Far North Prescribed Wells Area 2020–21 water resources assessment

Department for Environment and Water
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DEW Technical Note 2022/19

Government of South Australia
Department for Environment and Water

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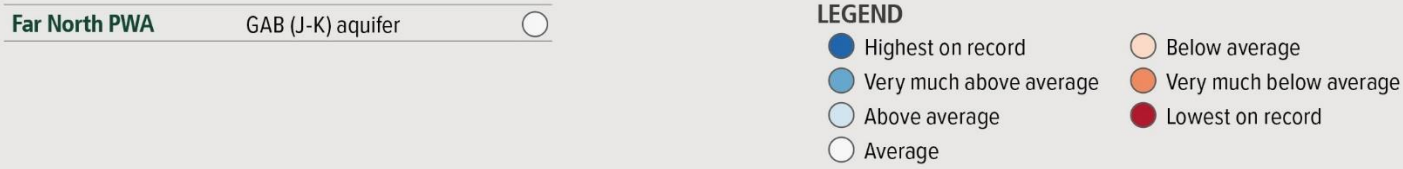
1 Summary



Rainfall

- Rainfall across the region was below-average in 2020–21.
- In 2020–21, total annual rainfall at Marree is 152 mm, 13% less than the long-term average annual rainfall, while rainfall at Marla is 198 mm, just 5% below the long-term average.
- Rainfall occurrence and intensity in South Australia's far north is episodic. The far north may go without significant rainfall for years, while monsoonal rain can deliver average annual rainfall in a single event.
- The Great Artesian Basin (GAB) Jurassic–Cretaceous (J-K) aquifer generally does not respond to incident rainfall. However, the demand for stock water in the pastoral industry is affected by stocking rates and the availability of feed, which is in turn affected by contemporary patterns in rainfall (Fu et al. 2020).

Groundwater

- In 2021, water levels from wells in the GAB (J-K) aquifer are variable, and the median well is classified 'Average'.
- Water levels in 7 wells are classified 'Lowest on record' – these are predominantly located in the south-central to north-eastern part of the Prescribed Water Area (PWA) between Marree and Moomba.
- Water levels in 6 wells are classified 'Highest on record'. Wells classified 'Average' or higher tend to be located around the western and southern margins of the extent of artesian groundwater.
- Five-year trends in water level show that the majority of wells (66%) show rising or stable water levels.
- Salinity results from 50 wells in the GAB J-K aquifer range between 487 mg/L and 5,246 mg/L, with a median of 1,836 mg/L.
- Groundwater salinity over the past ten years is stable.

Water use

- The Great Artesian Basin is the source of 76% of groundwater allocated in the Far North PWA (SAAL Landscape Board 2021).
- Groundwater is predominantly extracted for mining, petroleum, and stock and domestic purposes.
- Water use for mining and petroleum in 2020–21 is slightly below (3%) the previous year but 40% above the twenty-year average.

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 Far North Prescribed Wells Area (PWA) and collates rainfall, groundwater and water-use data for 2020–21.

1.2 Regional context

The Far North PWA is located in the South Australian Arid Lands (SAAL) Landscape Region and is bounded in the north and east by the state borders with New South Wales, Queensland and the Northern Territory. The Far North PWA (Figure 1.1) is an administrative region within which groundwater has been prescribed under the *Landscape South Australia Act 2019*. Further, groundwater allocation and sustainable management of groundwater resources within the Far North PWA is administered under the Far North Water Allocation Plan (WAP), which was adopted in February 2021. Groundwater in the Far North PWA is vital for sustaining the mining, petroleum, pastoral and tourism industries and the provision of community water supplies in the SAAL Landscape Region.

Springs, which are naturally occurring point discharges of groundwater, are important ecological features of the arid zone. They provide permanent habitats for aquatic flora and fauna that need standing water, and a reliable source of water for visiting fauna. Springs in the Far North PWA that are fed either fully or partially by Great Artesian Basin (GAB) aquifers rely on artesian pressure for the provision of their water needs. Therefore, it is essential that GAB pressures are maintained at levels that provide continuous groundwater discharge at rates sufficient to maintain the ecological value of the springs, whilst also allowing sustainable rates of extraction for consumptive purposes. The WAP employs the use of buffer zones around these springs (Zone A – 5 km from a spring, and Zone B – 5 to 50 km from a spring, Figure 1.1) within which specific principles outlining the acceptable change in water pressure apply to the taking of water, and these are outlined in Sections 6 and 7 of the WAP (SAAL Landscape Board 2021).

Groundwater in the Far North PWA is predominately sourced from the Cadna-owie Formation and Algebuckina Sandstone (and lateral equivalents), which form a single hydrogeological unit known as the Jurassic-Cretaceous (J-K) aquifer. The J-K aquifer contains the largest and regionally most important groundwater resource within the Far North PWA. Other groundwater resources in the PWA include the:

- shallow Quaternary and Tertiary sedimentary aquifers, including the Kati Thanda - Lake Eyre Basin
- Palaeozoic sedimentary aquifers, including sandstones of the Winton and Mackunda Formations as well as minor sandstones in the Rolling Downs Group, such as the Coorikiana and Bellinger Sandstone
- underlying Permo-Carboniferous to Early-Triassic sediments of the Cooper, Arckaringa and Pedirka basins
- basement crystalline fractured rock aquifers.

These aquifer units are further described in Section 4.1. Detailed descriptions can be found in the references provided in Section 2.4 and Section 6.

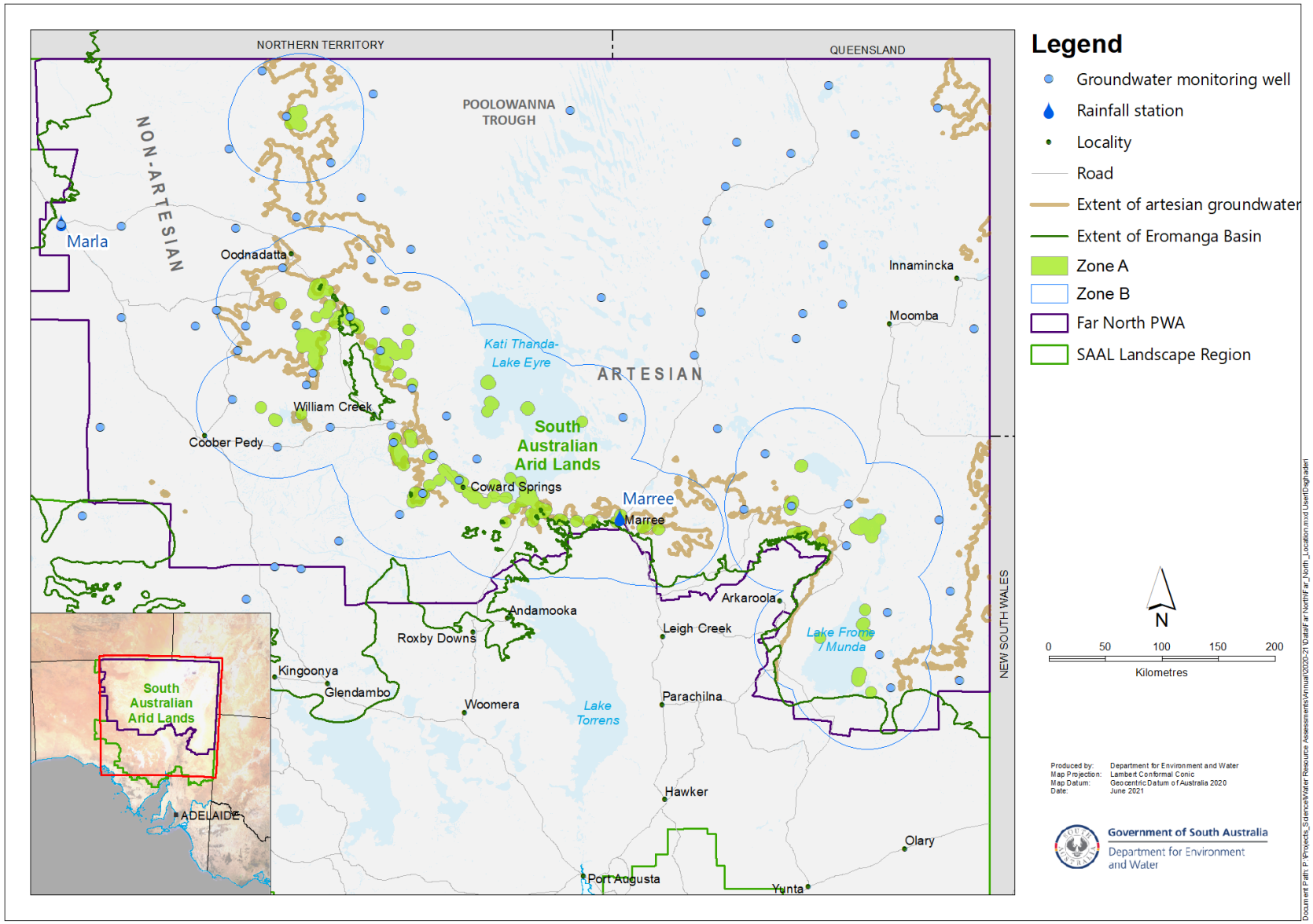


Figure 1.1 Location of Far North PWA

2 Methods and data

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

Table 2.1 Reporting period description

Parameter	Reporting period	Comment
Rainfall	1 July 2020 to 30 June 2021	Monthly data for July to September 2021 are also presented to provide additional context
Groundwater	1 January to 31 December 2021	The majority of the GAB aquifer is confined/artesian, hence not directly influenced by rainfall. Where groundwater levels are influenced by rainfall, the response is typically delayed, hence the lag in reporting period
Water use	1 July 2020 to 30 June 2021	In South Australia, water accounting is reported between 1 July through to 30 June of the following year

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

2.1 Rainfall

Daily rainfall observations have been used from selected Bureau of Meteorology (BoM) stations to calculate monthly and annual totals. Data have been obtained from the SILO Patched Point Dataset[1] service provided by the Queensland Government, which provides interpolated values to fill gaps in observations (Figure 3.1 and Figure 3.2).

2.2 Groundwater

2.2.1 Water level

Water level[2] data were obtained from wells in the Far North PWA monitoring network from manual measurements taken every six months. The water level in non-artesian wells was measured by dipping tape, while the pressure level in artesian wells was measured through a shut-in pressure test. All water level data were verified, and anomalous data excluded. The mean water level for each calendar year, for each well, was calculated and used for further analysis.

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

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

For wells with at least five years' data, the mean annual water level was ranked and described according to their decile range[3] from lowest to highest on record (Table 2.2). For the most recent year, the number of wells in each decile range was 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).

Five-year trends are calculated using mean annual 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).

The artesian portion of the GAB is given a tolerance threshold based on the most recent water temperature for the well, as higher temperatures (correlated to higher pressure levels) can lead to higher measurement errors. A tolerance threshold of 20 cm/y is applied for artesian wells with water temperatures greater than 40 degrees Celsius; other artesian wells have a tolerance threshold of 10 cm/y applied, and non-artesian wells have a tolerance threshold of 2 cm/y applied.

Table 2.2 Percentile/decile descriptions*

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

* Deciles and descriptions as defined by the Bureau of Meteorology[4]

2.2.2 Salinity

Water samples from flowing artesian wells are collected biannually from monitoring wells located across the Far North PWA. These samples are tested for electrical conductivity (EC) from which the salinity is calculated as total dissolved solids (TDS) and is measured in mg/L. Measurement of electrical conductivity of a water sample is often subject to small instrument errors.

Where more than one water sample has been collected in the course of a year, the annual mean salinity is used for analysis (e.g., Figure 4.4).

Salinity trends are calculated over a period of 10 years where there are at least seven years of salinity data. The trend line is calculated by linear regression and the percentage change in salinity is calculated using the following formula:

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

[3] 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.

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

The percentage of change over the trend period is then summarised in categories, depending on the range of change for each resource (e.g., Figure 4.5).

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

2.3 Water use

Water use information (Section 5) is based on metered extraction volumes where available. Currently, groundwater extractions are generally metered only for mining, petroleum and town water supply purposes. Operational mining water volumes are reported annually, via BHP's Olympic Dam GAB well fields report.[5] Water use in the petroleum industry is published online by Department of Energy and Mining.[6] Where meters are not installed (mainly domestic use and stock water), allocated volumes are reported instead.

2.4 Further information

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

Other important sources of information on water resources of the Far North PWA are:

- Summary reports on the groundwater resources of the Far North PWA and annual groundwater level and salinity status reports (Water Resource Assessments page on WaterConnect)[9]
- Water Allocation Plan for the Far North PWA (SAAL Landscape Board 2021)
- Far North PWA Groundwater Level and Salinity Status Report (DFW 2011)
- Hydrogeological Framework of the Western Great Artesian Basin (Keppel et al. 2013)
- Groundwater recharge, hydrodynamics and hydrochemistry of the Western GAB (Love et al. 2013)
- Groundwater-dependent ecosystems (Gotch, 2013).

[5] BHP's Olympic Dam well fields annual report at: https://www.bhp.com/-/media/bhp/regulatory-information-media/copper/olympic-dam/olympic-dam/annual-environment-reports/fy21-great-artesian-basin-wellfields-report.pdf

[6] Petroleum exploration and production system South Australia at https://peps.sa.gov.au/

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

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

[9] https://www.waterconnect.sa.gov.au/Systems/GSR/Pages/Default.aspx

3 Rainfall

Rainfall has very little direct influence on groundwater pressure levels across the majority of the GAB aquifer as it is mostly confined; the exception is around the western margin (discussed further in Section 4.2). In areas that are confined however, the demand for stock water in the pastoral industry is affected by stocking rates and the availability of feed, which is in turn affected by contemporary patterns in rainfall (Fu et al. 2020).

Rainfall occurrence and intensity is episodic, sometimes with marginal rainfall for years, while intense rainfall can deliver average annual amounts in a single event. Annual rainfall is generally less than 250 mm. However, rainfall in the far north of the state is highly variable and consequently, averages can be misleading. Average annual evaporation is extremely high, ranging from 2,400 to over 3,700 mm/y, which substantially exceeds average annual rainfall and often results in the rapid evaporation of surface water runoff.

At both Marla (BoM station 16085) and Marree (BoM station 17031) rainfall stations (Figure 1.1), rainfall in 2020–21 was slightly lower than each station's respective long-term average annual rainfall.

The Marree rainfall station provides a record of rainfall occurring in the southern part of the PWA. In 2020–21, annual rainfall is 152 mm, which is 13% less than the long-term average of 175 mm/y (1970 to 2021) (Figure 3.1).

The Marla rainfall station provides a record of rainfall occurring in the north-west of the PWA, where the J-K aquifer is sub-artesian. The annual rainfall total for 2020–21 is 198 mm, which is just 5% below the long-term average of 209 mm/y (1970 to 2021) (Figure 3.3).

Observed monthly rainfall is presented alongside the long-term monthly average for Maree (Figure 3.2) and Marla (Figure 3.4), which gives some insight into the variable nature of rainfall in the Far North PWA.

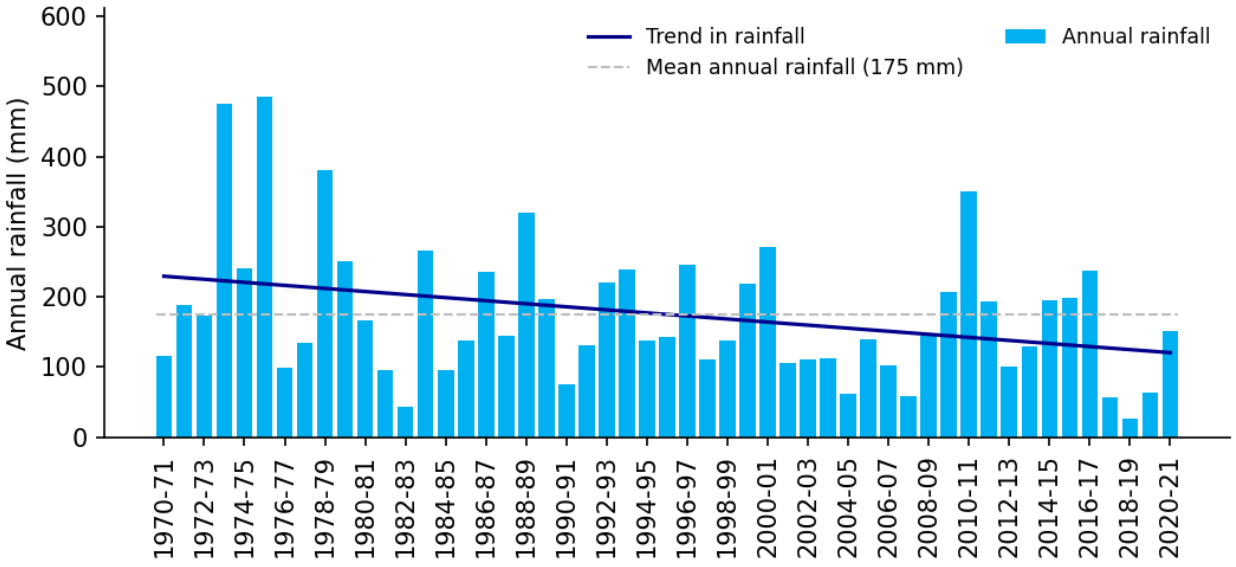


Figure 3.1 Annual rainfall from 1970–71 to 2020–21 at the Marree rainfall station (17031)

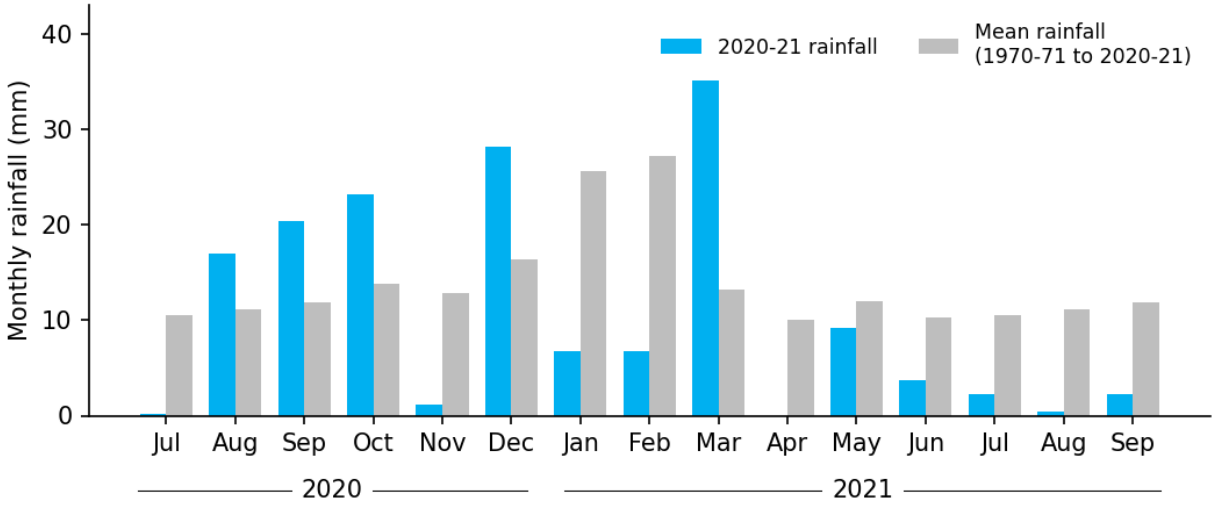


Figure 3.2 Monthly rainfall between July 2020 and September 2021, compared to the long-term monthly average at the Marree rainfall station (17031)

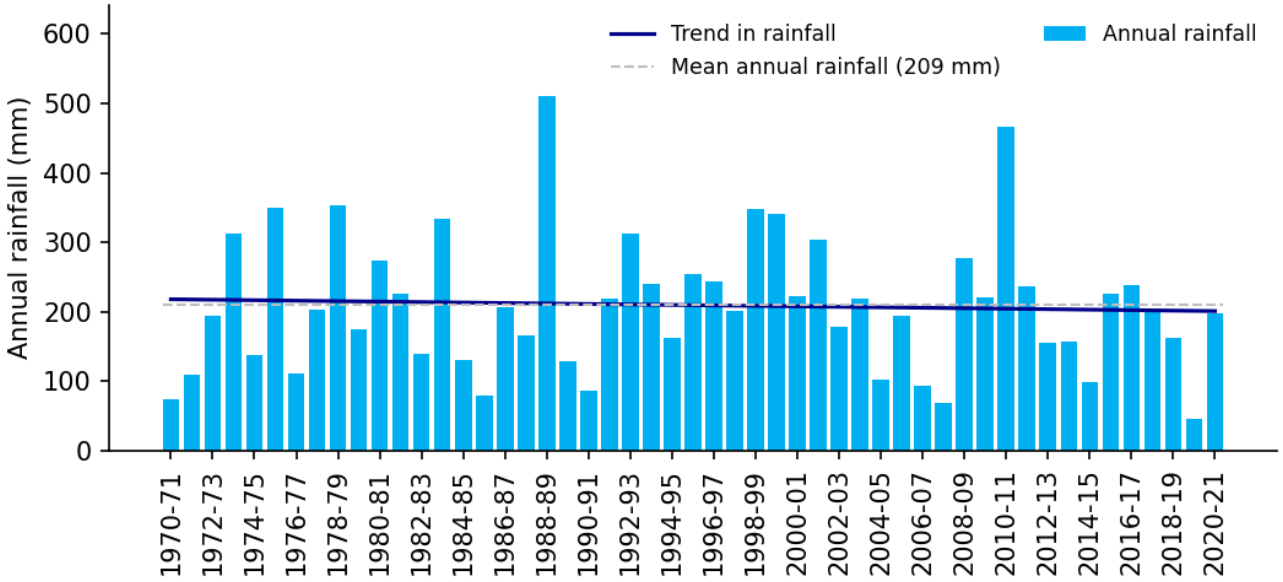


Figure 3.3 Annual rainfall from 1970–71 to 2020-21 at the Marla rainfall station (16085)

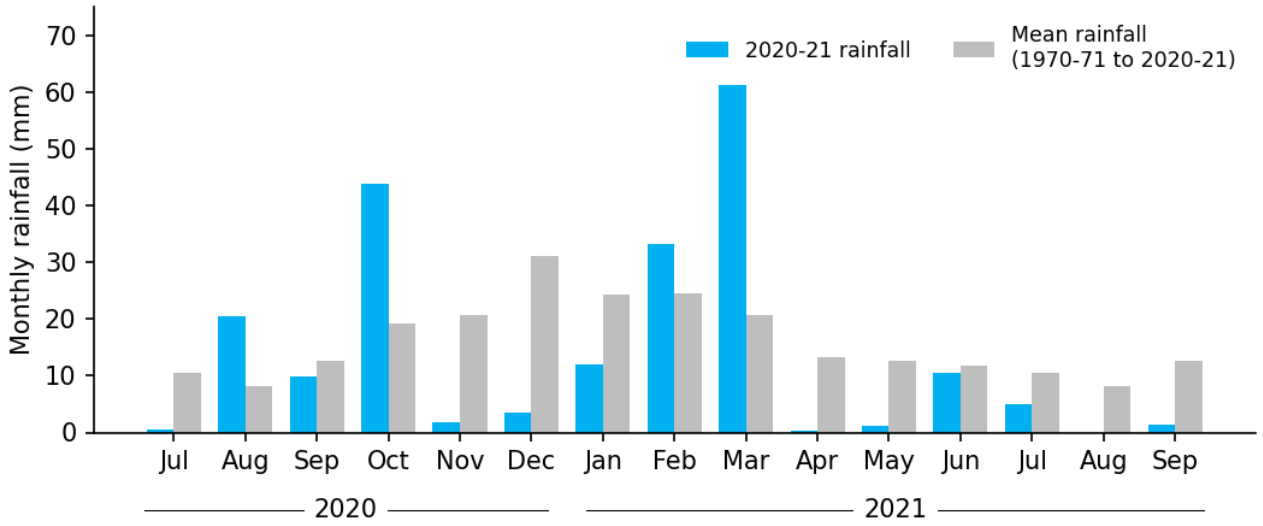


Figure 3.4 Monthly rainfall between July 2020 and September 2021 at the Marla rainfall station (16085)

4 Groundwater

4.1 Hydrogeology

The Great Artesian Basin (GAB) is a Jurassic to Cretaceous-aged super-basin containing non-marine and marine sediments that covers approximately one-fifth of the Australian continent (Krieg, Alexander and Rogers 1995). The GAB predominantly comprises the Eromanga, Surat and Carpentaria Basins. To the north-east of South Australia, the aquifer thickness is over 3,000 m, within the basin depocentres.

In South Australia, the GAB is composed of Eromanga Basin sediments that vary in thickness from less than 100 m on the margins of the basin to greater than 500 m near the Poolowanna Trough (Figure 1.1). The Cadna-owie Formation, Algebuckina Sandstone and lateral equivalents form the major water-bearing aquifer system (hereafter referred to as the J-K aquifer). Depth to the J-K aquifer is as much as 2,400 m in the State's north-east but rapidly decreases westwards, with the aquifer cropping out along the western margin.

Groundwater in the Far North PWA is predominately sourced from the J-K aquifer. For this reason, all groundwater data presented in this report relates to the J-K aquifer, unless otherwise stated. The majority of wells completed in the J-K aquifer within the Far North PWA are artesian wells.

Groundwater in the J-K aquifer in South Australia is primarily sourced through lateral in-flow from Queensland, New South Wales and the Northern Territory. Along the western margin of the J-K aquifer, some recharge occurs through flooding of ephemeral rivers in South Australia and the Northern Territory, although rates of recharge were likely greater in the past under wetter climatic conditions.

4.2 GAB J-K aquifer water level

In 2021, water levels in 41 out of 59 monitoring wells (69%) in the GAB aquifer in the Far North PWA are classified 'Average' or higher (see Section 2.2.1 for details of the classification; Figure 4.1). Seven wells are classified 'Lowest on record' – these are predominantly located in the south-central to north-eastern part of the PWA between Marree and Moomba. Most wells located around the western and southern margins of the extent of artesian groundwater are classified 'Average' or higher.

Five-year trends in water level are variable, with the majority of wells (66%) showing stable water levels or a rising trend. Rates range from a decline of 4.88 m/y to a rise of 4.29 m/y (the median change is a decline of 0.01 m/y) (Figure 4.2).

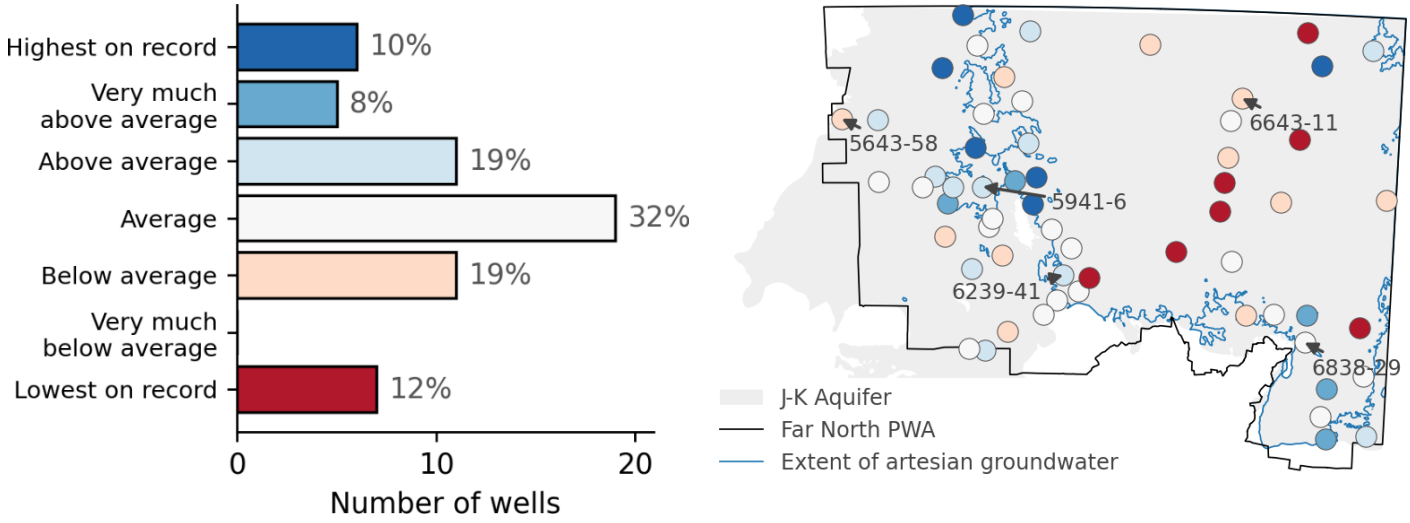


Figure 4.1 2021 water levels for wells in the GAB J-K aquifer

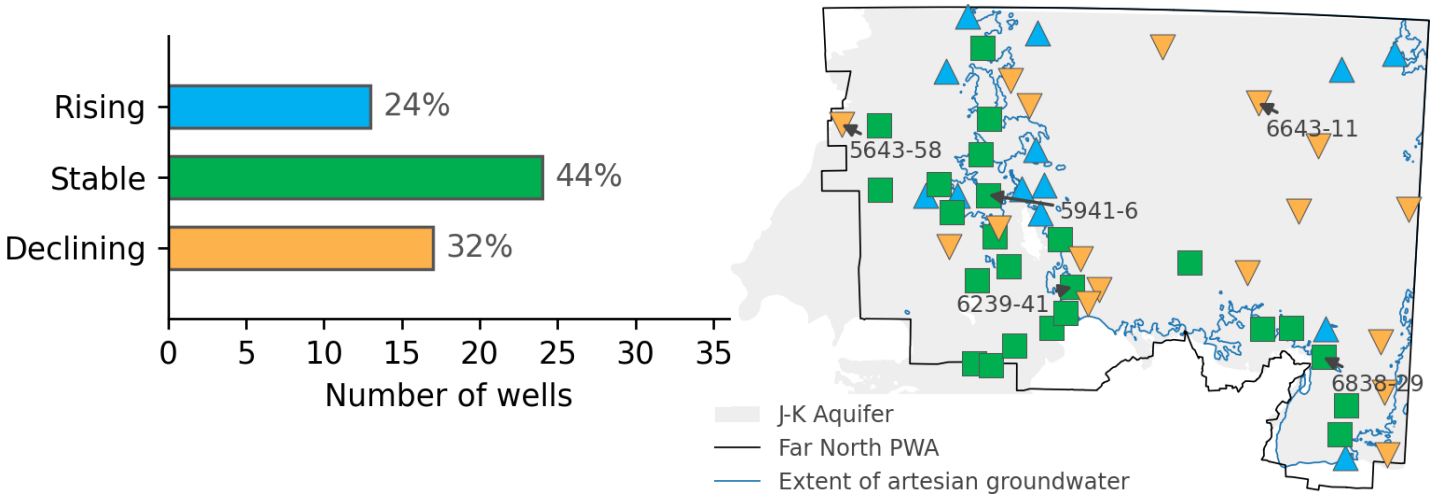


Figure 4.2 2017 to 2021 trend in water levels for wells in the GAB J-K aquifer

Hydrographs from a selection of representative monitoring wells are shown to illustrate common or important trends in the J-K aquifer (Figure 4.3). Monitoring well 5643-58 is located at Marla, in the far west of the PWA, where the aquifer is not artesian. Unlike the majority of wells in the Far North, the water level at 5643-58 appears to respond directly to incident rainfall, suggesting that recharge may occur locally. Large and intense rainfall events were recorded at Marla in 1988–89 and 2010–11 (Figure 3.3) and this is observed in the corresponding water level.

Several wells – e.g., 6239-41 (Strangways Bore 2) located in the south-west of the PWA near William Creek; 6838-29 (Woolatchi Bore) located in the south-eastern area near Lake Frome; and 5941-6 (Fergy's Bore) located in the central western area near Oodnadatta – show long-term rising (pressure) levels, consistent with rehabilitation works undertaken over the past few decades across the GAB. Pressure levels in these wells has been relatively stable since around 2010.

Bore 6643-11 is located at Goyder's Lagoon to the north of the PWA. It shows a generally declining trend since the late 1980s.

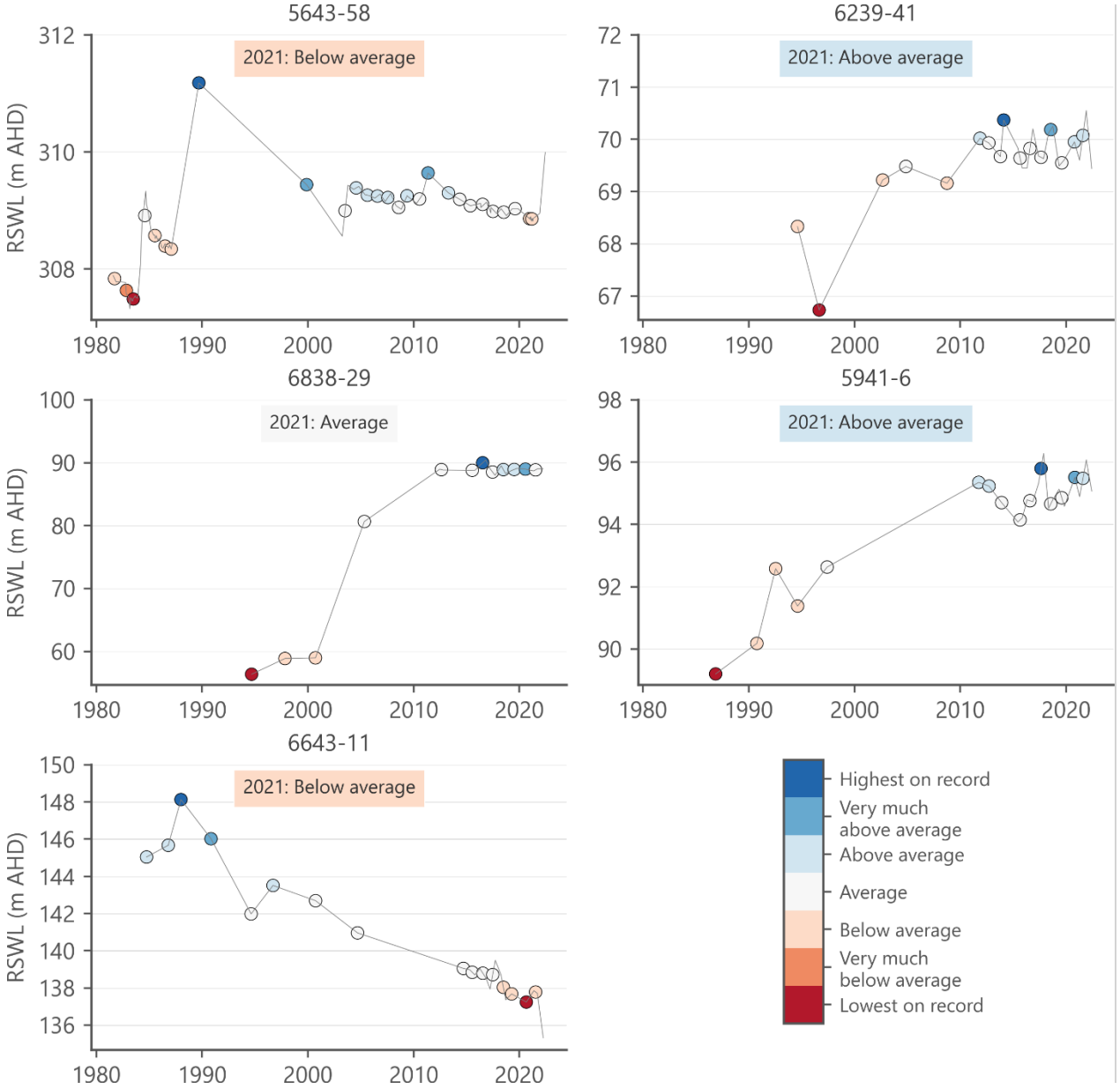


Figure 4.3 Selected GAB J-K aquifer hydrographs

4.3 GAB J-K aquifer salinity

In 2021, sampling results from 50 wells in the GAB J-K aquifer in the Far North PWA range between 487 mg/L and 5,246 mg/L, with a median of 1,836 mg/L (Figure 4.4). Wells with salinity less than 1,000 mg/L tend to be located in the south-central to north-eastern part of the PWA. Higher salinities above 3,000 mg/L tend to be found mostly near the western margin of the extent of artesian groundwater (Figure 4.4).

In the ten years to 2021, 36 of 40 wells (89%) show a decreasing trend in salinity (Figure 4.5). Ten-year trends show that rates of change in salinity vary from a decrease of 1.9% per year to an increase of 0.5% per year, with a median rate of 0.5% decrease per year (Figure 4.5).

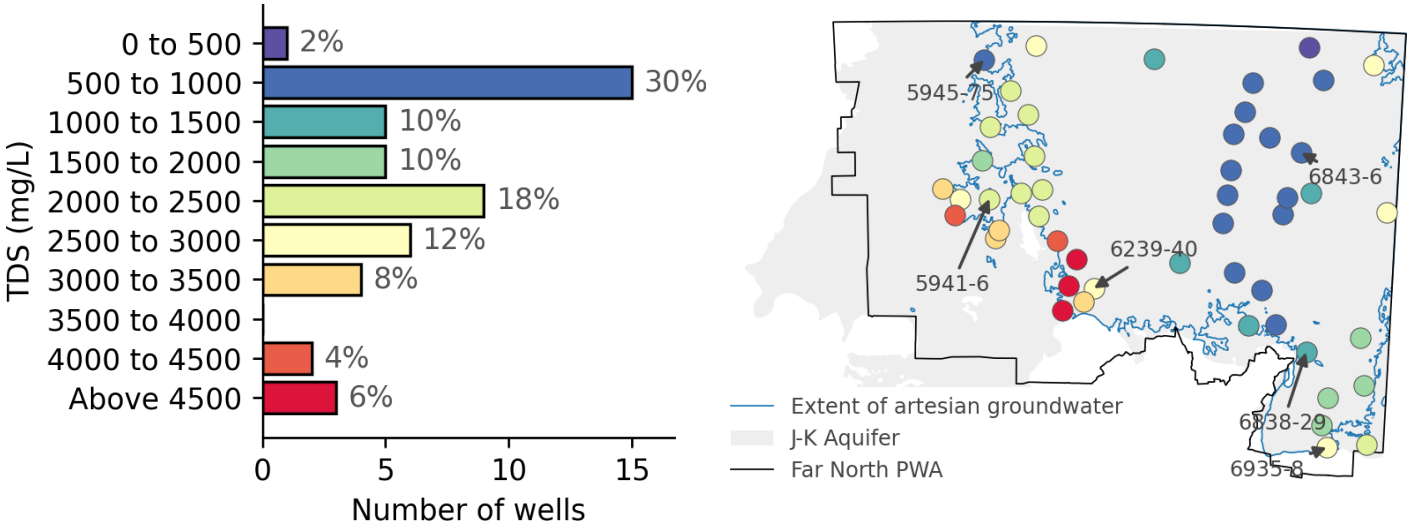


Figure 4.4 2021 salinity observations from wells in the GAB J-K aquifer

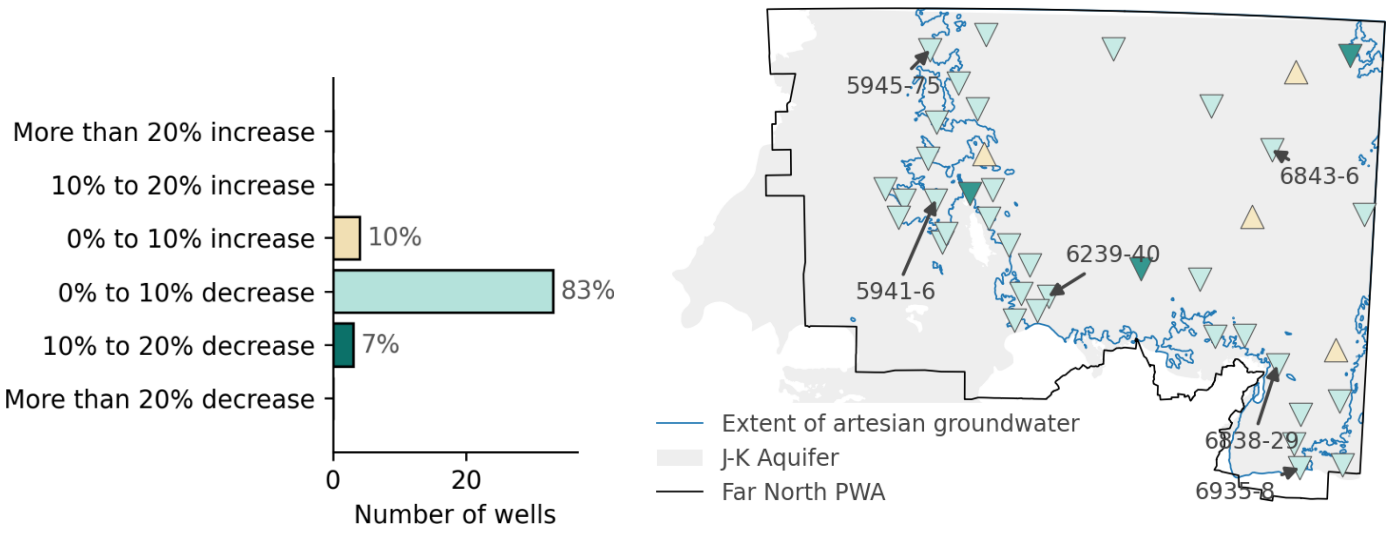


Figure 4.5 Salinity trend in the ten years to 2021 for wells in the GAB J-K aquifer

Salinity graphs from a selection of J-K monitoring wells (Figure 4.6), which are located only in the artesian part of the aquifer, indicate that the salinity of the GAB aquifer has remained relatively stable since salinity sampling commenced in the early 1900s.

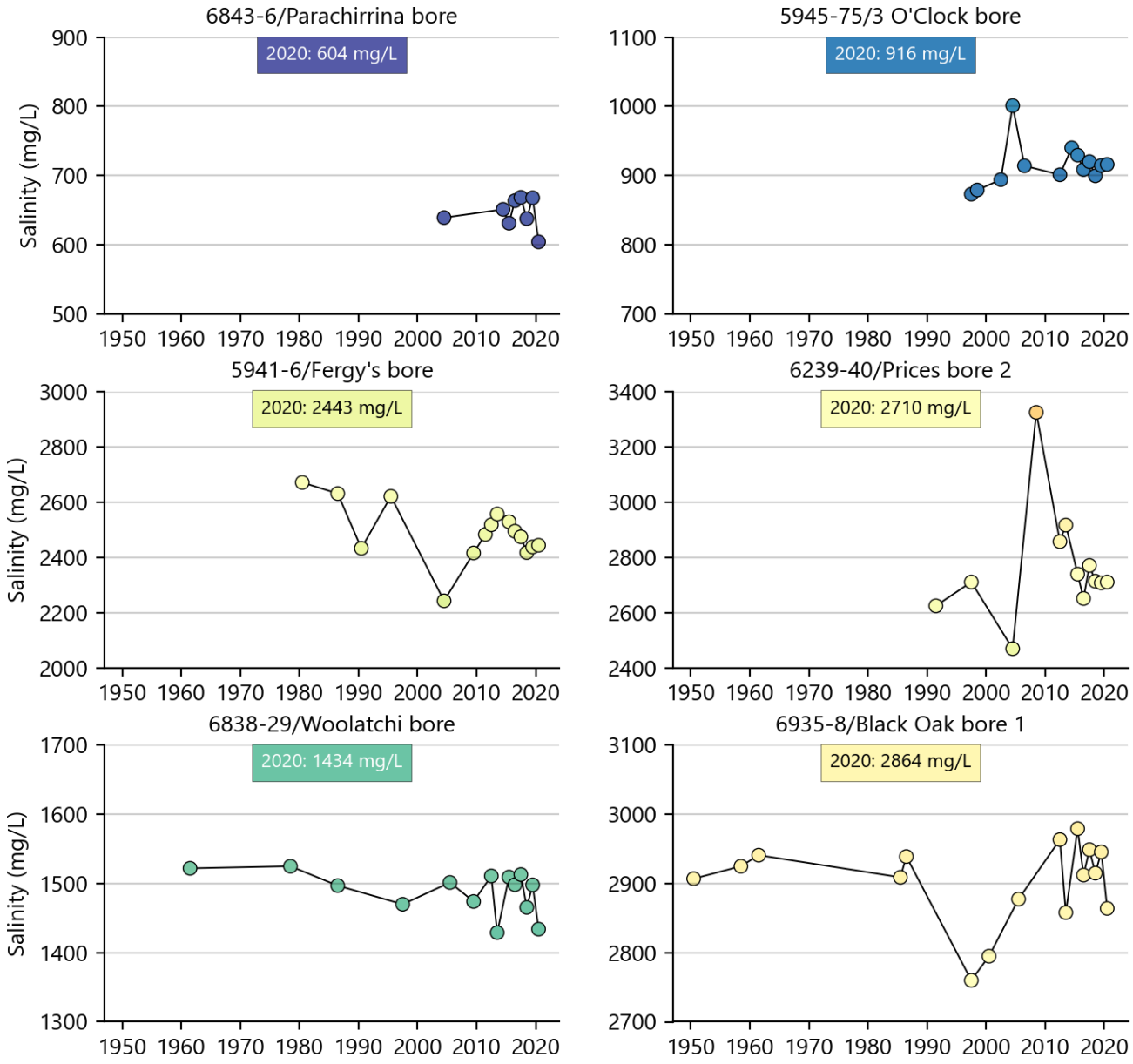


Figure 4.6 Selected GAB J-K aquifer salinity graphs

5 Water use

In the Far North PWA, groundwater is extracted predominantly to support mining and for stock and domestic purposes. The majority of allocated groundwater is sourced from the GAB (76%), though there are also considerable volumes sourced from other aquifers, including the underlying Arckaringa Basin (up to 17%) and the overlying Lake Eyre Basin (4%) (SAAL Landscape Board 2021).

Water use in some industries is metered, e.g., 'Oil and gas' water, which is co-produced as part of the petroleum industry (in the Cooper Basin); and 'Mining' water, which is extracted under a special allocation[10] for operation of the Olympic Dam mine, are metered. Metered extractions for these purposes total 32,922 ML in 2020–21 (Figure 5.1). This is a slight decrease from the previous year.

In addition to metered extraction data shown in Figure 5.1, allocated volumes across the Far North PWA in 2020–21 include:

- 11,191 ML for stock and domestic purposes
- 11,617 ML for mining[11]
- 630 ML for town water supply purposes
- 2,906 ML for amenities and camp water purposes
- 1,865 ML for other purposes.

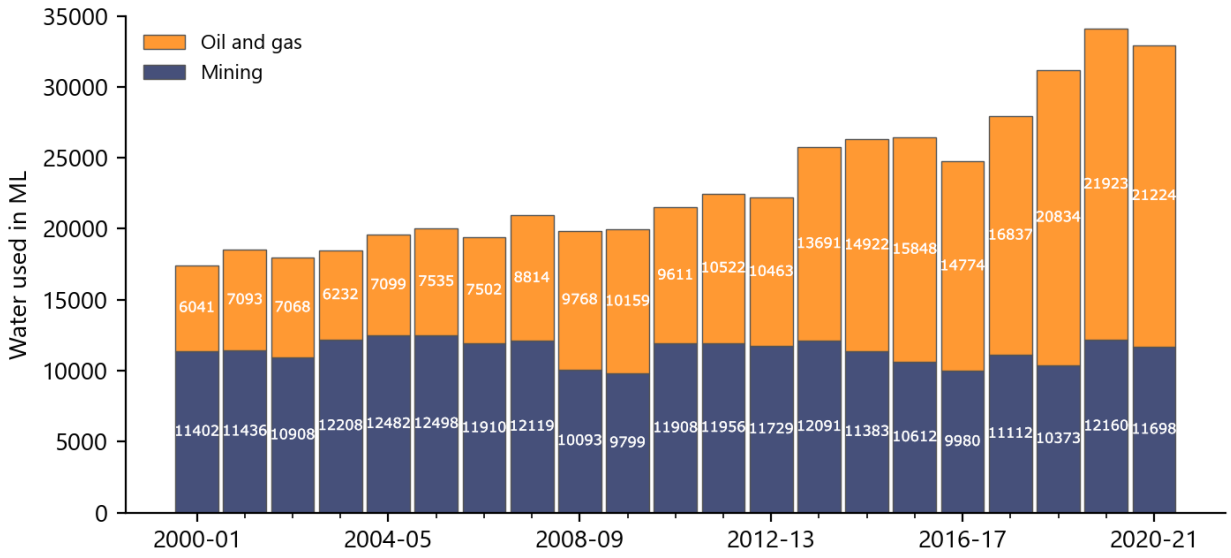


Figure 5.1 Water extraction for mining and petroleum from 2000–01 to 2020–21 in the Far North PWA

[10] Special Water Licence issued pursuant to the *Roxby Downs (Indenture Ratification) Act 1982*

[11] This allocation is predominantly from non-GAB (J-K aquifer) sources and separate from the extraction for mining, shown in Figure 5.1

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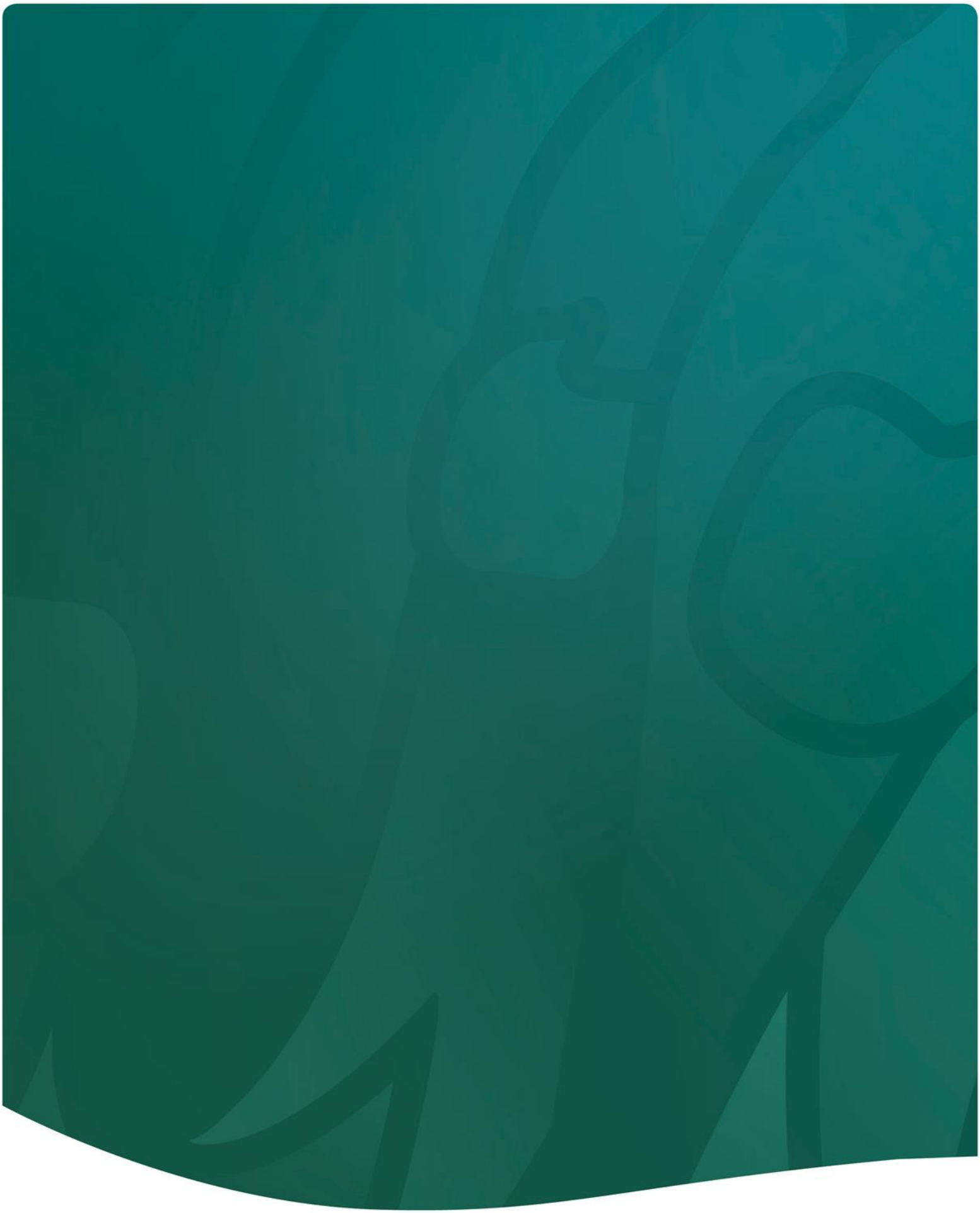

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