Technical information supporting the 2023 Groundwater: water level and salinity environmental trend and condition report card

Department for Environment and Water
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Government of South Australia
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Acknowledgement of Country

We acknowledge and respect the Traditional Custodians whose ancestral lands we live and work upon and we pay our respects to their Elders past and present. We acknowledge and respect their deep spiritual connection and the relationship that Aboriginal and Torres Strait Islanders people have to Country. We also pay our respects to the cultural authority of Aboriginal and Torres Strait Islander people and their nations in South Australia, as well as those across Australia.

Acknowledgements

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Summary

The 2023 release of South Australia's environmental trend and condition report cards summarises our understanding of the current condition of the South Australian environment, and how it is changing over time.

This document describes the indicators, information sources, analysis methods and results used to develop this report and the associated 2023 Groundwater: Water level and salinity report card. The reliability of information sources used in the report card is also described.

The Groundwater: Water level and salinity report card sits within the report card Water theme and Groundwater sub-theme. Report cards are published by the Department for Environment and Water and can be accessed at www.environment.sa.gov.au.

1 Introduction

1.1 Environmental trend and condition reporting in SA

The Minister for Climate, Environment and Water under the *Landscape South Australia Act 2019* is required to 'monitor, evaluate and audit the state and condition of the State's natural resources, coasts and seas; and to report on the state and condition of the State's natural resources, coasts and seas' (9(1(a-b)). Environmental trend and condition report cards are produced as the primary means for the Minister to undertake this reporting. Trend and condition report cards are also a key input into the State of the Environment Report for South Australia, which must be prepared under the *Environment Protection Act 1993*. This Act states that the State of the Environment Report must:

- include an assessment of the condition of the major environmental resources of South Australia (112(3(a))), and
- include a specific assessment of the state of the River Murray, especially taking into account the Objectives for a Healthy River Murray under the *River Murray Act 2003* (112(3(ab))), and
- identify significant trends in environmental quality based on an analysis of indicators of environmental quality (112(3(b))).

1.2 Purpose and benefits of SA's trend and condition report cards

South Australia's environmental trend and condition report cards focus on the state's priority environmental assets and the pressures that impact on these assets. The report cards present information on trend, condition, and information reliability in a succinct visual summary.

The full suite of report cards captures patterns in trend and condition, generally at a state scale, and gives insight to changes in a particular asset over time. They also highlight gaps in our knowledge on priority assets that prevent us from assessing trend and condition and might impede our ability to make evidence-based decisions.

Although both trend and condition are considered important, the report cards give particular emphasis to trend. Trend shows how the environment has responded to past drivers, decisions, and actions, and is what we seek to influence through future decisions and actions.

The benefits of trend and condition report cards include to:

- provide insight into our environment by tracking its change over time
- interpret complex information in a simple and accessible format
- provide a transparent and open evidence base for decision-making
- provide consistent messages on the trend and condition of the environment in South Australia
- highlight critical knowledge gaps in our understanding of South Australia's environment
- support alignment of environmental reporting, ensuring we 'do once, use many times'.

Environmental trend and condition report cards are designed to align with and inform state of the environment reporting at both the South Australian and national level. The format, design and accessibly of the report cards has been reviewed and improved with each release.

1.3 Groundwater water level and salinity

Groundwater is the largest freshwater resource in South Australia. Groundwater is vital for our town water supplies and sustains a range of ecosystems. It also provides for agriculture, mining and manufacturing industries.

Sustainable water management and planning is vital to our long-term water security (both quality and quantity), the environment and the economy. Groundwater level is a measure of groundwater quantity and groundwater salinity is a measure of groundwater quality.

The state's groundwater resources are affected by weather/climate and water-use demand patterns. Rainfall patterns influence groundwater recharge – including wet/dry cycles over the short/medium term and climate change over the longer term. Rainfall patterns also influence demand – more water is required during hotter/drier periods. The combination of these factors means that groundwater levels can decline during dry periods. Declining groundwater levels can lead to an increased risk of increasing salinity.

Key groundwater resources are managed under the *Landscape South Australia Act 2019* through water allocation plans. These plans provide the framework for sustainable management of water resources by considering the competing environmental, social and economic demands for water. They aim to strike the balance between improving resource condition and permitting extraction for consumptive use. Water allocation plans are periodically reviewed and updated.

2 Methods

The following methodology describes the process to use readily available groundwater data to define the trend and condition of groundwater resources at the state scale. It is a challenging task to distil the monitoring trends from a number of distinct groundwater resources, with widely different climatic conditions and degrees of resource development, while still offering meaningful conclusions.

Important groundwater resources across South Australia often have distinct characteristics; from unconfined to confined aquifers, and from vulnerable resources with low storage volumes to large robust resources with very large storage volumes. There are different drivers of groundwater trends, ranging from climatic influences, to streamflow and also extraction. Despite the benefits of a consistent approach as outlined in Section 1, the reporting methodology may not always appropriately communicate the condition of the various resources relative to the water resources management issues that differ for each resource. This challenge has somewhat been overcome by the adoption of variable tolerances/thresholds for different aquifer types (discussed in Section 2.4.1).

An additional difficulty in the production of this report (and associated report card) relates to the upscaling of results. The amalgamation (or averaging) of trend data from a lower level to a single result at a higher level may not provide an accurate indication of the resource condition. For example, any given prescribed area may have several different aquifers that display different monitoring trends, and within each aquifer, there may be different trends observed in different locations.

As part of the Water Resources Assessment Program (WRAP), the Department for Environment and Water (DEW) completes a suite of annual DEW Technical Notes and factsheets (DEW 2022) which provide additional detail with respect to groundwater level and salinity trends over time. These reports can be accessed via WaterConnect.

The assessment described in this report constitutes the same regions, and sub-regions where applicable, as selected for WRAP reporting. These regions have been identified as the most important groundwater resources across the state.

2.1 Indicator

The indicators used in the Groundwater (water level and salinity) report card are as follows.

For the assessment of **trend:**

- the five-year trend in groundwater level
- the five-year trend in groundwater salinity.

For the assessment of **condition:**

- long-term trends in groundwater level and salinity
- metered water use compared to statewide allocation.

2.2 Data sources

Groundwater level and salinity data are available at WaterConnect.

Sustainable limits for the applicable groundwater resources are sourced from the relevant Water Allocation Plans.

Allocation and extraction volumes are sourced from the State's Water Information and Licensing Management Application (WILMA).

2.3 Data collection

DEW is the lead agency for water monitoring in South Australia. DEW's Water Resource Monitoring Unit collects data from 3,645 groundwater sites across the state (DEW 2019). The dataset from this monitoring is augmented by data collected by other organisations and water users.

2.4 Methods to assign trend, condition and reliablity

Calculation of groundwater trend is based on data collected between 1 January 2018 and 31 December 2022.

Reporting of annual groundwater data is based on the calendar year, while groundwater extraction data (or, for example, surface water data), is based on the (earlier) financial year – this is due to the typically delayed response of groundwater systems.

2.4.1 Trend

To determine the trend in groundwater level, data over the past five years are analysed. This approach is consistent with methods adopted by other government agencies, such as the Bureau of Meteorology (BoM 2022).

The definition of a 'stable' water level is based on tolerances, whereby a well's groundwater level can show a rising or declining trend, but measure within a certain margin (tolerance) and still be considered stable. These tolerances vary with aquifer type and the scale of the resource. This approach is taken to: (1) accommodate wells that show water levels with such low rates of water level rise or decline that they can be considered stable and (2) account for very small errors (e.g. human or instrument error) that may occur in measurements of this kind, including water levels (where they are in the order of 1 to 2 cm).

The tolerances chosen to demarcate a stable water level are based on the trend (i.e. the average rate of change) in water level over the past five years. For sedimentary systems – i.e. for both regional confined systems with large storages and for moderately-sized unconfined and semi-confined to confined aquifers – the tolerance selected to delineate stable water levels is ±0.02 m/y. Fractured rock aquifers have generally lower storages and are assigned a tolerance of ±0.01 m/y while Eyre Peninsula's freshwater lenses in unconfined karstic limestone aquifers, that are generally less robust than unconsolidated sedimentary aquifers, are assigned a tolerance of ±0.004 m/y.

For the Far North Prescribed Wells Area (PWA), the artesian portion of the Great Artesian Basin 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 greater measurement errors. A tolerance threshold of ±0.2 m/y is applied for artesian wells with water temperatures greater than 40 degrees Celsius while other artesian wells are given a tolerance threshold of ±0.1 m/y. For non-artesian wells, a tolerance threshold of ±0.02 m/y is applied, which is similar to other sedimentary aquifers across the state.

For the assessment of water level trends, only water level data measured during the non-pumping season are used. The amount of pumping can vary from year to year and the proximity of pumping wells to observation 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. This method eliminates variations introduced due to intensity of pumping and its proximity to monitoring wells and better represents the robustness and recovery of the aquifer. As well as those variations associated with extraction, there are also natural variations in groundwater levels and salinity in response to

rainfall. To determine the trend in groundwater salinity, data over the past five years were analysed. The status for each well is then determined, based on whether the trend in salinity is either decreasing, increasing or stable.

In a similar approach to that taken for groundwater levels, the definition of 'stable' salinity is based on tolerances, whereby a well's groundwater salinity can show an increasing or decreasing trend, but measure within a certain margin (tolerance) and still be considered stable.

The tolerance chosen to delineate stable salinity is ±10%, measured over the past five years. A tolerance of ±10% was chosen to account for errors in measuring groundwater salinity (e.g. human or instrument error) and to compensate for possible errors due to:

- Timing of sample collection (i.e. seasonal differences such as winter versus summer)
- Inconsistencies in purging of wells before the salinity sample is collected
- Temperature effects
- Instruments calibration.

Table 2.1. Definition of trend classes used

Trend	Description	Threshold*					
		Water Level					Salinity
		Sedimentary Aquifers	Fractured Rock Aquifers	Eyre Peninsula's freshwater lenses	Great Artesian Basin <40ºC	Great Artesian Basin >40ºC	All aquifers
Getting better	The indicator is improving in status with good confidence	>0.02 m/y	>0.01 m/y	>0.004 m/y	>0.1 m/y	>0.2 m/y	<-10%
Stable	The indicator is neither improving or declining in status	±0.02 m/y	±0.01 m/y	±0.004 m/y	±0.1 m/y	±0.2 m/y	±10%
Getting worse	The indicator is declining in status with good confidence	<-0.02 m/y	<-0.01 m/y	<-0.004 m/y	<-0.1 m/y	<-0.2 m/y	>10%
Unknown	Data are not available, or are not available at relevant temporal scales, to determine any trend in the status of this resource						
Not applicable	This indicator of the natural resource does not lend itself to being classified into one of the above trend classes						

* Rate of change (m/y) or percentage change (%) over the past five years

2.4.2 Condition

The reported condition of the prescribed groundwater resources in South Australia is based on the long-term trends in groundwater levels and salinity, in conjunction with metered water use compared to statewide allocation in the 2021–22 water-use year. The condition classifications used in DEW's environmental trend and condition report cards are given in Table 2.2.

Table 2.2. Definition of condition classes used

Condition	Description
Very good	The natural resource is in a state that meets all environmental, economic and social expectations, based on this indicator. Thus, desirable function can be expected for all processes/services expected of this resource, now and into the future, even during times of stress (e.g. prolonged drought)
Good	The natural resource is in a state that meets most environmental, economic and social expectations, based on this indicator. Thus, desirable function can be expected for only some processes/services expected of this resource, now and into the future, even during times of stress (e.g. prolonged drought)
Fair	The natural resource is in a state that does not meet some environmental, economic and social expectations, based on this indicator. Thus, desirable function cannot be expected from many processes/services expected of this resource, now and into the future, particularly during times of stress (e.g. prolonged drought)
Poor	The natural resource is in a state that does not meet most environmental, economic and social expectations, based on this indicator. Thus, desirable function cannot be expected from most processes/services expected of this resource, now and into the future, particularly during times of stress (e.g. prolonged drought)
Unknown	Data are not available to determine the state of this natural resource, based on this indicator
Not applicable	This indicator of the natural resource does not lend itself to being classified into one of the above condition classes

2.4.3 Reliability

Information is scored for reliability based on the minimum of subjective scores (1 [worst] to 5 [best]) given for information currency, applicability, level of spatial representation and accuracy. Definitions guiding the application of these scores are provided in Table 2.3 for currency,

Table 2.4 for applicability, Table 2.5 for spatial representation and Table 2.6 for accuracy.

Table 2.3. Guides for applying information currency

Currency score	Criteria
1	Most recent information >10 years old
2	Most recent information up to 10 years old
3	Most recent information up to 7 years old
4	Most recent information up to 5 years old
5	Most recent information up to 3 years old

Table 2.4. Guides for applying information applicability

Applicability score	Criteria
1	Data are based on expert opinion of the measure
2	All data based on indirect indicators of the measure
3	Most data based on indirect indicators of the measure
4	Most data based on direct indicators of the measure
5	All data based on direct indicators of the measure

Table 2.5. Guides for applying spatial representation of information (sampling design)

Spatial score	Criteria
1	From an area that represents less than 5% the spatial distribution of the asset within the region/state or spatial representation unknown
2	From an area that represents less than 25% the spatial distribution of the asset within the region/state
3	From an area that represents less than half the spatial distribution of the asset within the region/state
4	From across the whole region/state (or whole distribution of asset within the region/state) using a sampling design that is not stratified
5	From across the whole region/state (or whole distribution of asset within the region/state) using a stratified sampling design

Table 2.6. Guides for applying accuracy information

Reliability	Criteria
1	Better than could be expected by chance
2	> 60% better than could be expected by chance
3	> 70 % better than could be expected by chance
4	> 80 % better than could be expected by chance
5	> 90 % better than could be expected by chance

2.5 Data transparency

Data transparency for this report (and associated report card) is represented in Appendix A.

3 Results

3.1 Trend

DEW's annual WRAP reports provide a summary of how groundwater levels and salinities for various aquifers within the state's prescribed regions have changed over the preceding five year period. The trend data used in the 2021–22 WRAP reports provide a summary of the trends observed for the period 2018–22. The reports indicate the percentage of groundwater wells which observed a rise in groundwater level, a decline in groundwater level or a stable groundwater level over the five year period. Additionally the reports provide similar information for groundwater salinity, noting that analysis is presented for long-term salinity trends, where sufficient data are available. These data have been used to determine if a prescribed area should be characterised as having 'rising or stable water levels and decreasing or stable salinity' (blue) or 'declining water levels and increasing salinity' (red).

Table 3.1 outlines the WRAP regions[1] and indicates the percentage of wells in each region which show a rise, decline or stable trend in both groundwater level and salinity over the five-year period. The percentage of wells that show either a rise in water level or stable levels have been summed together; similarly for salinity, the percentage of wells which show decreasing or stable salinity trends have been summed together.

WRAP regions are then defined[2] as having either:

- Rising or stable water levels and decreasing or stable salinity (blue + blue = blue)
- Declining water levels and increasing salinity (red + red = red)
- Declining water levels and decreasing or stable salinity (red + blue = purple), or rising or stable water levels and increasing salinity (blue + red = purple).

The data available for the WRAP regions were then combined to provide an overall trend for each prescribed area. Prescribed areas have between one and four WRAP regions within them. Where a clear majority of blue, red or purple regions exists, the majority is adopted accordingly. Where no clear majority exists, professional judgement was used to select the most appropriate overall result, taking into account the drivers of trends and the higher value uses of the resource. Consideration was also made of longer-term trends (where available) and robustness of the aquifer. The overall groundwater trends from 2018 to 2022 for each prescribed area are shown in Figure 3.1.

In providing an overall classification of trend in groundwater for the entire state, all wells included in annual water reporting were considered, using the process described above. Throughout the state, 54% of wells have a declining 5-year water level trend (red) and 85% of wells have a stable or decreasing salinity (blue). Hence the overall classification of 'stable' (i.e. within acceptable ranges; purple) is considered to be appropriate.

[1] The term 'WRAP regions' refers to the regions, and sub-regions where applicable, that have been adopted for reporting under the Water Resources Assessment Program

[2] Where sufficient salinity data are not available, some regions were assigned a blue or red status based on water level trends alone

Table 3.1. Summary of groundwater 5-year trend data over the period 2018 to 2022

Landscape region	Prescribed Area	WRAP Region	Sub Region	Water Level (%)				Salinity (%)				Rising or stable water levels and decreasing or stable salinity	Declining water levels and increasing salinity	Declining water levels and decreasing salinity, or Rising water levels and increasing salinity	Overall Trend for Prescribed Area 2018-2022
			(if applicable)	Rise	Decline	Stable	Rise + Stable	Increase	Decrease	Stable	Decrease + Stable				
Eyre Peninsula	Southern Basins PWA	Uley South Lens		29%	59%	12%	41%	14%	5%	82%	86%				
		Uley Wanilla Lens		13%	88%	0%	13%	38%	0%	63%	63%				
		Lincoln Basins		14%	77%	9%	23%	17%	0%	83%	83%				
		Coffin Bay A Lens		100%	0%	0%	100%	0%	0%	100%	100%				
	Musgrave PWA	Polda Lens		12%	85%	3%	15%	45%	0%	55%	55%				
		Bramfield Lens		29%	57%	14%	43%	25%	0%	75%	75%				
Hills and Fleurieu	McLaren Vale PWA	Maslin Sands		43%	43%	14%	57%	35%	0%	65%	65%				
		Port Willunga Formation		25%	69%	6%	31%	7%	12%	81%	93%				
		Fractured Rock		53%	40%	7%	60%	9%	5%	86%	91%				
	Western Mount Lofty Ranges PWRA	Permian Sand		71%	14%	14%	86%	NA	NA	NA	NA				
		Tertiary Limestone		93%	0%	7%	100%	NA	NA	NA	NA				
		Fractured Rock		63%	34%	3%	66%	38%	25%	38%	63%				
	Angas Bremer PWA	Murray Group Limestone		75%	9%	16%	91%	50%	20%	30%	50%				
Hills and Fleurieu + Murraylands and Riverland	Eastern Mount Lofty Ranges PWRA	Murray Group Limestone		79%	14%	7%	86%	33%	0%	67%	67%				
		Permian Sand	Finniss	65%	15%	20%	85%	17%	24%	59%	83%				
			Tookayerta	15%	62%	23%	38%								
		Fractured Rock		51%	46%	3%	54%	16%	21%	63%	84%				
Murraylands and Riverland	Marne-Saunders PWRA	Murray Group Limestone		30%	70%	0%	30%	14%	29%	57%	86%				
		Fractured Rock		33%	67%	0%	33%	33%	0%	67%	67%				
	Mallee PWA	Murray Group Limestone		34%	49%	17%	51%	4%	0%	96%	96%				
	Peake-Roby-Sherlock PWA	Confined aquifer		92%	8%	0%	92%	14%	0%	86%	86%				
Northern and Yorke	Barossa PWRA	Upper		38%	63%	0%	38%	25%	0%	75%	75%				
		Lower		47%	47%	7%	53%	13%	0%	88%	88%				
		Fractured Rock		67%	29%	5%	71%	0%	20%	80%	100%				
	Clare PWRA	Fractured Rock		43%	53%	3%	47%	20%	10%	70%	80%				
	Baroota PWRA			20%	80%	0%	20%	NA	NA	NA	NA				
Northern and Yorke + Green Adelaide	Northern Adelaide Plains PWA	T1		90%	5%	5%	95%	0%	7%	93%	100%				
		T2		85%	15%	0%	85%	19%	7%	74%	81%				
		Kangaroo Flat region		50%	25%	25%	75%	14%	57%	29%	86%				
Green Adelaide	Central Adelaide Plains	T1		82%	13%	5%	87%	0%	0%	100%	100%				
Limestone Coast	Lower Limestone Coast PWA	Unconfined	Coastal Plain and Donovans	15%	68%	17%	32%	12%	18%	70%	88%				
			Highlands	3%	95%	3%	5%	4%	11%	85%	96%				
		Confined		18%	62%	21%	38%	0%	0%	100%	100%				
	Padthaway PWA	Unconfined	Ranges	9%	73%	18%	27%	0%	0%	100%	100%				
			Flats	0%	100%	0%	0%	21%	16%	63%	79%				
	Tintinara-Coonalpyn PWA	Unconfined	Mallee Highlands	0%	86%	14%	14%	0%	0%	100%	100%				
			Plains	55%	32%	14%	68%								
		Confined		71%	19%	10%	81%	0%	0%	100%	100%				
	Tatiara PWA	Unconfined	Highlands	0%	54%	46%	46%	0%	0%	100%	100%				
			Plains	6%	85%	9%	15%	17%	6%	78%	83%				
		Confined		0%	100%	0%	0%	NA	NA	NA	NA				
SA Arid Lands	Far North PWA	Great Artesian Basin		31%	28%	41%	72%	3%	5%	93%	98%				

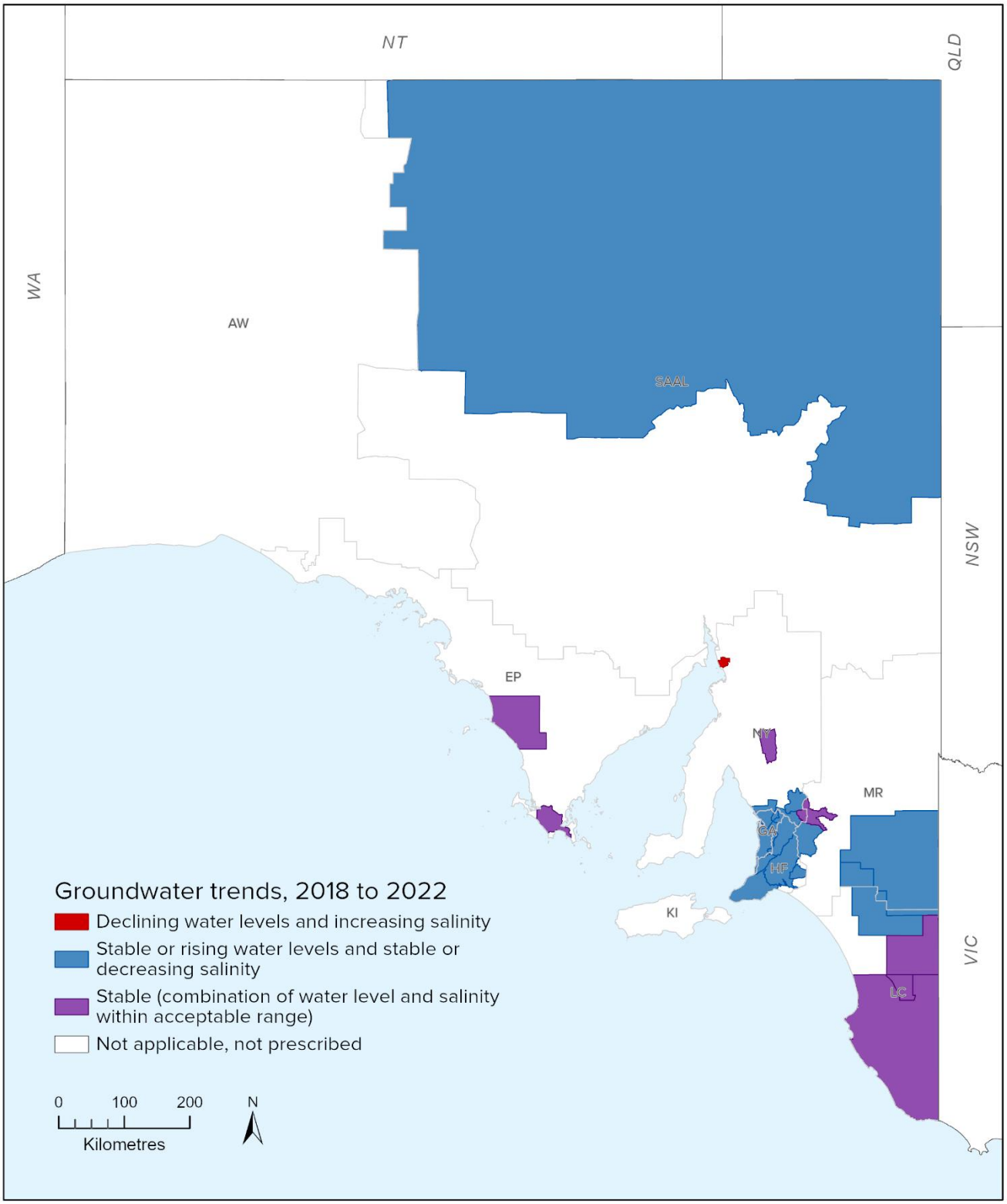


Figure 3.1. **Groundwater trends, 2018 to 2022, for each prescribed area**

3.2 Condition

The condition of the majority of the prescribed groundwater resources in South Australia is 'good'. This is based on: (1) the observed long-term trends in groundwater levels and salinity and (2) that metered water use is below the statewide full allocation (Figure 3.2). This provides the ability for most existing water users to meet their needs (Table 3.2).

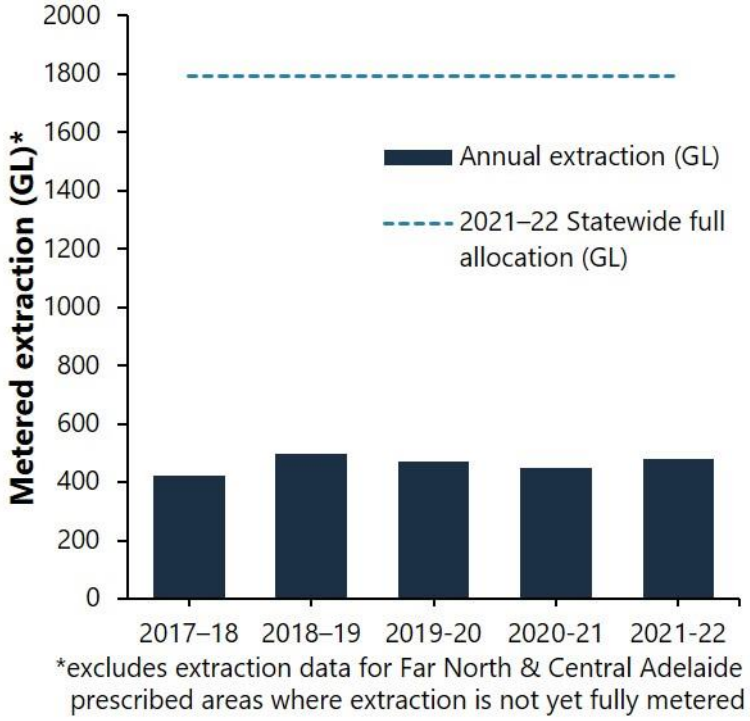


Figure 3.2. Metered groundwater extraction compared to the statewide full allocation volume in 2021–22

The summary of extraction and allocations for each prescribed area is shown in Table 3.2.

Table 3.2. Metered extraction as a percentage of licensed allocation

Landscape region	Prescribed area*	Metered extractions (ML) 2021–22	Full allocation (ML) 2021–22	Extraction as a % of allocation 2021–22
Eyre Peninsula	Southern Basins PWA	4,534	8,958	51%
	Musgrave PWA	55	1,028	5%
Hills and Fleurieu	McLaren Vale PWA	3,891	8,410	46%
	Western Mount Lofty Ranges PWRA	13,582	59,636	23%
	Angas Bremer PWA	1,495	8,942	17%
Hills and Fleurieu + Murraylands and Riverland	Eastern Mount Lofty Ranges PWRA	7,545	34,535	22%
Murraylands and Riverland	Marne-Saunders PWRA	1,371	4,536	30%
	Mallee PWA	32,382	61,353	53%
	Peake-Roby-Sherlock PWA	515	2,231	23%
Northern and Yorke	Barossa PWRA	2,628	8,707	30%
	Clare PWRA	887	2,221	40%
	Baroota PWRA	N/A	N/A	N/A
Northern and Yorke + Green Adelaide	Northern Adelaide Plains PWA	10,793	41,737	26%
	Kangaroo Flat region	716	1,766	41%
Green Adelaide	Central Adelaide Plains	N/A	11,309	N/A
	Dry Creek	452	850	53%
Limestone Coast	Lower Limestone Coast PWA	258,328	1,150,758	22%
	Padthaway PWA	30,181	67,713	45%
	Tintinara-Coonalpyn PWA	37,287	100,231	37%
	Tatiara PWA	73,663	164,370	45%
SA Arid Lands	Far North PWA	N/A	50,771	N/A
Total		480,340	1,790,062	27%

*PWA = Prescribed Wells Area; PWRA = Prescribed Water Resource Area

3.3 Reliability

The overall reliability score for this report card is 3 out of 5 based on Table 3.3 and is considered to be 'Good' reliability. The methodology used to determine the reliability score is provided in Section 2.4.3.

Table 3.3. Information reliability scores for groundwater

Indicator	Currency	Applicability	Spatial	Accuracy	Reliability
Groundwater level and salinity	5	5	3	N/A*	3

*The accuracy indicator has not been assessed in this report.

3.3.1 Notes on reliability

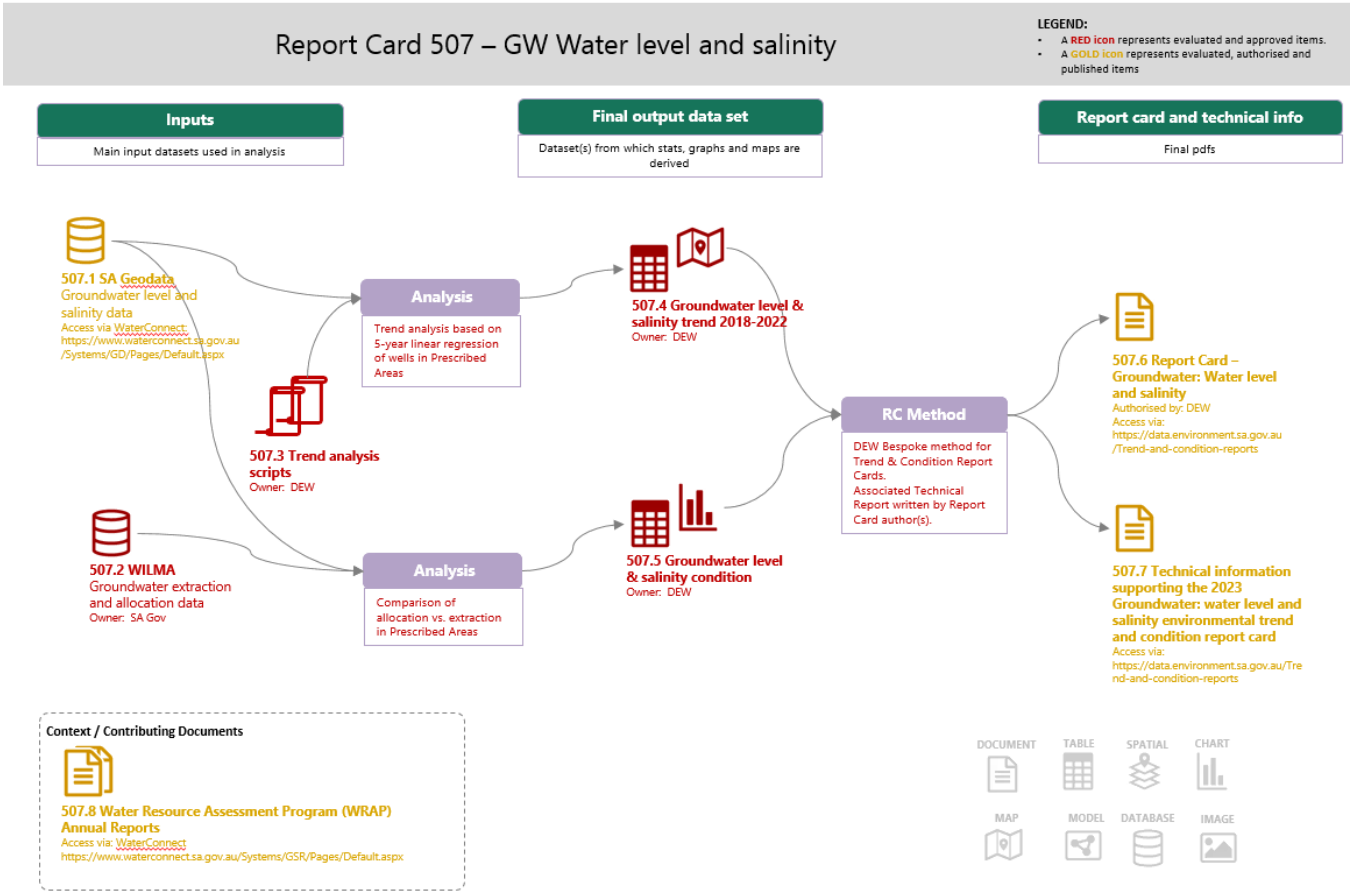
Currency: Groundwater level, salinity, allocation and extraction data are collated annually and 2022 data are represented in this report, hence the 'most recent information is (less than) 3 years old' (currency score 5).

Applicability: All groundwater data used are based on direct indicators of the measure (applicability score 5).

Spatial: Only prescribed groundwater resources are considered in this assessment. This approach captures most of the high value groundwater in South Australia, however spatially accounts for less than half of the state (spatial score 3).

4 Appendices

A. Managing environmental knowledge chart for Groundwater: Water level and salinity



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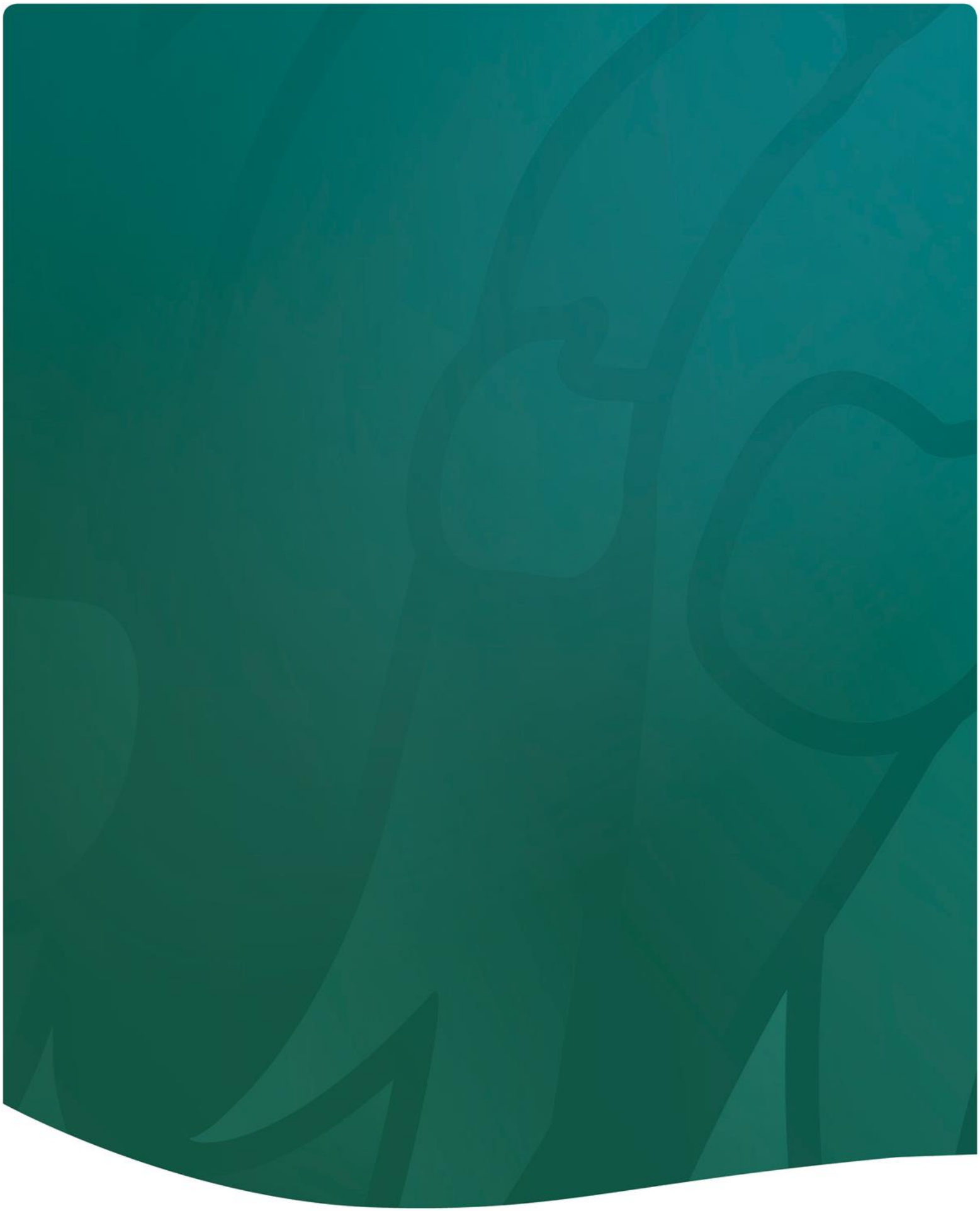

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