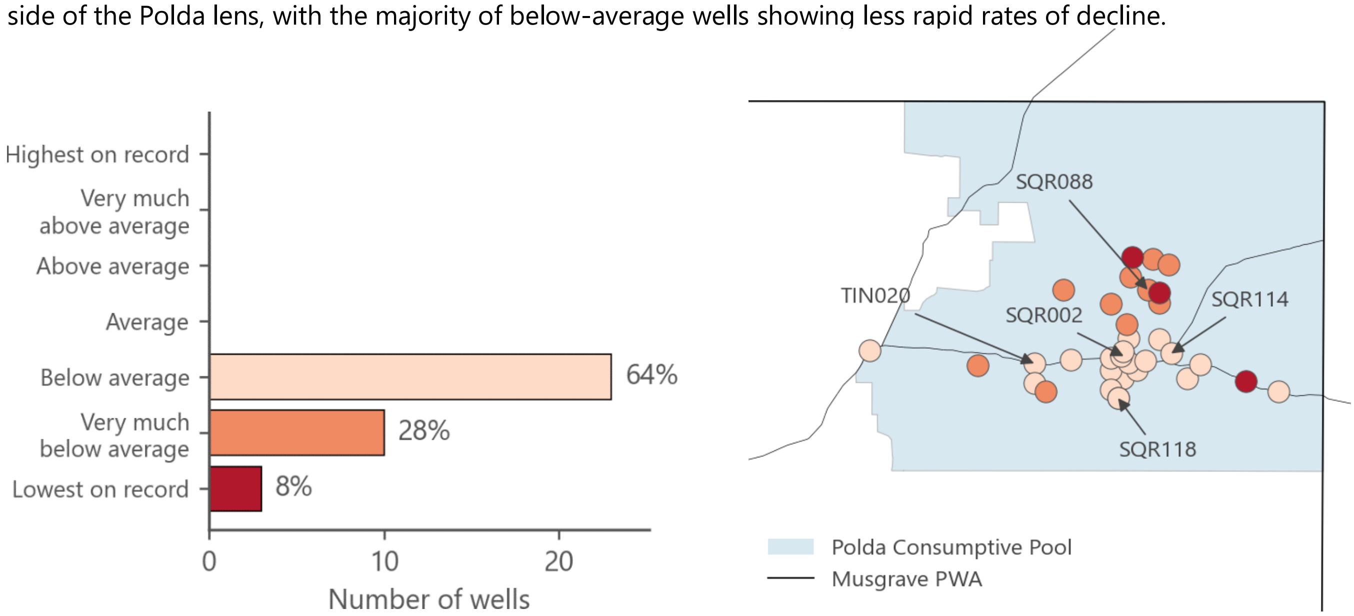

Figure 4.6. 2019 recovered water levels for wells in the QL aquifer in the Polda Consumptive Pool

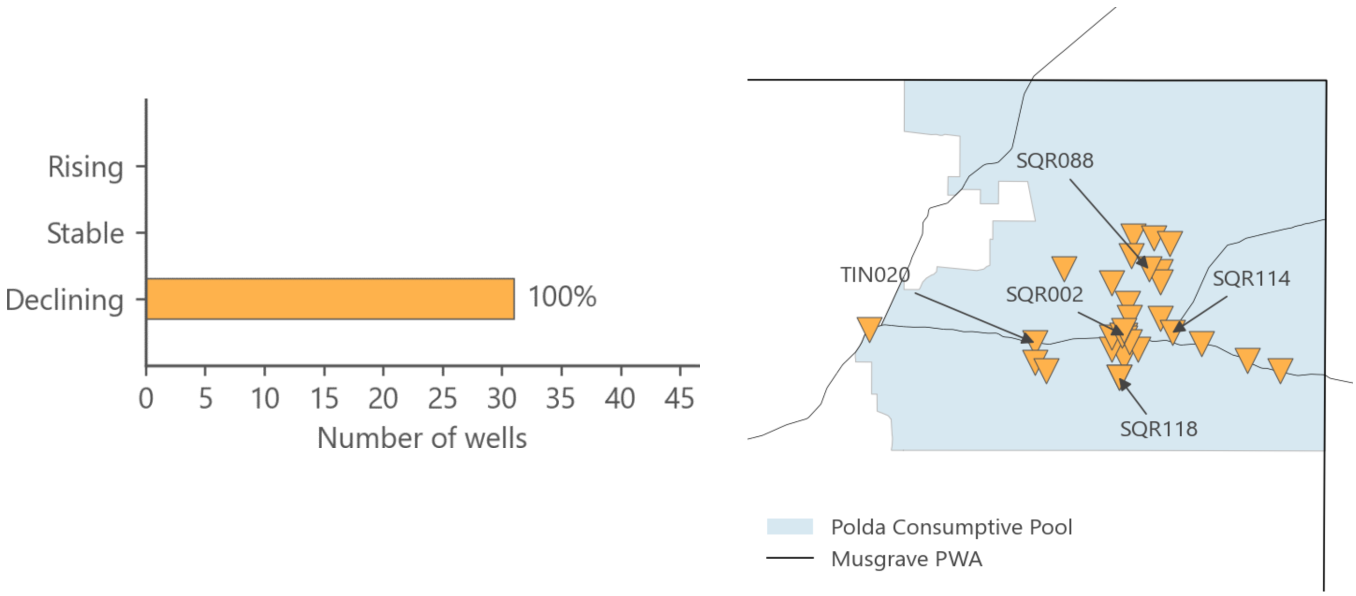

Figure 4.7. 2015-2019 trend in recovered water levels for wells in the QL aquifer in the Polda Consumptive Pool

Figure 4.8 shows a selection of hydrographs for QL aquifer monitoring wells in Polda. All of these wells reached their lowest level on record in 2009, with varying degrees of recovery following the reduction and then cessation of licensed extraction from Polda since 2008–09 (Section 5.1). High rainfall years in 2010–11 and 2013–14 led to short-term rises in water level in all wells.

SQR088 is located on the northern edge of the lens and TIN020 is located down-gradient from the main area of historical extraction from the Polda resource. Both of these wells experienced only minor recoveries over the past decade, with water levels in SQR088 in particular dropping to close to its historical low.

Other wells show more substantial recoveries over the past 10 years, such as those near the former SA Water pumping trench (SQR002) and farther east (SQR114) and south (SQR118). All these wells experienced recoveries during years of average and above-average rainfall, particularly prior to 2018. More recently water levels have declined for all wells throughout 2018 and 2019 despite good winter rainfall in 2018.

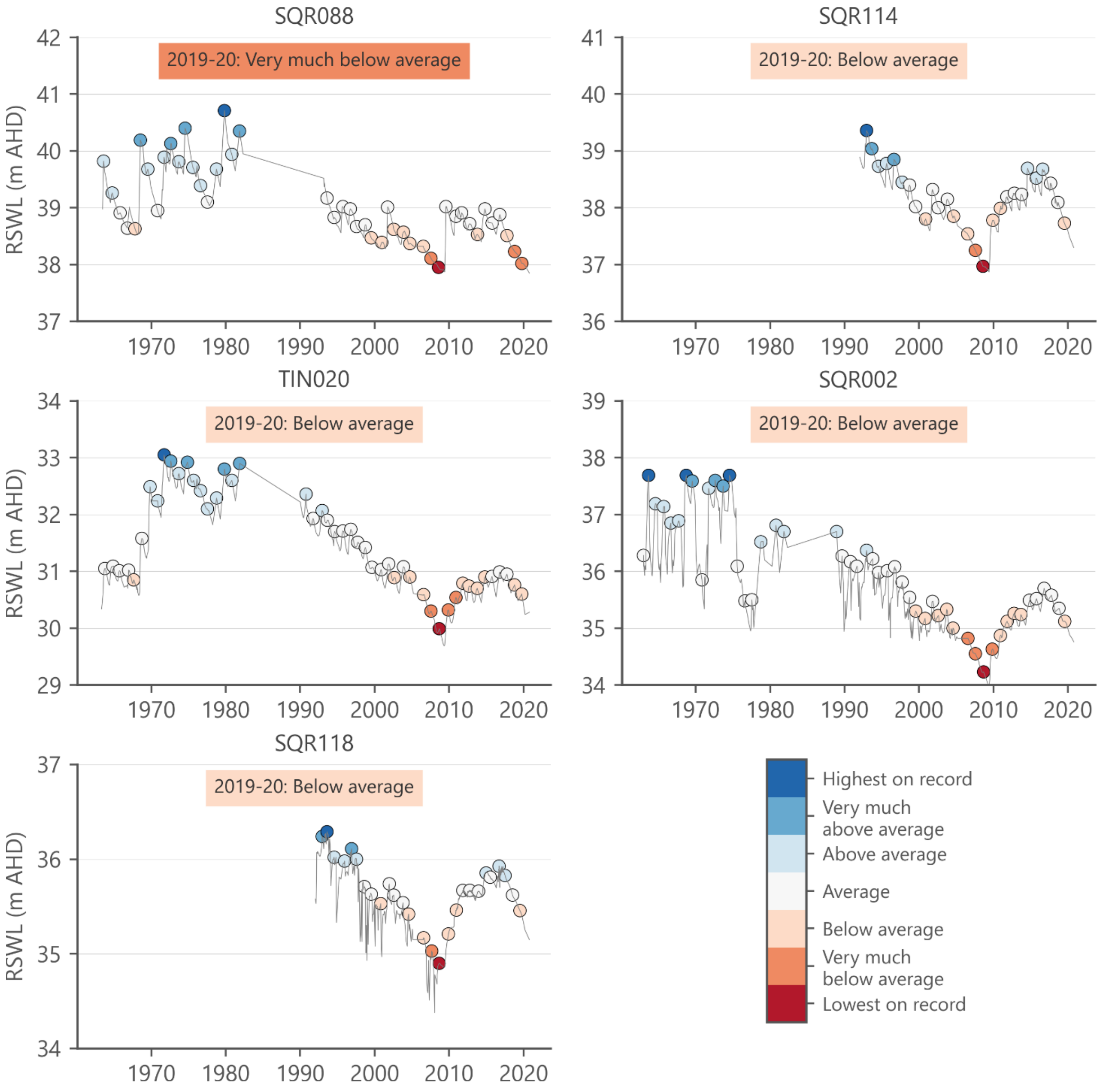

Figure 4.8. Selected hydrographs for wells in the QL aquifer in the Polda Consumptive Pool

4.3.4 Polda Consumptive Pool – salinity

In 2019, the groundwater salinity ranged from 466 to 2681 mg/L (Figure 4.9). Overall the median salinity was 826 mg/L.

Five-year trends in water salinity are predominantly stable (79% of wells; Figure 4.10). The percentage change in salinity over the past five years ranges from a decrease of 29% to an increase of 10% (median change is an increase of 1%, which is well within measurement error).

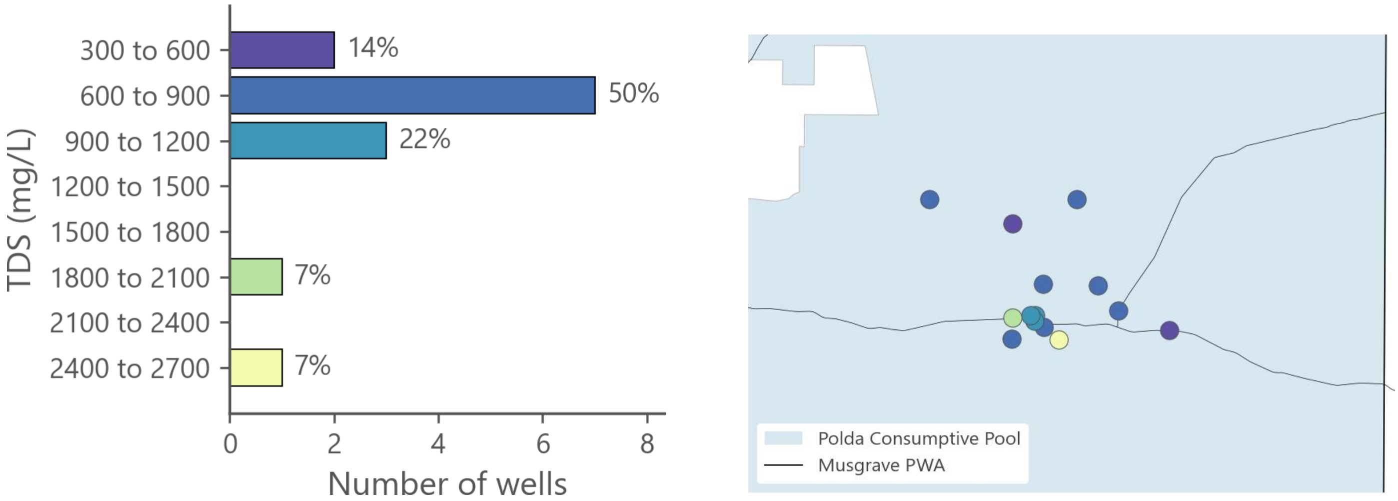

Figure 4.9. 2019 salinity observations from wells in the QL aquifer in the Polda Consumptive Pool

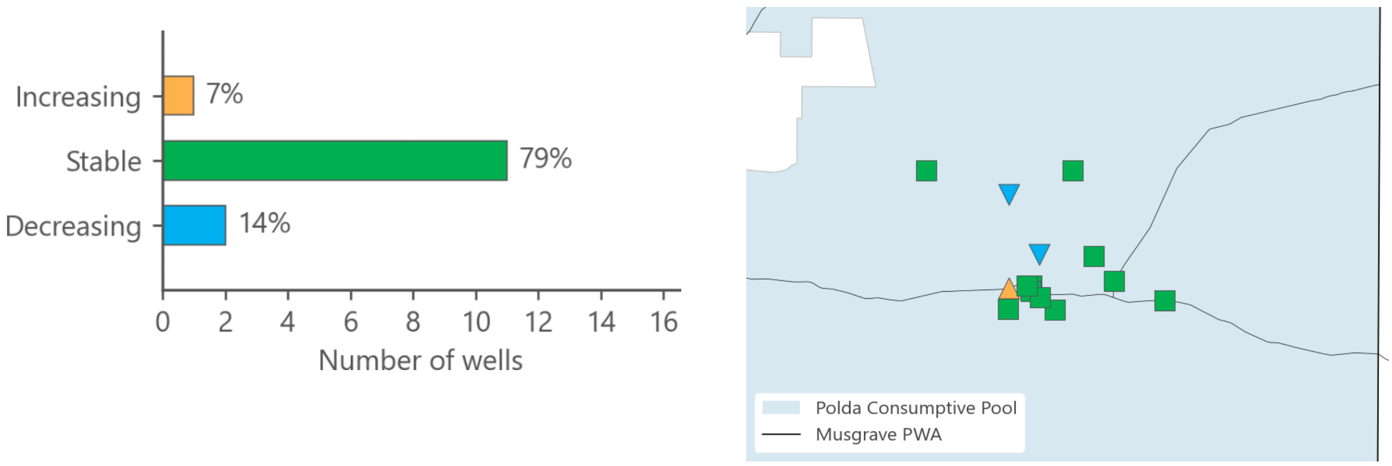

Figure 4.10. 2015-2019 trend in water salinity for wells in the QL aquifer in the Polda Consumptive Pool

4.4 Southern Basins PWA

4.4.1 Coffin Bay Consumptive Pool – water level

In 2019, average recovered water levels were observed in four out of a total of seven QL aquifer monitoring wells with long-term records compared to their historic record (Figure 4.11). Two wells showed below-average water levels and only one well showed a very-much-below-average level due to having a longer record than other wells in the area.

Over the last thirty years, water levels have declined in all wells with available data by a small amount. Declines range from 0.10 to 0.24 m, with a median decline of 0.15 m.

Five-year trends in water level are showing mainly rising (57% of wells) and stable (29% of wells; Figure 4.12) trends. However, water levels continue to be essentially stable, with very low rates of change: the maximum rate of change observed over the last five years is a declining trend of 2 cm/y in LKW055.

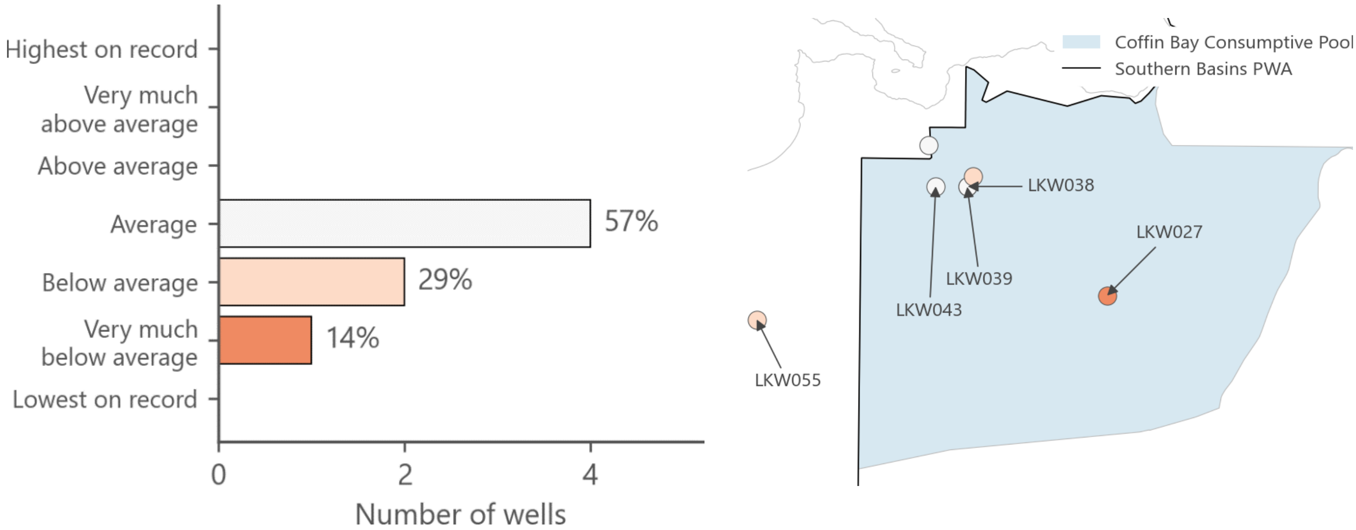

Figure 4.11. 2019 recovered water levels for wells in the QL aquifer in and around the Coffin Bay Consumptive Pool

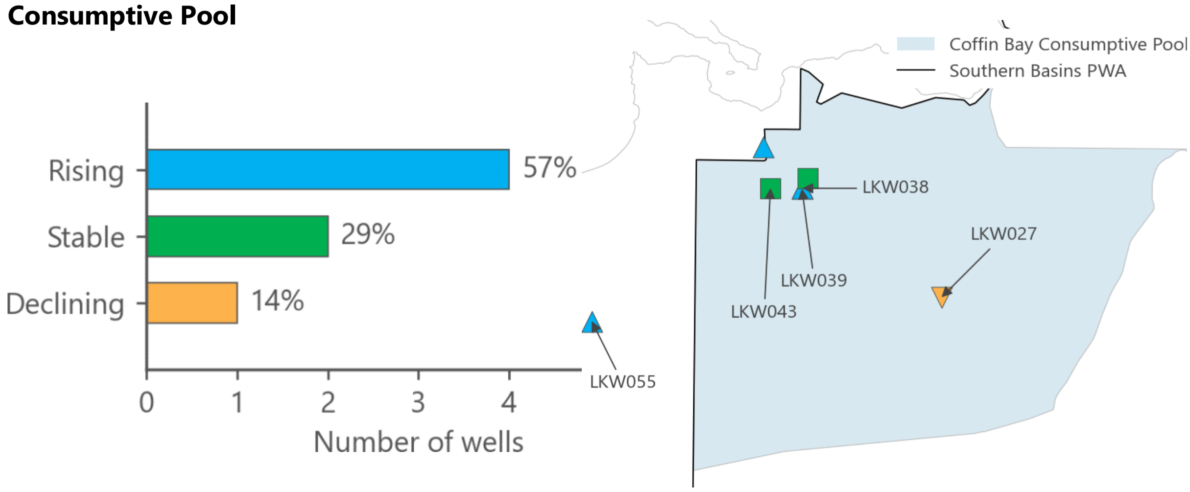

Figure 4.12. 2015-2019 trend in recovered water levels for wells in the QL aquifer in and around the Coffin Bay Consumptive Pool

Figure 4.13 shows hydrographs for a selection of QL aquifer monitoring wells in the Coffin Bay area.

LKW038 and LKW039 are located within the wellfield of SA Water production wells, which are used to supply water to the township of Coffin Bay. Both show seasonal changes with generally stable water levels over the past thirty years. Lowest-on-record levels seen in 2007 are likely related to below-average rainfall recorded in 2006 and 2007. Sudden rises in water level can be noted in the hydrographs, with highest-on-record levels in 1992 and 2013 likely related to high winter and spring rainfall in both of those years.

LKW043 and LKW055 are located in the western part of the Coffin Bay area and show generally stable trends.

LKW027 is located at a higher elevation to the south-east. Groundwater generally flows to the north-west from this location. Water levels were typically above average prior to 1992 and average or below-average since then. This is likely due to generally below-average rainfall between 1993–94 and 1998–99 (Figure 3.9) and increasing extraction from the Coffin Bay wellfield, which increased from approximately 20 ML in 1986 (EP NRM Board, 2016) to 266 ML in 2002–03 (Figure 5.3). Extraction has reduced since then and the water level in LKW027 has stabilised.

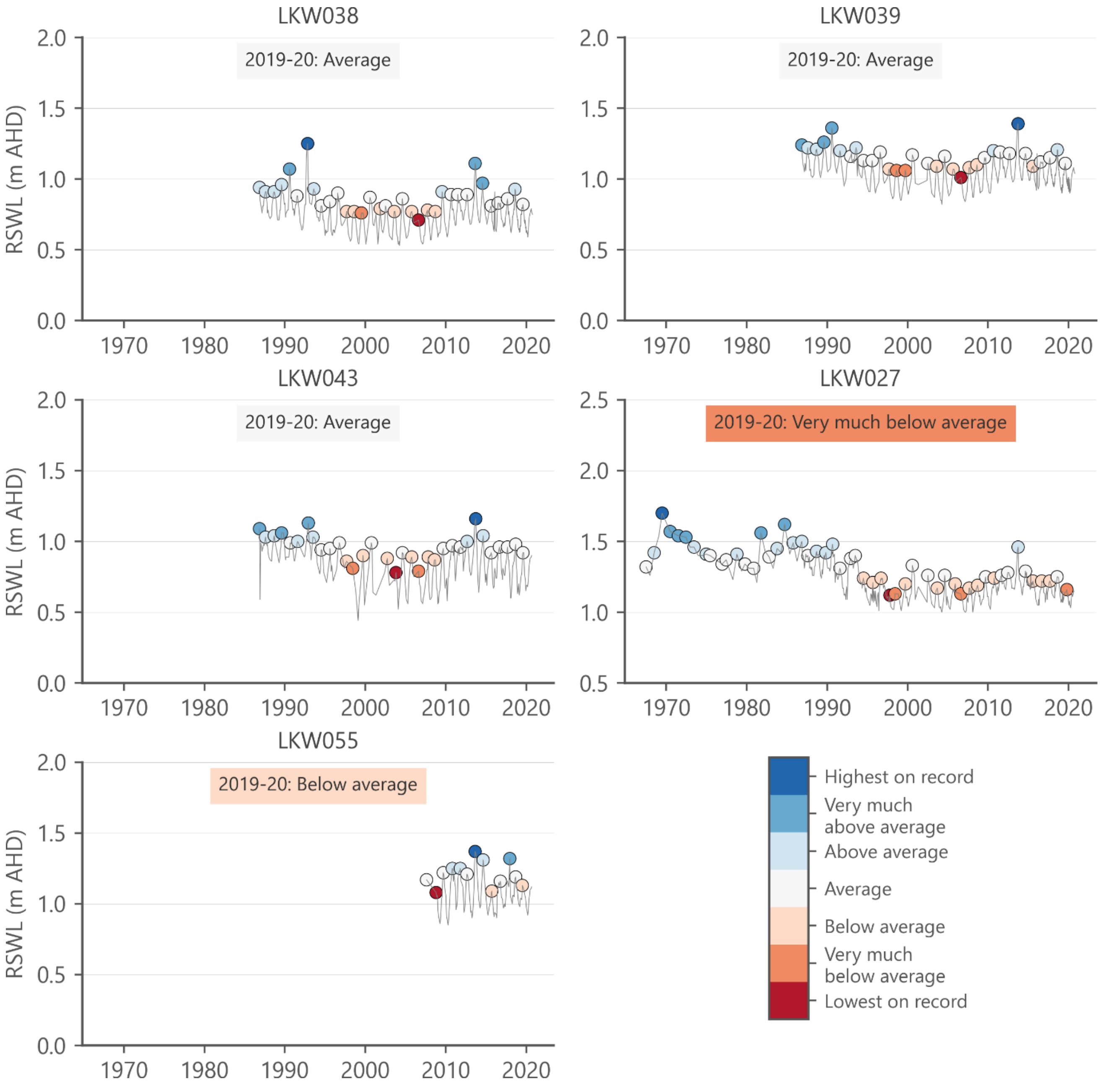

Figure 4.13. Selected hydrographs for wells in the QL aquifer in the Coffin Bay Consumptive Pool

4.4.2 Coffin Bay Consumptive Pool – salinity

In 2019, the groundwater salinity ranged from 367 mg/L to 1127 mg/L, with a median salinity of 422 mg/L. Eight out of nine wells (89%) had salinities below 1000 mg/L. The majority of wells were located in the SA Water production wellfield (Figure 4.14).

Five-year trends in salinity are available for the SA Water production wells. Trends are stable for three of four wells with sufficient data (75%; Figure 4.15). The percentage change in salinity over the past five years ranges from an increase of 4% to an increase of 10% (the median change is an increase of 6%).

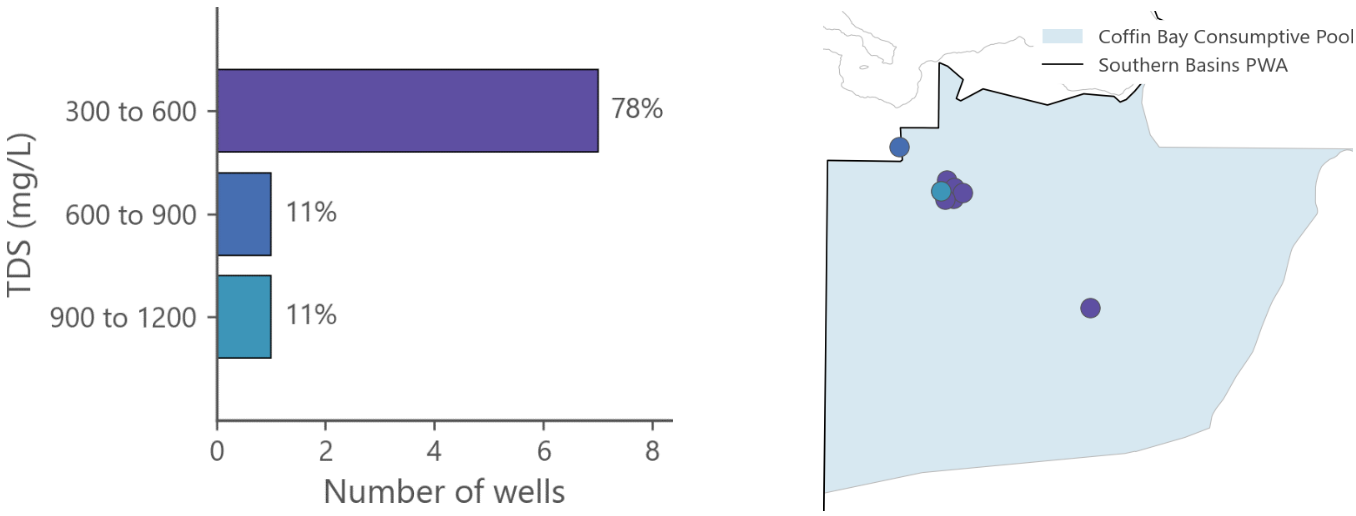

Figure 4.14. 2019 salinity observations from wells in the QL aquifer in the Coffin Bay Consumptive Pool

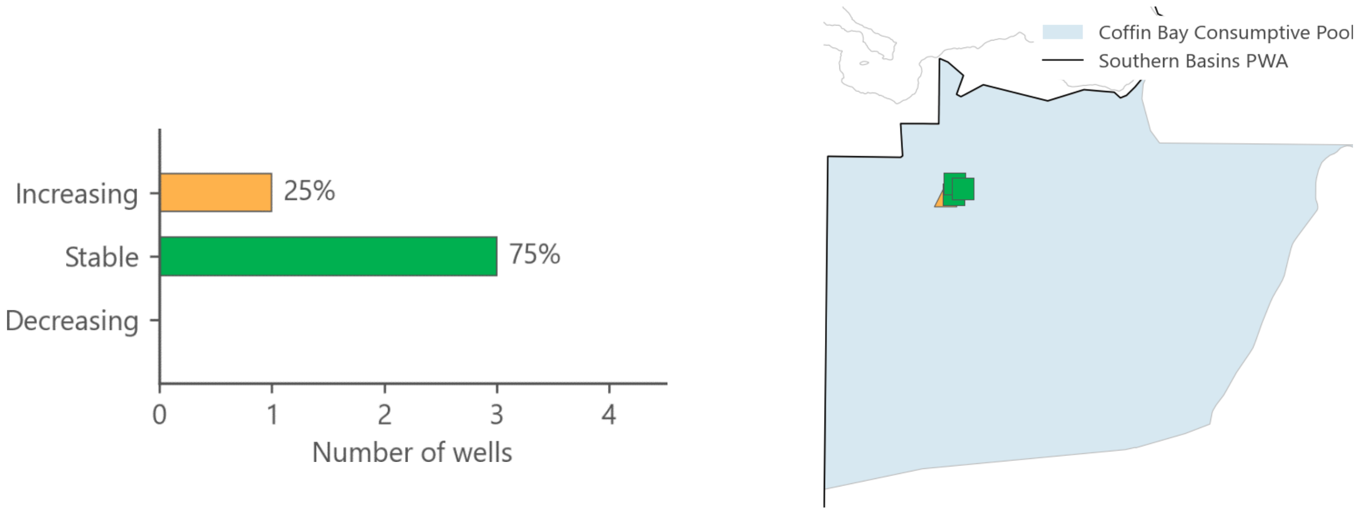

Figure 4.15. 2015-2019 trend in water salinity for wells in the QL aquifer in the Coffin Bay Consumptive Pool

4.4.3 Uley South Consumptive Pool – water level

In 2019, the majority of QL aquifer monitoring wells (20 of 38 wells; 53%) with suitable long-term records were at below-average recovered water levels compared to their historic record (Figure 4.16). Five wells were at their lowest level on record.

Over the last thirty years, water levels have declined in all wells with available data. Declines range from 0.77 m to 1.67 m, with a median decline of 1.13 m. Changes over the last twenty years are more variable, with a rise in water level in 40% of wells, and a decline in 60% of wells; overall changes in the last twenty years range from a decline of 0.68 m to a rise of 0.42 m (median change is a decline of 0.02 m).

Five-year trends in water level are showing almost entirely declining trends (90% of wells; Figure 4.17). The rates of change range from a decline of 0.20 m/y to a rise of 0.03 m/y (median rate of change is a decline of 0.07 m/y).

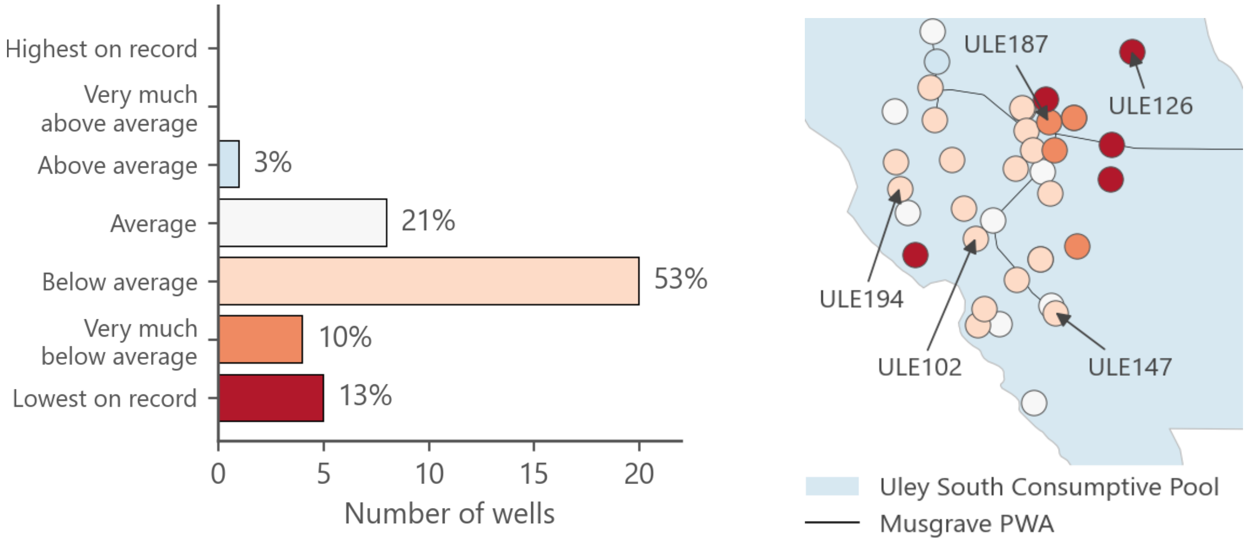

Figure 4.16. 2019 recovered water levels for wells in the QL aquifer in the Uley South Consumptive Pool

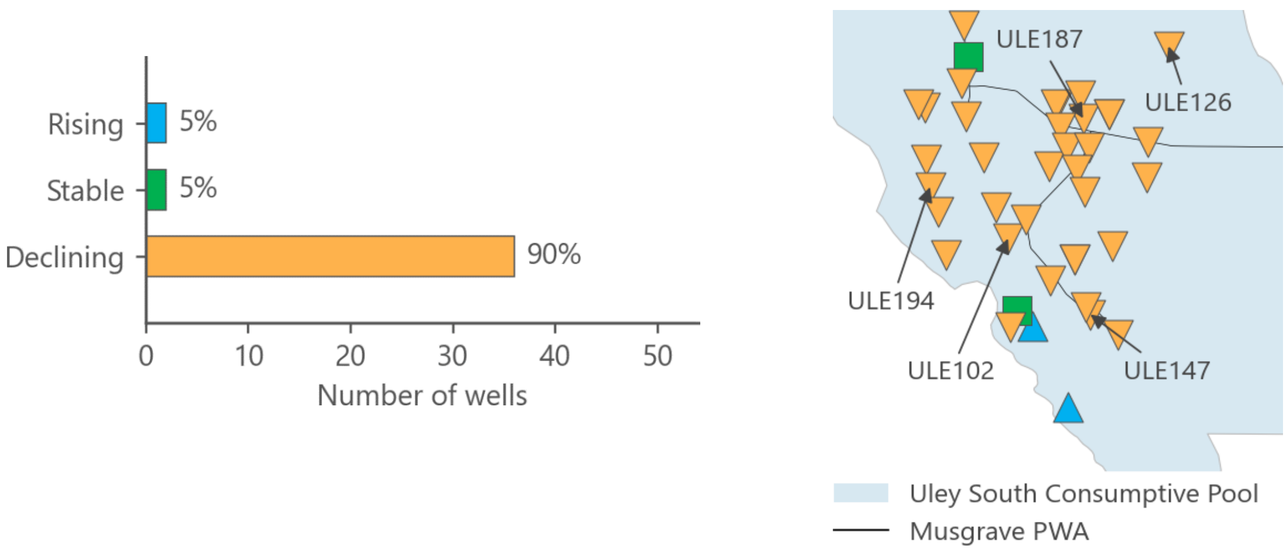

Figure 4.17. 2015 to 2019 trend in recovered water levels for wells in the QL aquifer in the Uley South Consumptive Pool

Figure 4.18 shows hydrographs from selected monitoring wells throughout the Uley South Consumptive Pool. Large-scale extraction from the basin began in 1976 and resulting declines in water level due to pumping were observed throughout the late 1970s across the central and southern part of the Uley South lens in the vicinity of pumping wells (ULE102, ULE147). Other wells more distant from pumping centres were not affected (e.g. ULE126 on the north-eastern margin).

Extended periods of below-rainfall (1976 to 1978, 1993 to 1999, and 2006 to 2008) have also resulted in water level declines. This decline was most significant throughout the 1990s and early to mid-2000s, with many wells reaching their lowest level on record in 1999, 2005, or 2006 (ULE194, ULE102, ULE187, and ULE147).

Water levels in most wells either stabilized (ULE126) or rose (ULE194, ULE102, ULE147) over the period from 2010 to 2015. This is likely related to a reduction in pumping, which reduced to levels of around 5000 ML/y since 2010, down from a peak of 7000 ML/y between 1999–2000 and 2004–05, and also a period of slightly above-average rainfall from 2008–09 to 2011–12.

Water levels have been declining since 2015 in almost all wells, likely due to below-average rainfall, particularly in 2014–15 and 2016–17 (Section 3.2).

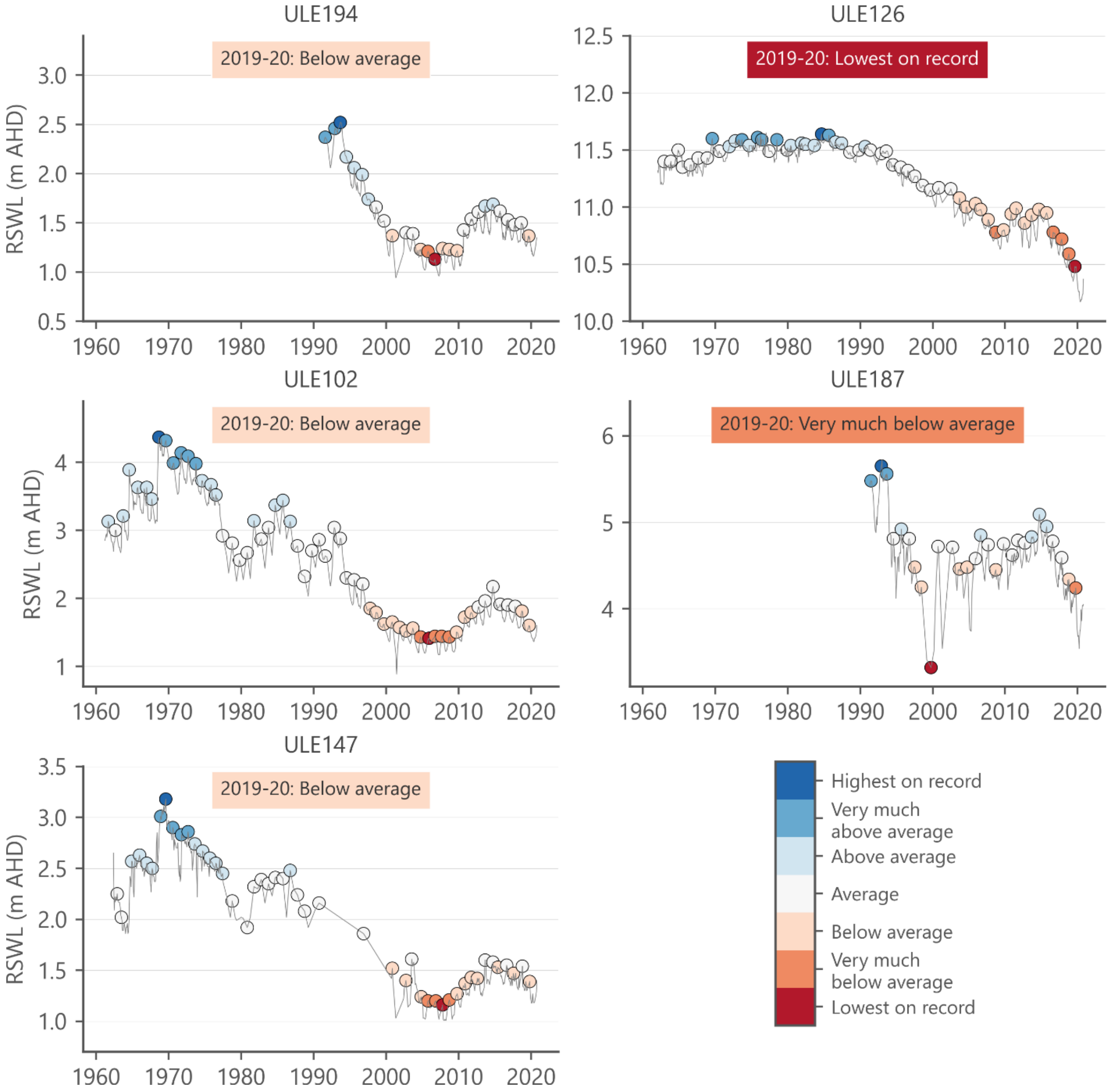

Figure 4.18. Selected hydrographs for wells in the QL aquifer in the Uley South Consumptive Pool

4.4.4 Uley South Consumptive Pool – salinity

In 2019, the groundwater salinity in samples from 21 wells ranged from 389 mg/L to 699 mg/L, with a median of 509 mg/L. Samples are obtained from a combination of SA Water production wells (13 wells) and dedicated monitoring wells (8 wells).

Five-year trends in water salinity are stable in almost all wells (13 of 14 wells; 93%; Figure 4.20). The percentage change in salinity over the last five years ranges from a decrease of 6% to an increase of 10% (median change is an increase of 3% over five years).

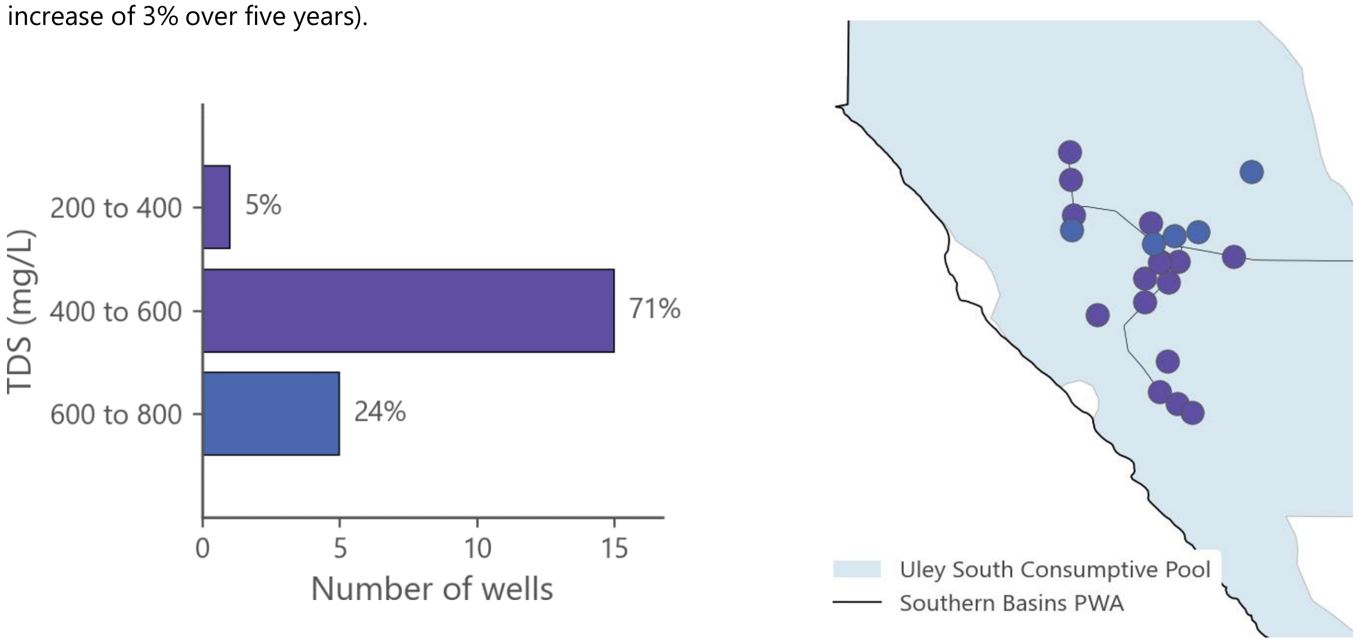

Figure 4.19. 2019 salinity observations from wells in the QL aquifer in the Uley South Consumptive Pool

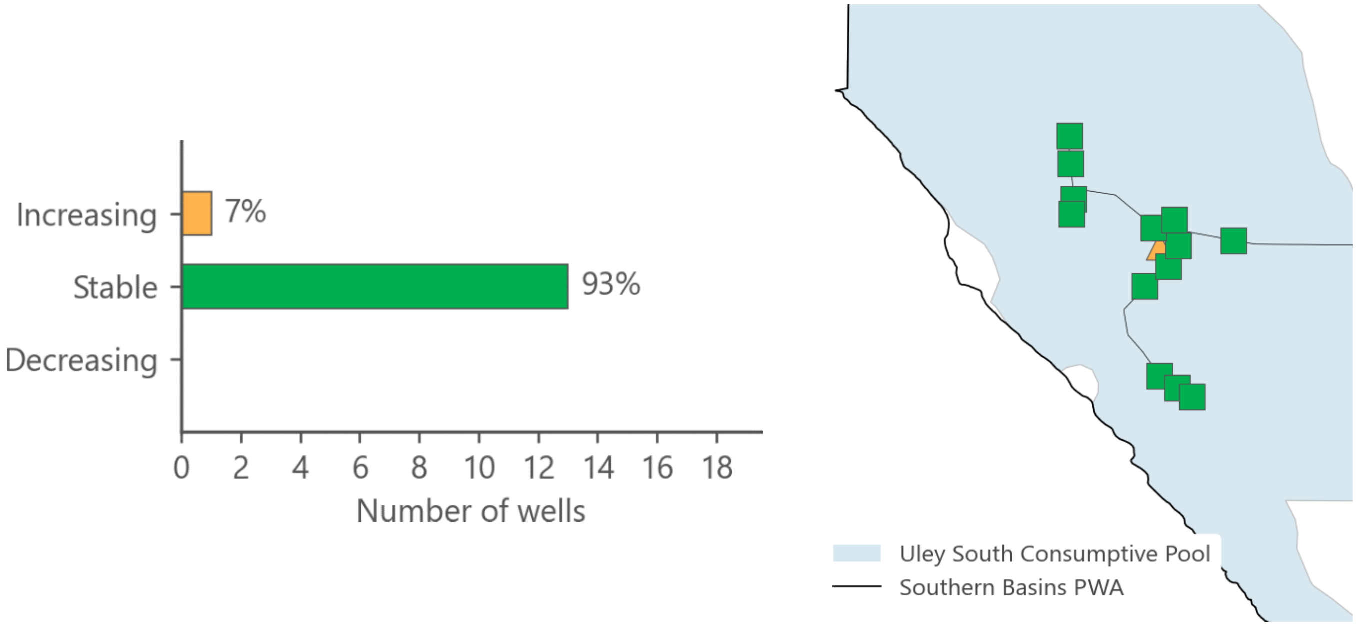

Figure 4.20. 2015-2019 trend in water salinity for wells in the QL aquifer in the Uley South Consumptive Pool

4.4.5 Uley Wanilla Consumptive Pool – water level

In 2019, the majority (73%) of QL aquifer monitoring wells with long-term records were at lowest levels on record compared to their historic record (Figure 4.21), while four wells (27%) show below-average levels.

Over the last thirty years, water levels have declined in all wells, with declines ranging from 4.63 to 0.93 m, with a median decline of 3.02 m.

Five-year trends in water level are declining in all wells with rates of decline ranging from 0.40 m/y to 0.05 m/y (the median rate of decline is 0.16 m/y) (Figure 4.22).

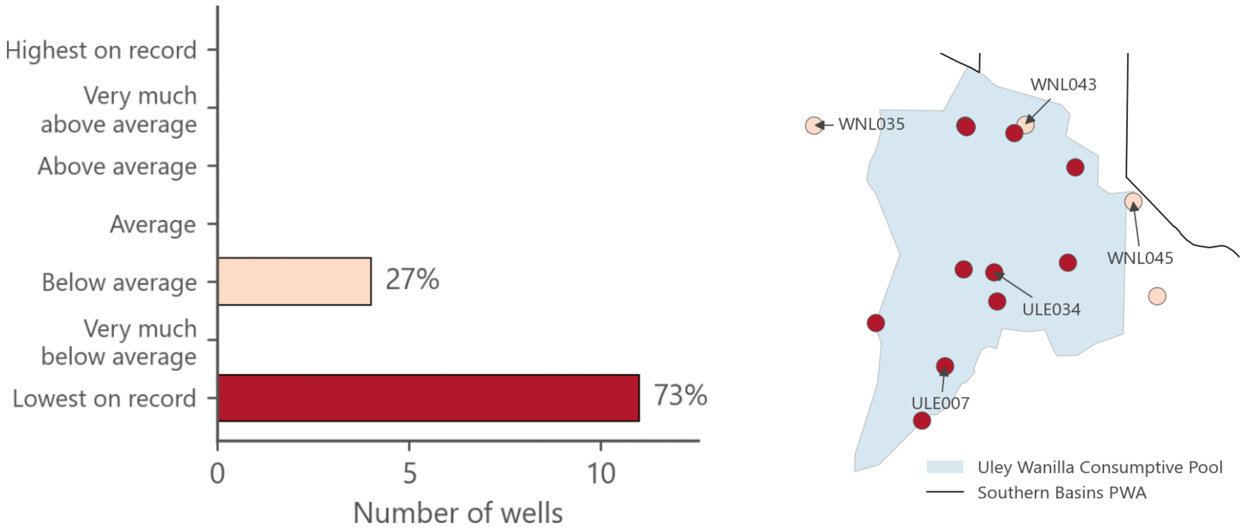

Figure 4.21. 2019 recovered water levels for wells in the QL aquifer in the Uley Wanilla Consumptive Pool

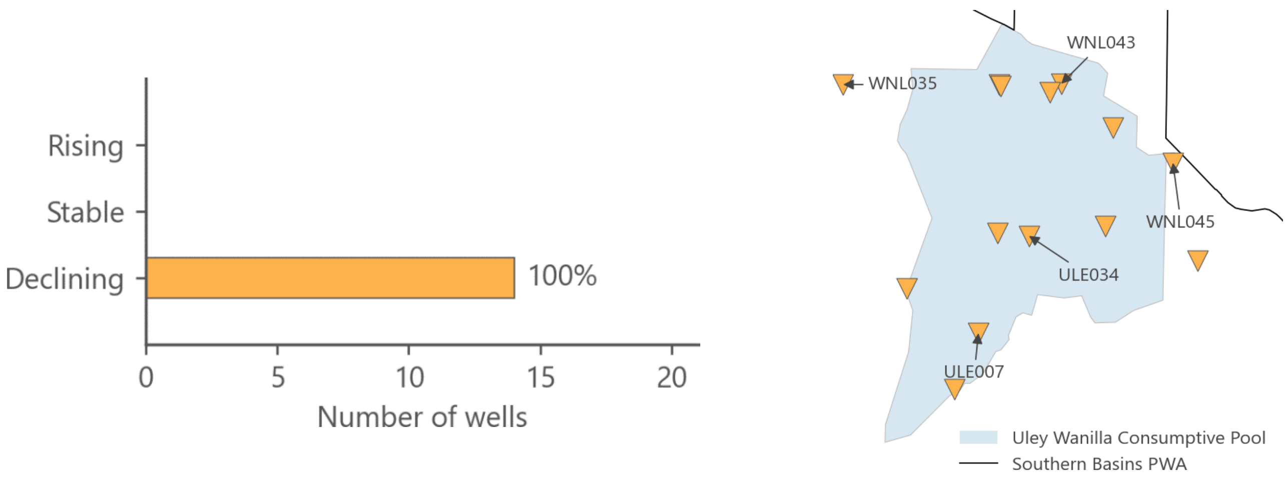

Figure 4.22. 2015-2019 trend in recovered water levels for wells in the QL aquifer in the Uley Wanilla Consumptive Pool

Figure 4.23 shows hydrographs from a selection of monitoring wells to illustrate common or important trends in the Uley Wanilla Basin. The trends appear to be fairly consistent, with a long-term decline since monitoring began.

In 1949, the Uley Wanilla lens was the first groundwater lens to be developed to augment the Tod River Reservoir with the extraction of more than 2000 ML/y from 1958 to 1963, causing declines in groundwater levels (ULE007).

Extraction volumes were reduced in 1963 which allowed for the recovery of water levels, but increased above 2000 ML/y again from 1975 to 1978 (Figure 5.3) causing water level declines during that period (e.g. ULE034 and WNL035).

Groundwater levels declined further up until 2010 which may be caused by a combination of high extraction volumes (1987-1994), the interception of recharge and direct use of groundwater by vegetation and the steep watertable gradients that promote lateral groundwater flow to the south. Water levels rose from 2010 to 2016, likely due to above-average rainfall, after which the levels have been declining again across the area, with the majority of wells at their lowest level on record.

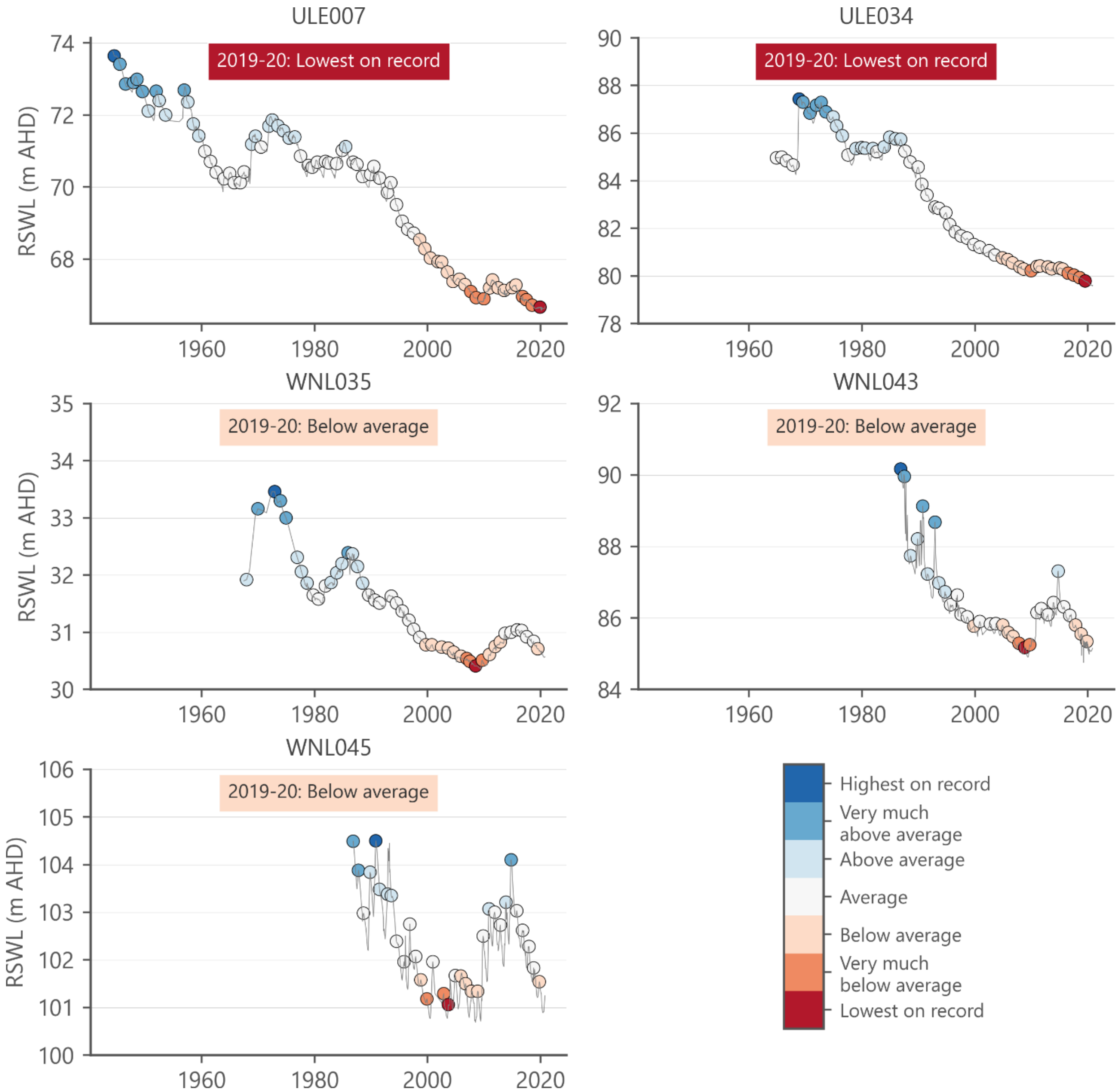

Figure 4.23. Selected hydrographs for wells in the QL aquifer in the Uley Wanilla Consumptive Pool

4.4.6 Uley Wanilla Consumptive Pool – salinity

In 2019, the groundwater salinity ranged from 448 mg/L to 1121 mg/L, with a median salinity of 595 mg/L. Nine out of ten wells (90%) had salinities below 1000 mg/L. The majority of wells were located in the SA Water production wellfield (Figure 4.24).

Five-year trends in salinity are available for the SA Water production wells. Trends are stable for four of six wells with sufficient data (67%). The percentage change in salinity over the past five years ranges from a decrease of 1% to an increase of 23% (the median change is an increase of 6%) (Figure 4.25).

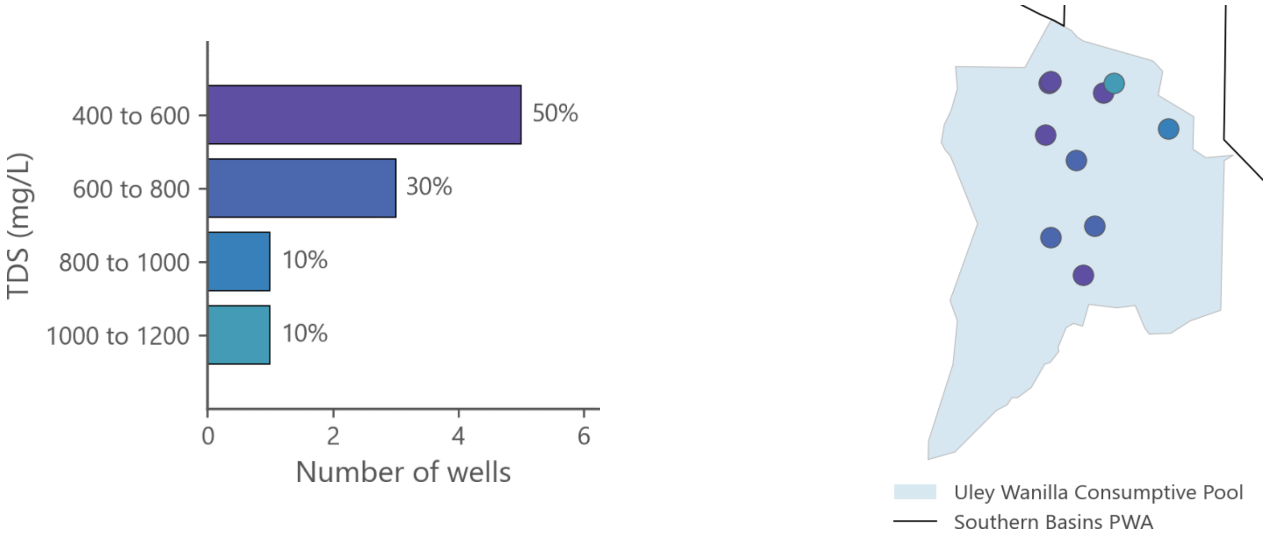

Figure 4.24. 2019 salinity observations from wells in the QL aquifer in the Uley Wanilla Consumptive Pool

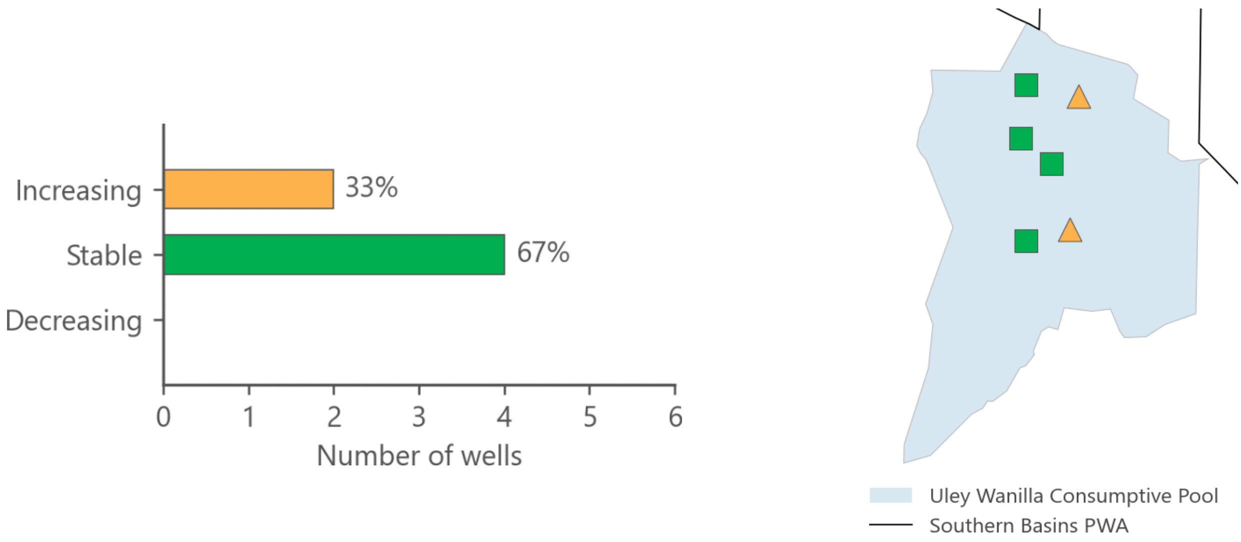

Figure 4.25. 2015-2019 trend in water salinity for wells in the QL aquifer in the Uley Wanilla Consumptive Pool

4.4.7 Lincoln South Consumptive Pool – water level

In 2019, the majority (86%) of QL aquifer monitoring wells with long-term records were at below-average to lowest-on-record levels when compared to their historic record (Figure 4.26), while three wells showed average levels.

Over the last thirty years, water levels have declined in all wells, with declines ranging from 1.54 to 0.46 m, with a median decline of 0.61 m.

Five-year trends in water level are declining in 90% of wells with rates of decline up to 0.05 m/y (the median rate of decline is 0.03 m/y) (Figure 4.27).

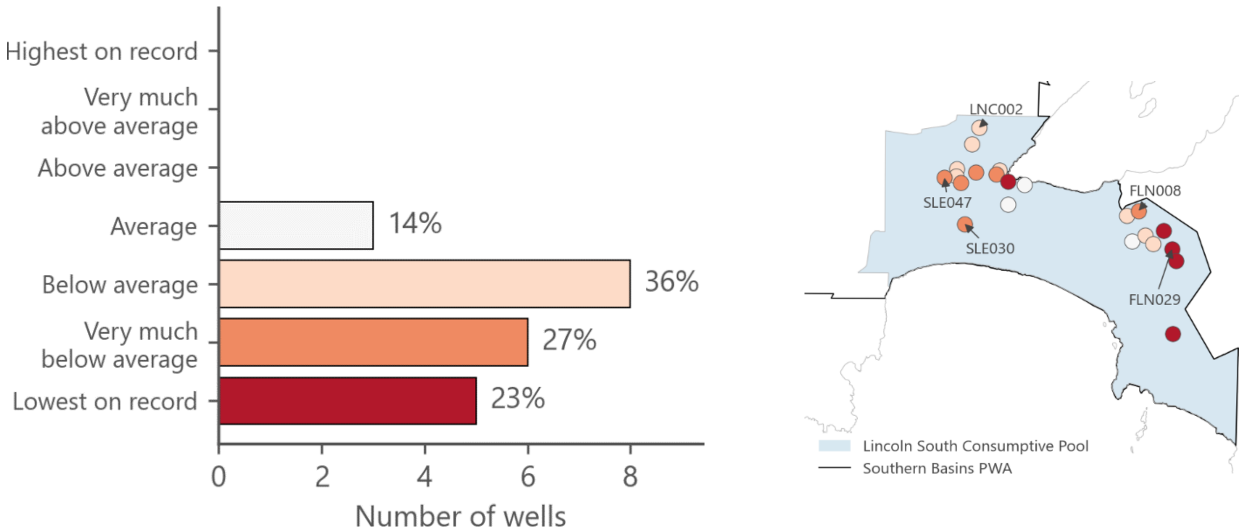

Figure 4.26. 2019 recovered water levels for wells in the QL aquifer in the Lincoln South Consumptive Pool

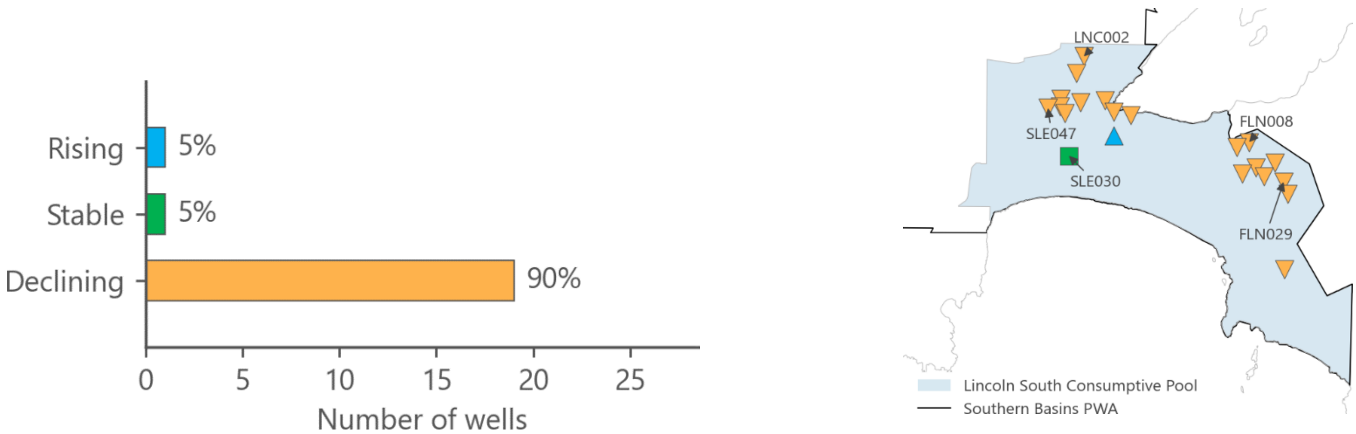

Figure 4.27. 2015-2019 trend in recovered water levels for wells in the QL aquifer in the Lincoln South Consumptive Pool

Figure 4.28 shows hydrographs from a selection of monitoring wells to illustrate common or important trends in the Lincoln South Basin. Lincoln Basin water levels show long-term declining trends related to declining rainfall patterns (Figure 3.12) and sustained groundwater extraction since the development of the resource in 1961 (Figure 5.3). Major declines in water levels generally coincide with periods of high historic groundwater extraction (e.g. 1960s, 1970s and late 1990s). However, groundwater extraction volumes have been negligible since 2012-13 and declines in water level are most likely due to dry conditions in recent years.

SLE047 and SLE030 are located to the east of the basin and recorded a gradual declining trend with a total decline of 1.15 m and 0.52 m, respectively, over the last 50 years.

Similarly to the east of the basin, FLN029 and FLN008 display a gradual declining trend since monitoring began with a total decline of 1.34 m and 0.72 m over the past 50 years.

LNC002 is located further inland to the north-west of the area and is also showing a declining trend with a total decline of 2.4 m since 1970.

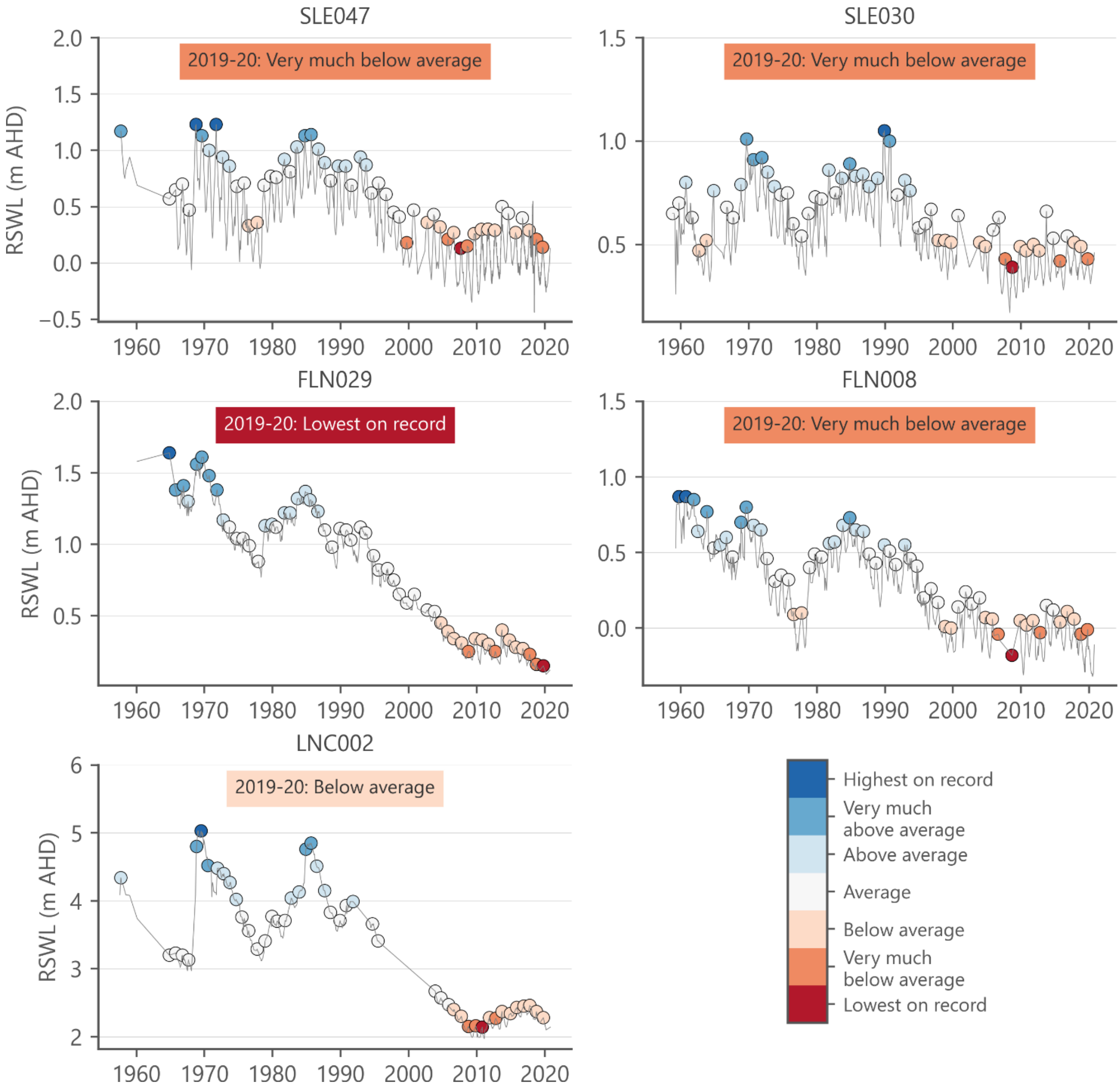

Figure 4.28. Selected hydrographs for wells in the QL aquifer in the Lincoln South Consumptive Pool

4.4.8 Lincoln South Consumptive Pool – salinity

In 2019, the groundwater salinity ranged from 621 mg/L to 1508 mg/L, with a median salinity of 1104 mg/L. Six out of 14 wells (43%) had salinities below 1000 mg/L (Figure 4.29).

Five-year trends in salinity are available for the SA Water production wells. Trends are stable for all six wells with sufficient data over the past five years (Figure 4.30).

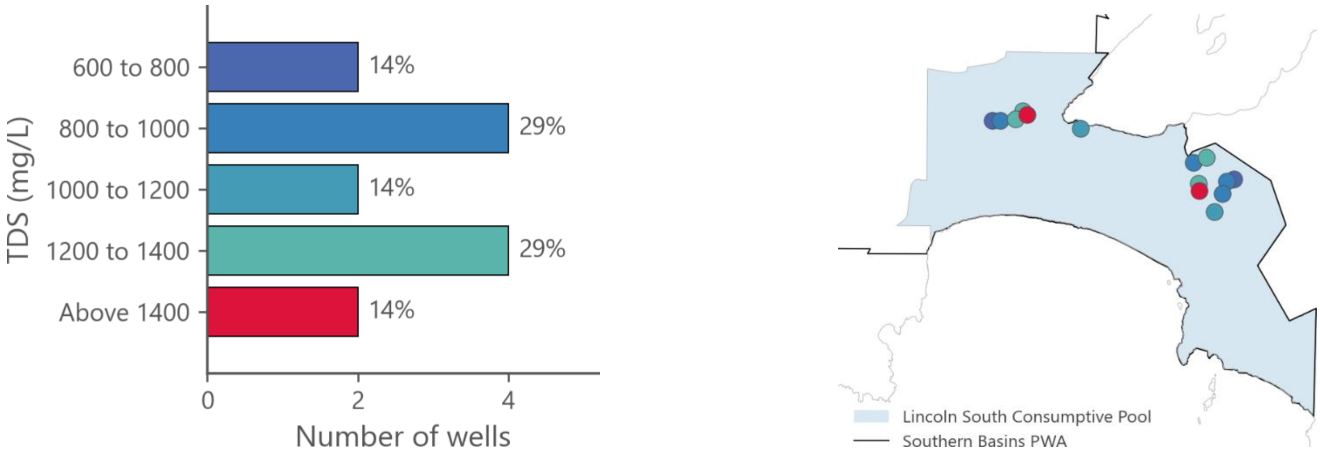

Figure 4.29. 2019 salinity observations from wells in the QL aquifer in the Lincoln South Consumptive Pool

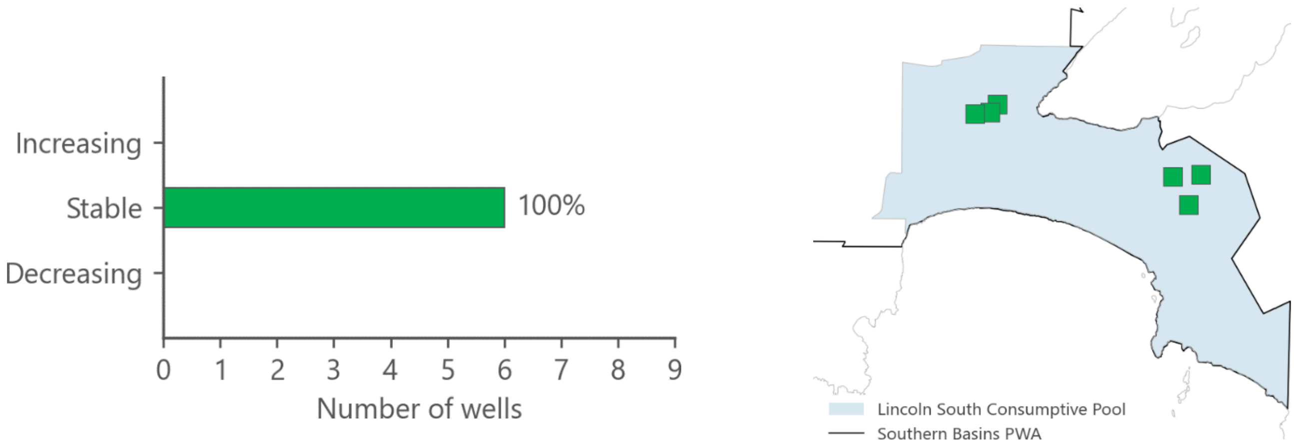

Figure 4.30. 2015-2019 trend in water salinity for wells in the QL aquifer in the Lincoln South Consumptive Pool

5 Water use

There is a general absence of reliable surface water and good quality groundwater on the Eyre Peninsula. The available fresh groundwater resources in both the Musgrave and Southern Basins PWAs are therefore used for a variety of purposes, including town water supplies, stock and domestic use, irrigation and mining.

5.1 Musgrave PWA

Groundwater extraction in the Musgrave PWA began on a large scale in the 1960s and has fluctuated significantly in years since (Figure 5.1).

Total licensed groundwater use in 2018–19 was 92 ML in the Musgrave PWA (Figure 5.2), with 99% of this volume being pumped from the Bramfield Consumptive Pool (Figure 5.2).

Extractions in 2018–19 in the Bramfield Consumptive Pool were 91 ML, an increase of 7% compared to 2017–18. This is similar to historical extractions since 2002–03 (Figure 5.2).

Extractions in 2018–19 in the Polda Consumptive Pool were 940 kL, a decrease of 65% from the 2017–18 extraction of 2720 kL (Figure 5.2). This is largely caused by a reduction in the proportion of water available for pumping under the water allocation plan. The Polda resource was historically used to extract much larger volumes for the reticulated water supply, but pumping has reduced significantly since 2008–09 (Figure 5.2).

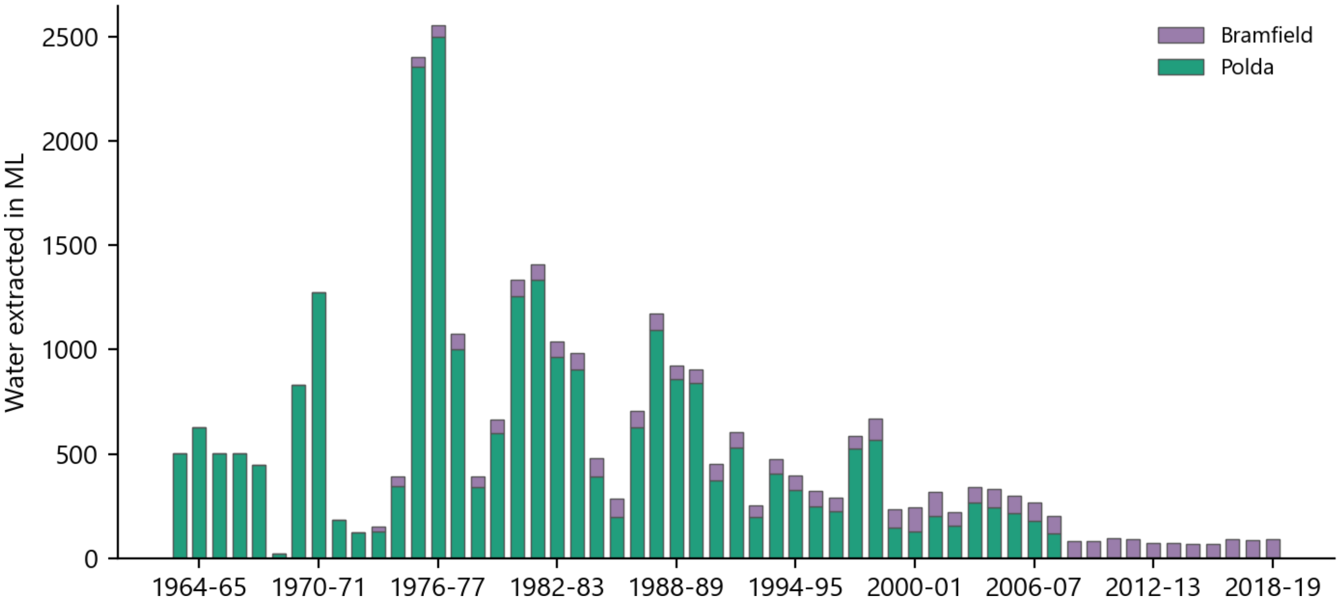

Figure 5.1. Historical groundwater extraction from groundwater resources in the Musgrave PWA

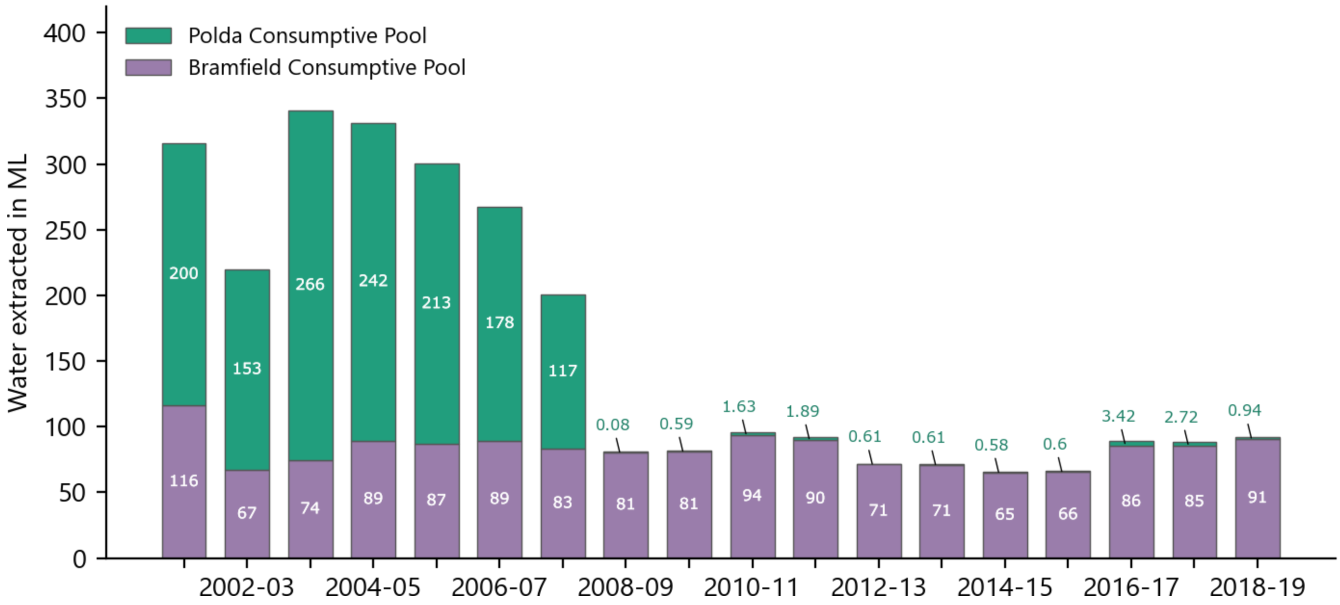

Figure 5.2. Licensed groundwater extraction for 2001–02 to 2018–19 in the Musgrave PWA

5.2 Southern Basins PWA

In the Southern Basins PWA, historical patterns of groundwater extraction have varied significantly since the beginning of large-scale groundwater extraction in the 1950s. Since the late 1970s, the majority of extraction has occurred from the Uley South lens (Figure 5.3).

Total licensed groundwater use in 2018–19 was 5099 ML in the Southern Basins PWA (Figure 5.4), with 95% of this being taken from the Uley South lens.

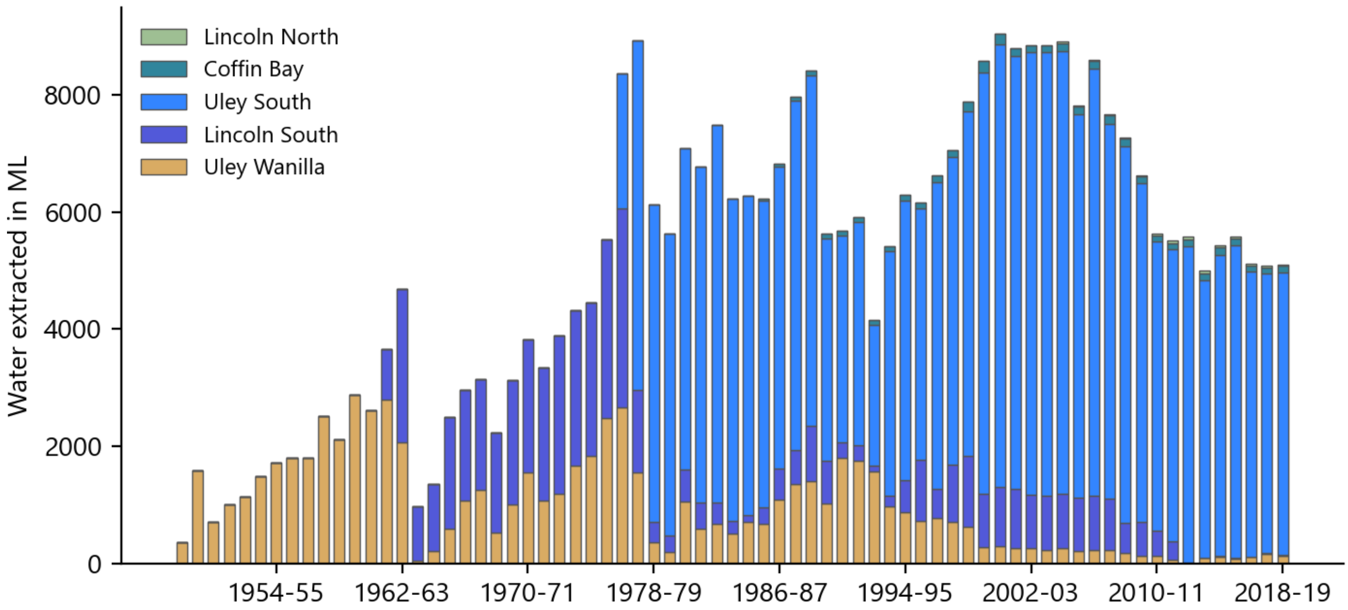

Figure 5.3. Historical groundwater extraction from groundwater resources in the Southern Basins PWA

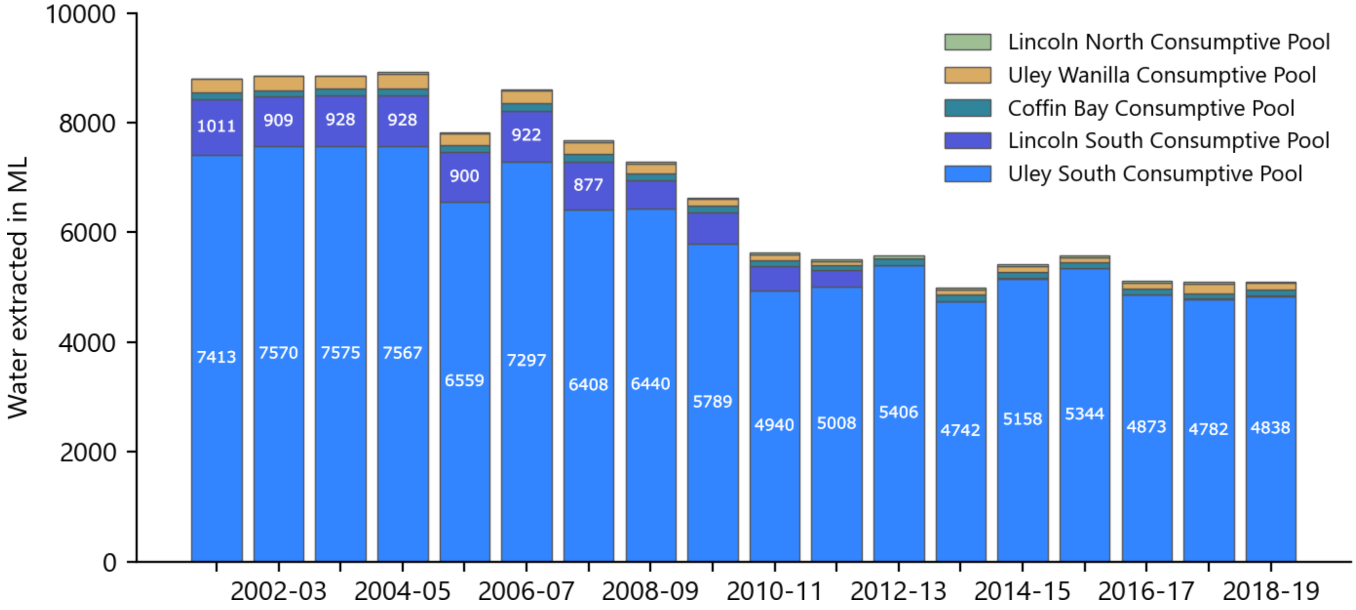

Figure 5.4. **Licensed groundwater extraction for 2001–02 to 2018–19 in the Southern Basins PWA**

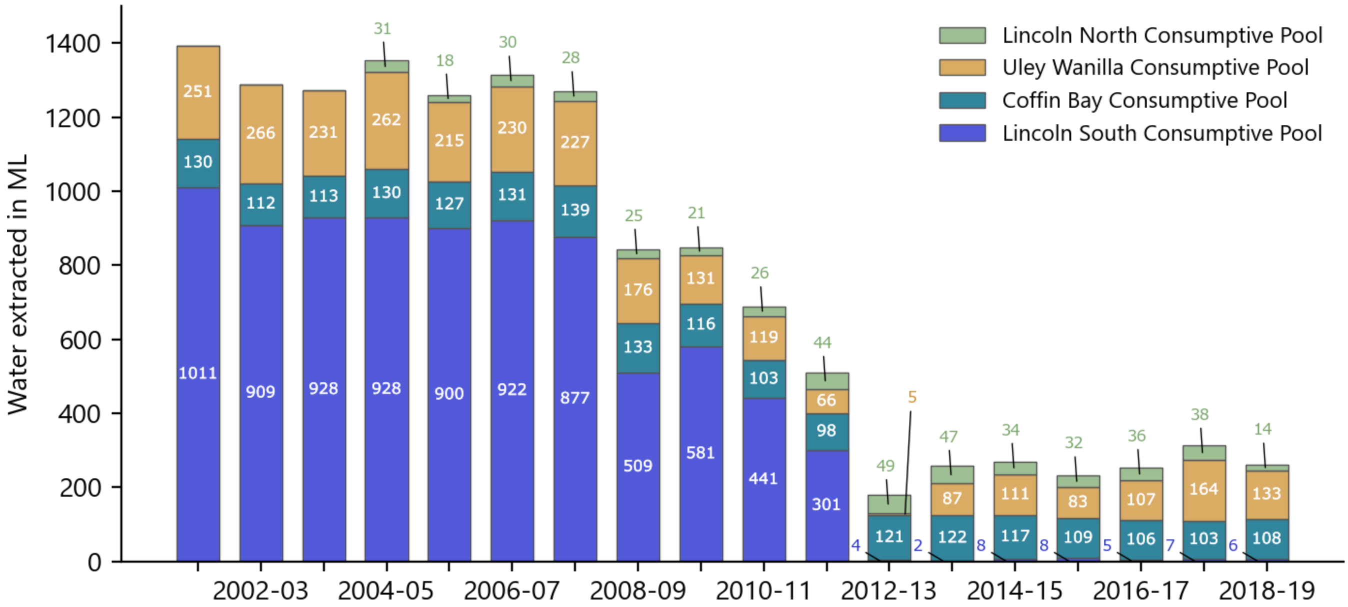

Figure 5.5. **Licensed groundwater extraction for 2001–02 to 2018–19 in the Southern Basins PWA for the Lincoln North, Uley Wanilla, Coffin Bay, and Lincoln South consumptive pools.**

5.2.1 Uley South

Licensed extractions in 2018–19 in Uley South were 4838 ML, an increase of 1.2% (56 ML) compared to 2017–18. The volume 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).

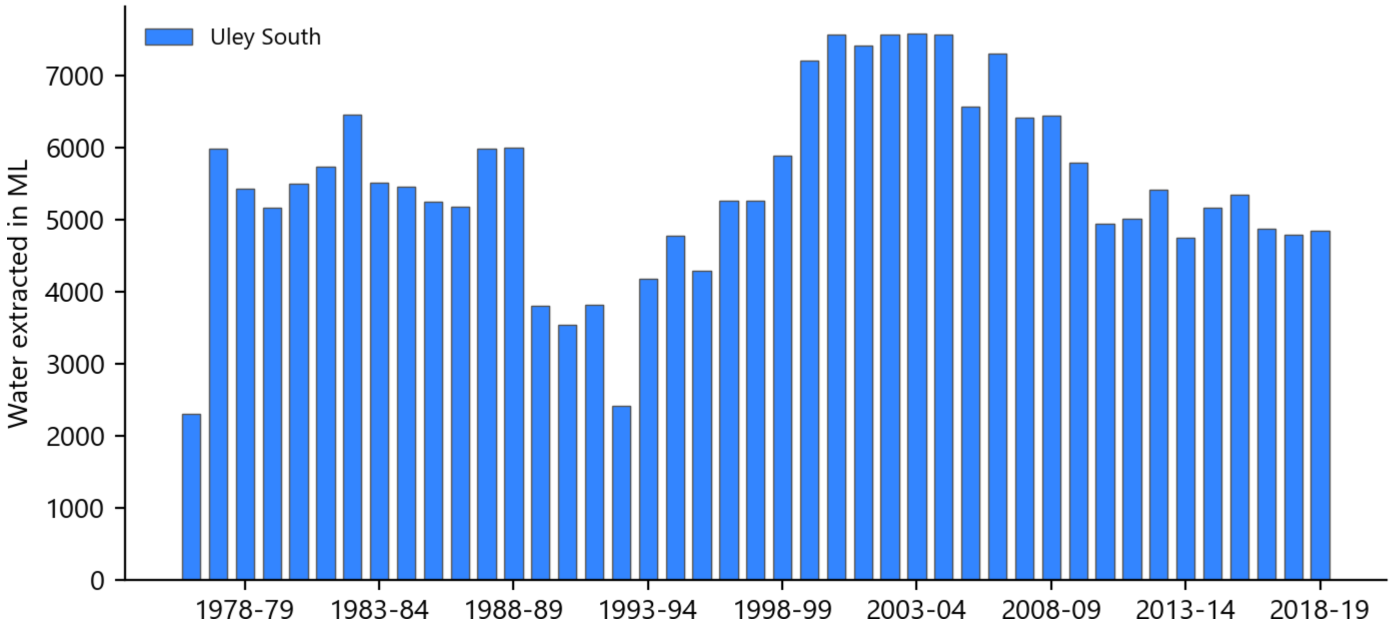

Figure 5.6. Historical groundwater extraction from the Uley South groundwater resource

5.2.2 Uley Wanilla

The Uley Wanilla Basin was the first groundwater basin to be developed in 1949 when the Tod River Reservoir supplies were no longer sufficient to supply the region's growing water demand. Extractions from Uley Wanilla have been decreasing steadily since 1993 in response to falling groundwater levels (Figure 5.3). Figure 5.5 shows marked reductions from 2008 onwards. Extraction in 2018–19 was 133 ML, a reduction of 19% (31 ML) compared to 2017–18, and approximately half of the volumes extracted prior to 2007–08.

5.2.3 Lincoln South

Extractions from groundwater resources in the Lincoln Basin commenced in 1961. As a result of high salinities relative to nearby lenses, extraction volumes decreased significantly when the better quality Uley South Basin was developed in 1977 (Figure 5.3). Extraction was between 900 and 1000 ML/y prior to 2008–09, followed by significant reductions in that year and again in 2012–13, as a result of concerns about salinity increases due to up-coning of underlying saline groundwater (Figure 5.5). Licensed extractions were 6 ML in 2018–19 and have been below 10 ML/y since 2012–13.

5.2.1 Coffin Bay

Licensed groundwater extraction at Coffin Bay in 2018–19 was 108 ML, an increase of 5% (5 ML) compared to 2017–18 (Figure 5.5). The volume has reduced steadily since 2012–13, but has generally been stable between 100 and 150 ML since the early 2000s (Figure 5.7).

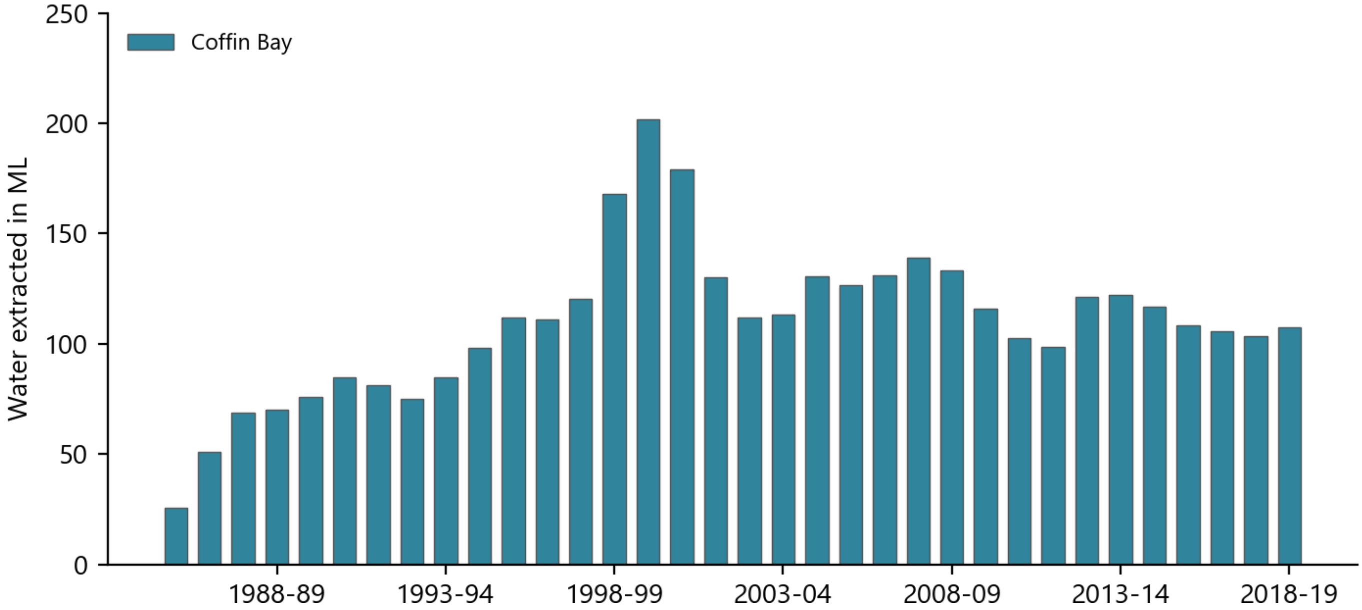

Figure 5.7. Historical groundwater extraction from the Coffin Bay groundwater resource

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.

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.

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