Technical information supporting the 2023 Streamflow and Flow regime (zero flow days) environmental trend and condition report cards

Department for Environment and Water
August, 2023

DEW Technical note 2023/59

Government of South Australia

Department for Environment and Water

1. Document classification

Ensure appropriate classification is contained in header (see here for guidance):
https://data.sa.gov.au/sites/default/files/Toolkit/Data-Classification-Marking-Decision-Diagram.pdf

2. Release authorisation

Ensure intended release authorities are recorded in Table 1 below as per Section 2B of document preparation, review, and publishing process.

Table 1. Release authority nominations: Name of person with authority to release each type of document

Internal review	Technical review: Kumar Savadamuthu (DEW, Principal Hydrologist, Water Science); Policy review: Water and River Murray Water Leaders (DEW, WaRM directors); Business owner approval: Sue Hutchings (DEW, A/ Executive Director, WaRM)
External review	External peer review: Matt Gibbs (CSIRO, Principal Hydrologist)
Release approval	Matthew Ward (DEW, Director, Science and Information)

Table 2. Document version, type and Release Date: This table records the date that authority was granted to release the recorded version. No date indicates it has not been approved for release

Document location	2023 Report Cards Tech Reports (env.sa.gov.au)
Version	1
Release type	Public
Release authority	
Release date	

All hard copies of this document are uncontrolled.
Refer to the file held in iShare for the authorised version.

Department for Environment and Water
Government of South Australia
August 2023

81-95 Waymouth St, ADELAIDE SA 5000
Telephone +61 (8) 8463 6946
Facsimile +61 (8) 8463 6999
ABN 36702093234

www.environment.sa.gov.au

Preferred way to cite this publication

Department for Environment and Water (2023). *Technical information supporting the 2023 Streamflow and Flow regime (zero flow days) environmental trend and condition report cards*, DEW Technical report 2023/59, Government of South Australia, Department for Environment and Water, Adelaide.

Download this document at https://data.environment.sa.gov.au

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

This document was prepared by the Water Science and Monitoring Branch and the Freshwater, River Murray and Coorong Science Team from the Department for Environment and Water (DEW). DEW would like to acknowledge the contributions that have enabled this report and associated report card possible. Consultation for this report has taken place with relevant DEW staff within the Water Science and Monitoring, and Science and Information branches including Principal Hydrologists, Principal Ecologists, Manager Surface Water, Manager Water Science and Director Water Science and Monitoring. The department would like to thank all of those who had a role in reviewing this report and report card.

Contents

List of figures

List of tables

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 report cards:

- Streamflow
- Flow regime (zero flow days).

The reliability of information sources used in the report card is also described.

These report cards sit within the report card Water theme and Surface water 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, and
- 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 Streamflow and flow regime

The streamflow and the flow regime (zero flow days) trend and condition report cards provide the trend and condition of surface water resources in South Australia's prescribed water resource areas (PWRAs) and non-prescribed areas at the Landscape Region scale. The surface water PWRAs include Barossa, Clare Valley, Marne-Saunders, Morambro Creek and Nyroca Channel, Eastern Mount Lofty Ranges and Western Mount Lofty Ranges. The non-prescribed areas include Kangaroo Island, the Limestone Coast, Northern and Yorke, Eyre Peninsula, and SA Arid Lands. The River Murray is excluded from this technical document (and associated report card) and is reported in a separate suite of report cards. The 2023 report cards are an update to the last set of report cards produced in 2020. This document provides the technical background, data used, methodology and results that underpin the report card.

Streamflow and flow regime are highly variable across the landscape, which presents challenges in providing an assessment for the state as one geographical unit. Hence, the assessment was undertaken at multiple spatial scales – individual monitoring sites, prescribed and non-prescribed areas, landscape regions – and the combined results are presented as state-wide trend and condition. The trend and condition scores for streamflow and flow regime were assessed using streamflow data collected from representative streamflow monitoring sites across the state. Annual streamflow data from individual sites, that are considered representative for an area, were combined to represent the entire area and for a common analysis period (1986 to 2022).

2 Methods

This section describes the indicators, data sources, data collection for this report and the methods used to analyse and present these data. Annual values for the indicators presented in this report correspond to the financial year or 'water-use year' period (i.e. 1 July to 30 June), as defined in the Bureau of Meteorology Australian Water Information Dictionary.

2.1 Indicators

The following indicators are used for the 2023 report cards to assess the trend and condition of the streamflow and flow regime in the prescribed and non-prescribed water resource areas of South Australia:

- Trends in total streamflow (water quantity)
- Number of flowing days recorded at key monitoring locations across the state.

2.2 Data sources

The following data sources were used in the assessment of the flow regime and the streamflow of the prescribed and non-prescribed surface water resources:

- Streamflow data for each prescribed and non-prescribed surface water area was taken from the Aquarius database maintained by the Department for Environment and Water (DEW). Data are publicly available online at https://water.data.sa.gov.au/
- Additional information regarding prescribed and non-prescribed surface water resources was taken from the respective water allocation plans, annual surface water status reports, natural resource management plans, and other hydrological reports and investigations which are available at www.waterconnect.sa.gov.au.

2.3 Prescribed and non-prescribed water resources areas (PWRAs and non-PWRAs)

Streamflow monitoring sites are operated throughout South Australia, with the exception of the Alinytjara Wilu<u>r</u>ara landscape region. The water resources that are most heavily relied upon and those that have been identified as being at the greatest risk of degradation, have been prescribed across the state and are actively managed through Water Allocation Plans (WAPs) in Prescribed Water Resources Areas (PWRAs). Assessment of streamflow and flow regime was undertaken at multiple spatial scales: individual sites, prescribed and non-prescribed areas, landscape regions and the whole of the state (Figure 2.1). The selected surface water monitoring sites for each of the assessed areas are provided in Table 2.1 and the selection criteria is provided in section 2.4.

The River Murray is excluded from this technical document (and corresponding report card) and is reported in a separate suite of report cards.

Table 2.1. Areas used for the assessment of trends and condition for the indicators reporting.

	Area / Landscape Region		Streamflow monitoring sites
Prescribed areas	Barossa	Northern and Yorke (NY)	North Para River at Yaldara (A5050502)
	Clare	Northern and Yorke (NY)	Wakefield River at Rhynie (A5060500)
	Marne Saunders	Murraylands and Riverland (MR)	Marne River at Marne Gorge (A4260605) Saunders Creek at Saunders Gorge (A4261174)
	Morambro	Limestone Coast (LC)	Morambro Creek (A2390531)
	Eastern Mount Lofty Ranges (EMLR)	Hills and Fleurieu (HF)	Finniss River at Yundi (A4260504) Currency Creek near Higgins (A4260530) Bremer River near Hartley (A4260533) Angas River at Angas Weir (A4260503)
	Western Mount Lofty Ranges (WMLR)	Hills and Fleurieu (HF)	Scott Creek at Scott Bottom (A5030502) River Torrens at Mount Pleasant (A5040512) Sixth Creek at Castambul (A5040523) Kersbrook Creek u/s Millbrook Reservoir (A5040525) Kangarilla Creek at Bakers Gully (A5030503) Myponga River u/s Reservoir (A5020502) Yankalilla Creek d/s Blackfellows Creek (A5011006) Onkaparinga River u/s Hahndorf dissipater (A5031001) Inman River u/s Treatment works (A5010503)
Non-prescribed areas	Kangaroo Island (KI)		Rocky River u/s Gorge Falls (A5130501) Timber Creek at South Coast Rd (A5131002) Middle River u/s Reservoir (A5131015)
	Limestone Coast (LC)		Mosquito Creek (A2390519) Tatiara Creek at Bordertown (A2390534)
	Northern and Yorke (NY)		Broughton River at Mooroola (A5070503) Hill River at Andrews (A5070500) Hutt River near Spalding (A5070501)
	Eyre Peninsula (EP)		Tod River (A5120500)
	SA Arid Lands (SAAL)		Diamantina River @ Birdsville (A0020101) Cooper Creek (A0030501) Willochra Creek (A5090502)

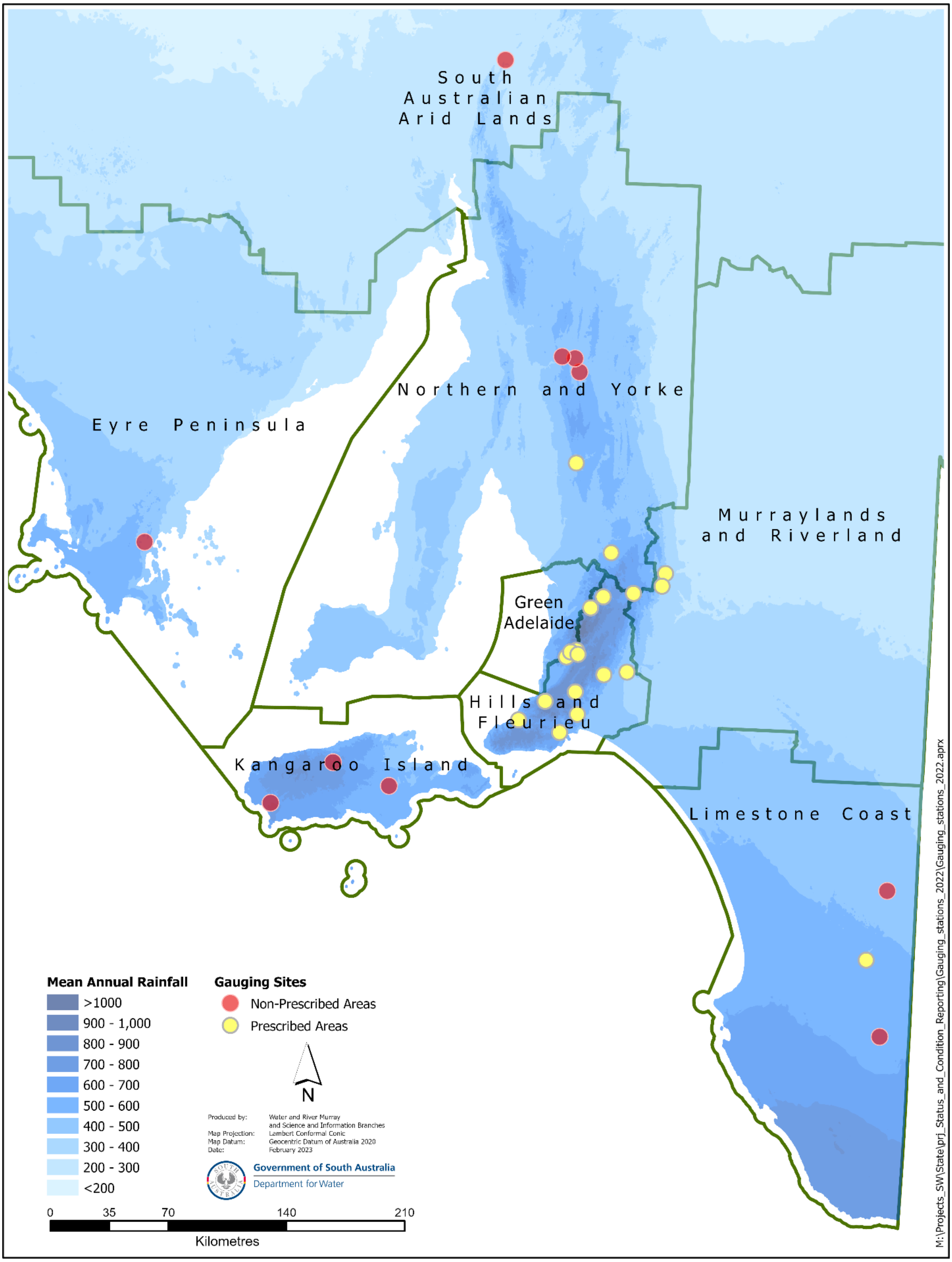


Figure 2.1. Streamflow monitoring sites across the landscape regions of SA. *Two sites in the far-north of the SA Arid Lands region are to the north of the map extent.

2.4 Spatial data aggregation

Streamflow spatial data aggregation for the total streamflow and flow regime analysis was undertaken at multiple spatial scales from individual sites, prescribed and non-prescribed areas, landscape regions and the whole of the state. There is an assumption here that the sites selected for streamflow are a representative cross section of the sites across each of the areas assessed. Any biases in the site selection, due to limited streamflow monitoring infrastructure and data, will significantly influence the overall results.

2.4.1 Streamflow

For areas with unconnected catchments that are highly developed and with variable hydrology, like the Eastern and Western Mount Lofty Ranges PWRA, the total annual streamflow was calculated by adding annual streamflow from monitoring sites from individual catchments within the area.

A single streamflow monitoring site was used as a representative site in areas where there is limited streamflow monitoring infrastructure and data. A single site was also used where streamflow monitoring is located at the end of the system that captures the total streamflow for the area. The same representative streamflow monitoring sites used for the total streamflow metric were used for the flow regime analysis.

2.5 Data analysis

2.5.1 Streamflow

Daily streamflow observations were used from selected DEW monitoring sites to calculate annual streamflow (July to June). Annual totals for the 1986 to 2022 period of record were calculated at each spatial scale as the sum of the annual values from all the sites represented at that scale. For instance, the total streamflow at the prescribed and non-prescribed area scale is presented as the sum of all the sites within an area (e.g., annual streamflow for EMLR prescribed area is presented as the sum of annual values for the Finniss River, Currency Creek, Bremer River, and Angas River). Annual streamflow was estimated using a double mass analysis for sites with partial records. The double mass analysis approach, which fits a linear regression using the calculated cumulative annual flows (observed data) for two nearby sites with a strong correlation (>0.9), was used to infill periods with missing records for sites with partial records.

2.5.2 Flow regime

The term 'Flow regime' refers to the timing, duration, magnitude, and frequency of flows through a watercourse. For instance, the temporal variability of streamflow events significantly influences aquatic biodiversity, with longer flowing periods linked to ecosystems with higher diversity and supporting more sensitive species. Physical and chemical processes such as nutrient transport and groundwater–surface water interactions are also heavily influenced by the flow regime. The key identified part of the flow regime used for this assessment is intermittency, as this is considered to be the master variable driving aquatic ecosystem condition in seasonal or ephemeral rivers (Datry et al. 2014).

Intermittency, measured as annual number of flowing days, is the flow regime metric assessed and reported in this document. Evaluation of this metric provides a simple yet effective assessment of the waterway flow regime of seasonal or ephemeral rivers. The annual number of flow days (July to June) is measured as the number of days with total streamflow greater than 0. Years with more than 5% missing data were removed from the assessment to limit the impact of missing data being interpreted as days with no flow. No infilling of data was undertaken.

The flow regime assessment was undertaken for the same period as the streamflow assessment, from 1986 to 2022, except for the Angas River in the Eastern Mt Lofty Ranges. The Angas River site was used for water supply until 1995 and the cessation of this extraction resulted in a significant change in the flow regime. To account for this, the Angas River site only reports on data from 1996 onwards.

2.6 Methods to assign trend, condition and reliablity

2.6.1 Trend

The trend for total streamflow and flow regime (number of flowing days per year, July to June) was analysed using a Bayesian linear modelling approach. This modelling approach was used as it provides more information surrounding the results over a simple linear regression. Bayesian modelling also provides credible intervals allowing for an objective and transparent assessment of trend, as it provides an estimate of the likelihood of the trend assessed.

Data modelling was performed without any transformations since the data were normally distributed. To assess the total streamflow data, a Gaussian distribution was used. Meanwhile, the flow regime was assessed using a negative binomial distribution given that the values were integers. There were no assumptions made about the prior distribution of the data in any of the modelling runs. All other default settings were retained during the modelling process.

Modelling was undertaken using a Gaussian model in R Studio (version 2022.02.2+485 "Prairie Trillium", R version 4.2.0 (2022-04-22 ucrt) [R Core Team, 2013]) using Bayesian Generalized Linear Models (implementing the stan-glm function in the rstanarm package [Stan Development Team 2016]). A total of 5000 iterations was used for each model run for each metric (i.e. streamflow and flow regime). The proportion of positive/negative slopes are reported along with the mean slope and confidence intervals around the mean.

The Area model (covering either prescribed or non-prescribed areas as defined in Table 2.1.) was run as metric (i.e. annual streamflow or annual flow days) against year (i.e. 2021–22, July to June) by area with a random factor of site. The Landscape Region model was run as metric against year by landscape region with a random factor of site. The State model was run as metric against year with a fixed factor of area (defined in in Table 2.1) and a random factor of site. The model for individual sites was run as metric against year with no additional random or fixed factors for each site individually. Random factors are used where there is not data for every possible option (i.e., there are more sites per area than are represented in the data). Fixed factors are used where all possible options are represented in the data (i.e., all the defined areas have data). The Bayesian linear modelling approach provides a very robust assessment of trend with a high level of confidence in the result.

Trend for each metric and model was classified based on the proportion of positive or negative slopes returned by the 5000 modelling iterations following the IPCC classification system (Mastrandrea et al. 2010) is provided in Table Table 2.2. A final trend and description based on the IPCC classification are also provided in Table Table 2.2..

Table 2.2. Definition of trend classes used

Proportion of negative slopes	IPCC Classification	Report card trend	Description
>= 0.99	Virtually certain decrease	Getting worse	Over a scale relevant to tracking change, the indicator is declining in status with good confidence
0.95 – 0.9899	Extremely likely decrease		
0.90 – 0.9499	Very likely decrease		
0.66 – 0.8999	Likely decrease		
0.33 – 0.6599	Stable	Stable	Over a scale relevant to tracking change, the indicator it is neither improving nor declining in status
0.10 – 0.3299	Likely increase	Getting better	Over a scale relevant to tracking change, the indicator is improving in status with good confidence
0.05 – 0.0999	Very likely increase		
0.01 – 0.0499	Extremely likely increase		
<= 0.01	Virtually certain increase		
-	-	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

2.6.2 Condition

The assessment of condition for total streamflow and flow regime (number of flowing days per year, July to June) was based on the percentile of the annual streamflow volume and the percentile of annual number of flowing days for the most recent year (2021–22). Assuming that environmental, economic and social expectations have evolved based on the historical distribution of streamflow, the following percentile rating system was used to give a condition score and the definitions for each condition assessment are provided in Table 2.3.

Table 2.3. Definition of condition classes used for total streamflow and flow regime

Condition	Description	Threshold
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)	Greater than or equal to the 90th percentile
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)	Greater than or equal to the 30th percentile but less than 90th percentile
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)	Between the 30th and the 10th percentile
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)	Less than or equal to the 10th percentile
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	-

2.6.3 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 for each category are provided in Table 2.4.

Table 2.4. **Guides for scoring information currency, applicability, spatial representation, and accuracy of information to determine reliability**

Score given	Information currency	Information applicability	Spatial representation	Information accuracy
1	Information >10 years old	Data are based on expert opinion of the measure	From an area that represents less than 5% the spatial distribution of the asset within the region/state or spatial representation unknown	Better than could be expected by chance
2	Information up to 10 years old	All data based on indirect indicators of the measure	From an area that represents less than 25% the spatial distribution of the asset within the region/state	> 60% better than could be expected by chance
3	Information up to 7 years old	Most data based on indirect indicators of the measure	From an area that represents less than half the spatial distribution of the asset within the region/state	> 70 % better than could be expected by chance
4	Information up to 5 years old	Most data based on direct indicators of the measure	From across the whole region/state (or whole distribution of asset within the region/state) using a sampling design that is not stratified	> 80 % better than could be expected by chance
5	Information up to 3 years old	All data based on direct indicators of the measure	From across the whole region/state (or whole distribution of asset within the region/state) using a stratified sampling design	> 90 % better than could be expected by chance

2.7 Data transparency

Data transparency for this report card is represented in Appendix 5.1 and 5.2.

3 Results

3.1 Trend

3.1.1 Streamflow

Annual streamflow volumes (in megalitres [ML]) for the prescribed areas are presented from Figure 5.1 to Figure 5.6 and from Figure 5.8 to Figure 5.12 for the non-prescribed areas. A consolidated chart of streamflow volumes from each prescribed and non-prescribed area is represented in Figure 5.7 and Figure 5.13.

At the site scale, of the 29 flow monitoring sites that were assessed, 28 were classed as 'getting worse' with the percentage of negative slopes varying from 'likely decrease' to 'virtually certain decrease', and only Willochra Creek was classed as 'getting better'. The trend result for Willochra Creek is heavily biased due to the unprecedented flows experienced two years in a row from 2018 to 2020 which are by far the highest flows on record for this site. The results for the site scale analysis are summarised in Table 3.1.

Table 3.1. Summary of the Bayesian model outputs (5000 iterations) used to assess the streamflow trend at the site scale

	Site	Mean slope (ML per year)	Percentage of negative slopes	Lower 90% confidence interval	Upper 90% confidence interval	IPCC trend classification	Report card trend
Prescribed	Yaldara (A5050502)	-372.48	97.8%	-682.43	-72.56	Extremely likely decrease	Getting worse
	Wakefield (A5060500)	-85.45	66.4%	-408.93	231.22	Likely decrease	Getting worse
	Marne Gorge (A4260605)	-209.65	99.2%	-349.70	-74.49	Virtually certain decrease	Getting worse
	Saunders (A4261174)	-18.17	98.7%	-31.25	-4.73	Extremely likely decrease	Getting worse
	Morambro (A2390531)	-125.08	96.2%	-239.60	-10.28	Extremely likely decrease	Getting worse
	Finniss (A4260504)	-476.44	98.9%	-797.02	-133.22	Extremely likely decrease	Getting worse
	Currency (A4260530)	-166.26	100.0%	-251.98	-80.50	Virtually certain decrease	Getting worse
	Bremer (A4260533)	-370.81	94.8%	-736.87	4.59	Very likely decrease	Getting worse
	Angas (A4260503)	-108.18	93.4%	-228.36	11.53	Very likely decrease	Getting worse
	Scott Creek (A5030502)	-67.40	98.9%	-111.47	-23.25	Extremely likely decrease	Getting worse

	Mount Pleasant (A5040512)	-24.66	76.5%	-81.01	32.45	Likely decrease	Getting worse
	Sixth Creek (A5040523)	-83.94	81.5%	-240.37	69.31	Likely decrease	Getting worse
	Kersbrook (A5040525)	-27.26	79.4%	-86.01	26.01	Likely decrease	Getting worse
	Bakers Gully (A5030503)	-43.81	75.5%	-149.81	62.08	Likely decrease	Getting worse
	Myponga (A5020502)	-86.44	92.0%	-185.18	13.98	Very likely decrease	Getting worse
	Yankalilla (A5011006)	-107.64	95.2%	-214.75	-1.50	Extremely likely decrease	Getting worse
	Inman Valley (A5010503)	-41.95	66.0%	-206.02	125.50	Likely decrease	Getting worse
Non-prescribed	Rocky River (A5130501)	-122.50	79.9%	-356.06	119.16	Likely decrease	Getting worse
	Timber Creek (A5131002)	-78.73	86.4%	-204.26	44.29	Likely decrease	Getting worse
	Middle River (A5131015)	-153.95	91.4%	-339.76	31.95	Very likely decrease	Getting worse
	Mosquito Creek (A2390519)	-703.25	98.9%	-1190.95	-214.14	Extremely likely decrease	Getting worse
	Tatiara (A2390534)	-159.82	100.0%	-235.77	-81.76	Virtually certain decrease	Getting worse
	Broughton River (A5070503)	-722.96	97.3%	-1362.55	-111.07	Extremely likely decrease	Getting worse
	Hill River (A4260530)	-114.50	95.5%	-227.60	-3.31	Extremely likely decrease	Getting worse
	Hutt River (A5070501)	-143.41	91.8%	-311.60	24.87	Very likely decrease	Getting worse
	Tod River (A5120500)	108.42	7.8%	-22.65	237.61	Very likely increase	Getting better
	Diamantina River @ Birdsville (A0020101)	-12099.11	69.4%	-54221.27	28959.56	Likely decrease	Getting worse
	Cooper Creek (A0030501)	-42839.99	91.1%	-95490.17	11756.69	Very likely decrease	Getting worse
	Willochra Creek (A5090502)	841.00	0.9%	226.25	1478.62	Virtually certain increase	Getting better

At the prescribed and non-prescribed area scale (defined in Table 2.1), all areas were classed as getting worse with the proportion of negative slopes indicating ‘likely decrease’ for 8 of the areas, one indicating ‘very likely decrease’ (Barossa PWRA), and one ‘extremely likely decrease’ (SAAL, Table 3.1 and Figure 3.1). The distribution of the modelled slopes for each area is presented in Figure 3.1.

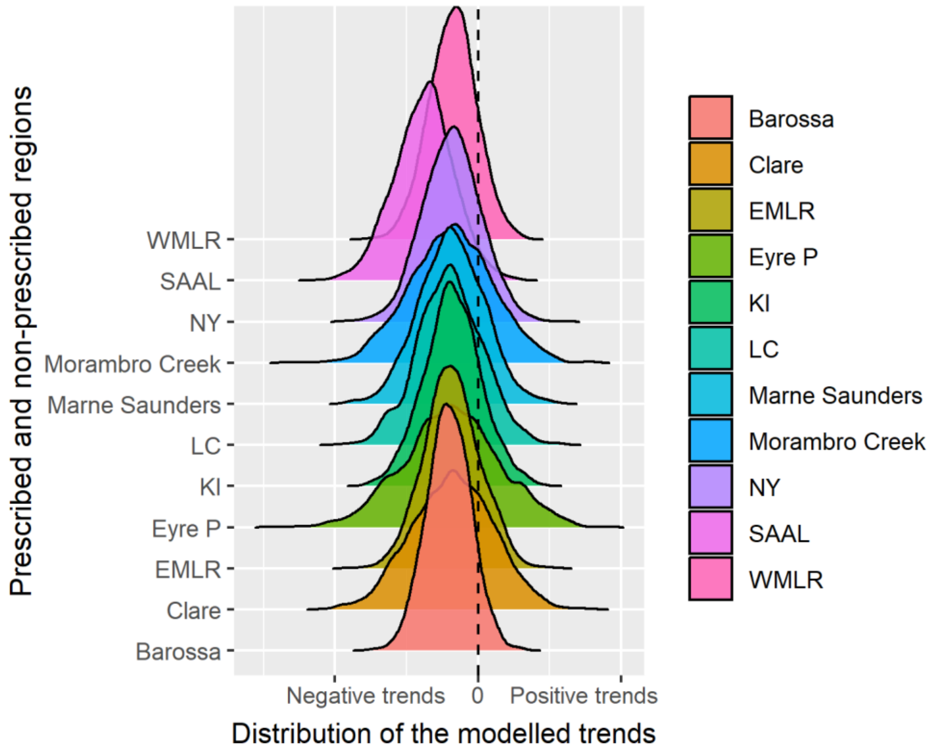


Figure 3.1. Density plots showing the distribution of negative and positive slopes of streamflow data modelled by the Bayesian trend assessment for the prescribed and non-prescribed areas as defined by Table 2.1.

Table 3.2. Summary of the Bayesian model outputs (5000 iterations) used to assess the streamflow trend at the prescribed or non-prescribed area scale.

	Area	Mean slope (ML per year)	Percentage of negative slopes	Lower 90% confidence interval	Upper 90% confidence interval	IPCC trend classification	Report card trend
Prescribed	Barossa	-2054.63	91.8%	-4574.60	432.52	Very likely decrease	Getting worse
	Clare	-1780.99	72.8%	-6421.84	2793.23	Likely decrease	Getting worse
	Marne Saunders	-1859.79	79.2%	-5607.85	1832.83	Likely decrease	Getting worse
	Morambro Creek	-1870.49	74.2%	-6715.44	2900.71	Likely decrease	Getting worse
	EMLR	-1831.25	82.5%	-4924.75	1493.23	Likely decrease	Getting worse
	WMLR	-1769.76	85.9%	-4520.84	928.93	Likely decrease	Getting worse
Non-prescribed	KI	-1792.89	82.4%	-5111.00	1621.66	Likely decrease	Getting worse
	LC	-1956.37	80.3%	-5811.84	1824.94	Likely decrease	Getting worse
	NY	-1836.07	82.1%	-5075.41	1540.61	Likely decrease	Getting worse
	EP	-1858.85	71.7%	-7419.46	3685.56	Likely decrease	Getting worse
	SAAL	-3804.53	96.9%	-7282.44	-463.99	Extremely likely decrease	Getting worse

The data from prescribed and non-prescribed areas also indicate that the frequency of subsequent above average flow years has decreased since the early 1990s and there is an increased number of below average streamflow years over the last decade (Table 3.3). For the prescribed areas, there is a drying pattern with streamflow as you move northwards.

Table 3.3. Number of years with below average (0-30th percentile), average (30-70th percentile) or above average (70-100th percentile) annual streamflow over the last decade for the prescribed and non-prescribed areas.

	Area	Below average* 0-30th percentile	Average 30-70th percentile	Above average 70-100th percentile
Prescribed	Barossa	5	4	1
	Clare	5	3	2
	Marne Saunders	5	4	1
	Morambro Creek	4	4	2
	EMLR	3	5	2
	WMLR	2	6	2
Non-prescribed	KI	3	4	3
	LC	4	4	2
	NY	7	0	3
	EP	3	2	5
	SAAL	3	6	1

*Based on a simplified Bureau of Meteorology percentile[1] classification

The assessment at the landscape region scale also showed consistent decreasing trends with all regions classified as 'getting worse' (Figure 3.2 and Table 3.4). The proportion of negative slopes classed 5 regions as 'likely decrease', one as 'very likely decrease' (EP), and one as 'extremely likely decrease' (SAAL). The Cooper and Diamantina rivers in SAAL have significantly larger catchment areas and therefore experienced significantly larger flows than Willochra Creek. Consequently, at the landscape level, the Willochra site has very little influence on the total flow trend result. The state scale assessment showed an overall negative trend and was classed as 'getting worse' with over 90% of modelled slopes being negative and indicating a 'very likely decrease' (Table 3.4).

1 The nth percentile of a set of data is the value at which n% of the data is below it. For example, if the 75th percentile annual flow is 100 ML, 75% of the years on record had annual flow of less than 100 ML. Median streamflow: 50% of the records were above this value and 50% below. 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.

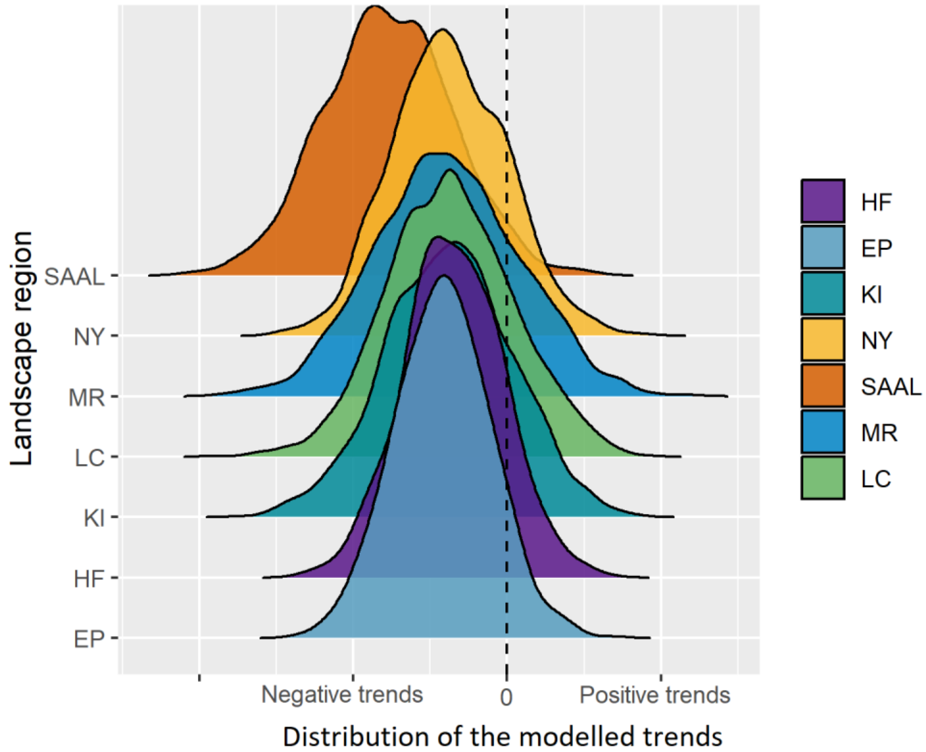


Figure 3.2. Density plots showing the distribution of negative and positive slopes of streamflow modelled by the Bayesian trend assessment for the landscape regions as defined by Table 2.1.

Table 3.4. Summary of the Bayesian model outputs (5000 iterations) used to assess the trend of streamflow at the landscape region scale and the state scale.

Landscape Region	Mean slope (ML per year)	Percentage of negative slopes	Lower 90% confidence interval	Upper 90% confidence interval	IPCC trend classification	Report card trend
EP	-2090.88	91.0%	-4654.17	443.89	Very likely decrease	Getting worse
HF	-1750.95	86.6%	-4424.17	875.33	Likely decrease	Getting worse
KI	-1907.95	81.1%	-5357.16	1445.41	Likely decrease	Getting worse
LC	-1856.56	81.6%	-5126.56	1641.31	Likely decrease	Getting worse
MR	-1954.83	79.3%	-5771.38	1974.09	Likely decrease	Getting worse
NY	-1879.04	83.8%	-4818.26	1215.00	Likely decrease	Getting worse
SAAL	-3882.235	96.5%	-7235.28	-446.57	Extremely likely decrease	Getting worse
State	**-2064.231**	**91.8%**	**-4519.86**	**397.38**	**Very likely decrease**	**Getting worse**

3.1.2 Flow regime (Number of flowing days)

At the site scale, of the 29 flow monitoring sites that were assessed, 10 were classed as 'getting worse' with the proportion of negative slopes varying from 'likely decrease' to 'virtually certain decrease' and 19 sites were classed as 'stable', while no sites were classed as 'getting better'. The results for the individual sites are summarised in Table 3.5.

Table 3.5. Summary of the Bayesian model outputs (5000 iterations) used to assess the flow regime trend at the site scale

	Site	Mean slope (flow days per year)	Percentage of negative slopes	Lower 90% confidence interval	Upper 90% confidence interval	IPCC trend classification	Report card trend
Prescribed	Yaldara (A5050502)	-0.009	94.8%	-0.017	0.000	Very likely decrease	Getting worse
	Wakefield (A5060500)	-0.001	55.4%	-0.007	0.006	Stable	Stable
	Marne Gorge (A4260605)	-0.068	90.2%	-0.153	0.020	Very likely decrease	Getting worse
	Saunders (A4261174)	-0.144	96.3%	-0.281	-0.013	Extremely likely decrease	Getting worse
	Morambro (A2390531)	-0.037	93.8%	-0.078	0.003	Very likely decrease	Getting worse
	Finniss (A4260504)	0.000	52.6%	-0.007	0.006	Stable	Stable
	Currency (A4260530)	-0.001	53.9%	-0.011	0.010	Stable	Stable
	Bremer (A4260533)	-0.014	91.3%	-0.031	0.003	Very likely decrease	Getting worse
	Angas (A4260503)	0.000	51.7%	-0.014	0.014	Stable	Stable
	Scott Creek (A5030502)	-0.002	72.6%	-0.009	0.004	Likely decrease	Stable
	Mount Pleasant (A5040512)	-0.011	97.6%	-0.019	-0.002	Extremely likely decrease	Getting worse
	Sixth Creek (A5040523)	-0.001	58.5%	-0.008	0.006	Stable	Stable
	Kersbrook (A5040525)	-0.004	72.9%	-0.016	0.008	Likely decrease	Stable
	Bakers Gully (A5030503)	-0.015	99.8%	-0.023	-0.007	Virtually certain decrease	Getting worse
	Myponga (A5020502)	-0.002	64.6%	-0.009	0.006	Stable	Stable
	Yankalilla (A5011006)	0.002	46.1%	-0.035	0.040	Stable	Stable
	Inman Valley (A5010503)	0.000	49.3%	-0.012	0.012	Stable	Stable

Non-prescribed	Rocky River (A5130501)	-0.004	79.8%	-0.013	0.004	Likely decrease	Stable
	Timber Creek (A5131002)	-0.019	81.5%	-0.054	0.016	Likely decrease	Stable
	Middle River (A5131015)	0.021	39.9%	-0.118	0.161	Stable	Stable
	Mosquito Creek (A2390519)	-0.066	100.0%	-0.087	-0.045	Virtually certain decrease	Getting worse
	Tatiara (A2390534)	0.004	23.7%	-0.006	0.014	Likely increase	Stable
	Broughton River (A5070503)	0.000	51.7%	-0.008	0.008	Stable	Stable
	Hill River (A5070500)	-0.019	82.4%	-0.054	0.015	Likely decrease	Stable
	Hutt River (A5070501)	-0.020	99.9%	-0.030	-0.011	Virtually certain decrease	Getting worse
	Tod River (A5120500)	0.000	47.2%	-0.015	0.015	Stable	Stable
	Diamantina River @ Birdsville (A0020101)	-0.002	59.6%	-0.015	0.011	Stable	Stable
	Cooper Creek (A0030501)	-0.009	91.9%	-0.019	0.002	Very likely decrease	Getting worse
	Willochra Creek (A5090502)	0.026	15.4%	-0.016	0.068	Likely increase	Stable

At the prescribed and non-prescribed area scale (defined by Table 2.1), all areas were classed as 'getting worse' with the exception of Eyre Peninsula. For all of the areas, except the Eyre Peninsula, the percentage of negative slopes was greater than 95%, with five areas showing 100% negative slopes (Table 3.6 and Figure 3.3). The overall assessment of regions getting worse, despite multiple sites showing stable trends, is due to the manner in which the modelling process scales up to the regional scale. As there is not data for everywhere in the region, the model assumes overall regional trend based on the combined trends of sites within the region as well as the overall combined trends across the state to build an overall picture. In this instance, the stable trends (most of which are slightly negative but not strong enough to warrant a 'getting worse' trend result) were insufficient to overcome the strong negative trends observed across the region. This is considered a suitable approach when the objective is to inform a state-wide assessment of trend and condition. It is also worth noting that the magnitude of the trend is not what denotes the final trend result, rather it is the consistency of negative trend results (regardless of their magnitude).

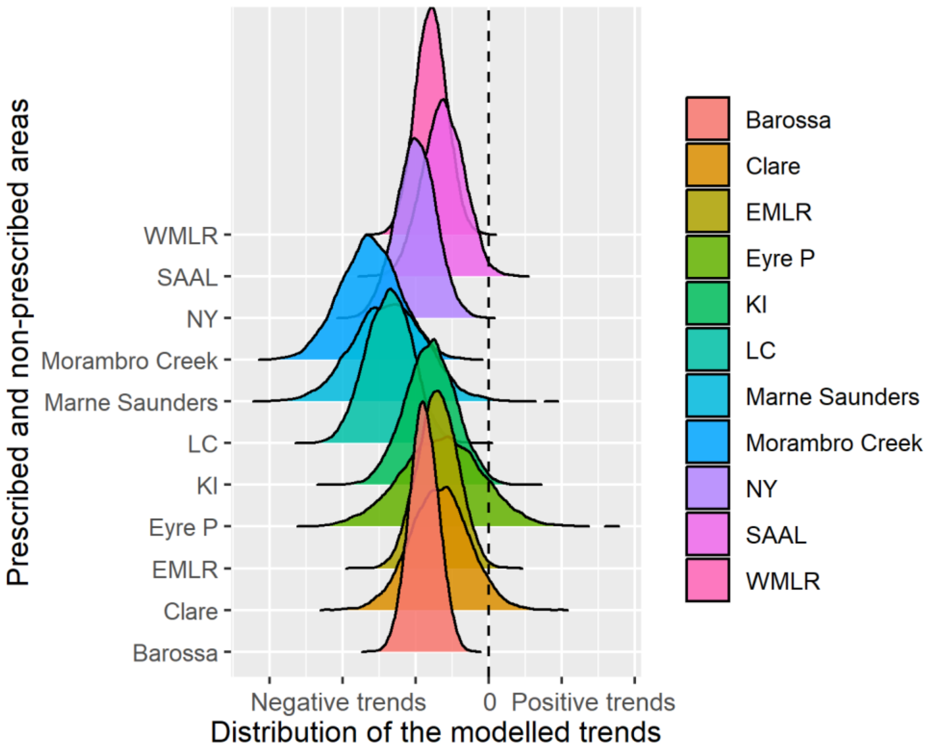
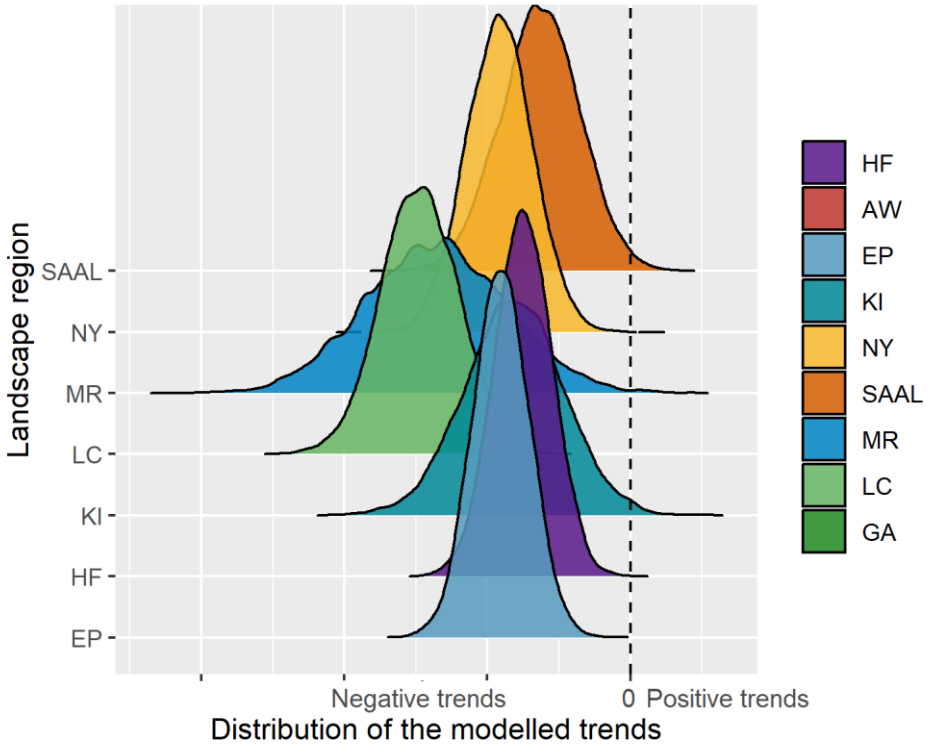


Figure 3.3. Density plots of the slopes of the number of flowing days by area modelled by the Bayesian trend assessment for the areas as defined by Table 2.1.

Table 3.6. Summary of the Bayesian model outputs (5000 iterations) used to assess the flow regime trend at the prescribed and non-prescribed area scale

	Area	Mean slope (flow days per year)	Percentage of negative slopes	Lower 90% confidence interval	Upper 90% confidence interval	IPCC trend classification	Report card trend
Prescribed	Barossa	-0.009	100.0%	-0.012	-0.006	Virtually certain decrease	Getting worse
	Clare	-0.007	95.3%	-0.013	0.000	Extremely likely decrease	Getting worse
	Marne Saunders	-0.014	99.6%	-0.022	-0.005	Virtually certain decrease	Getting worse
	Morambro Creek	-0.016	100.0%	-0.023	-0.009	Virtually certain decrease	Getting worse
	EMLR	-0.007	99.6%	-0.012	-0.002	Virtually certain decrease	Getting worse
	WMLR	-0.008	100.0%	-0.011	-0.004	Virtually certain decrease	Getting worse
Non-prescribed	KI	-0.008	99.1%	-0.014	-0.002	Virtually certain decrease	Getting worse
	LC	-0.014	100.0%	-0.019	-0.009	Virtually certain decrease	Getting worse
	NY	-0.010	100.0%	-0.015	-0.006	Virtually certain decrease	Getting worse
	EP	-0.006	87.9%	-0.016	0.003	Likely decrease	Stable
	SAAL	-0.006	98.6%	-0.011	-0.002	Extremely likely decrease	Getting worse

The assessment at the landscape region scale also showed consistent decreasing trends with all regions classified as ‘getting worse’ (Figure 3.4 and Table 3.7). At this scale all the landscape regions showed greater than 99% negative slopes and four showed 100% negative slopes. The state scale assessment showed an overall negative trend and was classed as ‘getting worse’ with 100% of modelled slopes being negative and indicating a ‘virtually certain decrease’ (Table 3.7). The same explanation regarding individual sites being stable but the landscape region result being negative described for the region scale applies for this assessment too.



S

Figure 3.4. Density plots of the slopes modelled by the Bayesian trend assessment for the landscape regions as defined by Table 2.1.

Table 3.7. Summary of the Bayesian model outputs (5000 iterations) used to assess the flow regime trend at the at the Landscape Region and State scales.

Landscape Region	Mean slope (flow days per year)	Percentage of negative slopes	Lower 90% confidence interval	Upper 90% confidence interval	IPCC trend classification	Report card trend
EP	-0.009	100.0%	-0.012	-0.006	Virtually certain decrease	Getting worse
HF	-0.008	100.0%	-0.011	-0.004	Virtually certain decrease	Getting worse
KI	-0.008	99.2%	-0.014	-0.003	Virtually certain decrease	Getting worse
LC	-0.015	100.0%	-0.019	-0.010	Virtually certain decrease	Getting worse
MR	-0.014	99.6%	-0.022	-0.006	Virtually certain decrease	Getting worse
NY	-0.009	100.0%	-0.013	-0.005	Virtually certain decrease	Getting worse
SAAL	-0.006	98.9%	-0.011	-0.002	Extremely likely decrease	Getting worse
State	-0.009	100.0%	-0.012	-0.006	Virtually certain decrease	Getting worse

3.2 Condition

3.2.1 Streamflow

Across the state there was considerable variability in the classification of the condition of the streamflow for 2021–22 (Table 3.8). At the individual site scale, the percentile ranged from 'poor' to 'very good'.

The poorest conditions were observed for the NY where 3 of the 5 sites were classified as 'poor', with the Hill River (A5070500) not recording any flow for 2021-22. Rocky River (A5130501) in KI recorded the best condition and was classified as "very good".

The condition assessment for the Landscape Regions defined in Table 2.1 classified EP, HF, KI and SAAL as 'good' and LC, MR and NY as 'fair' (Table 3.8). The overall condition for the State was classed as 'good' for the most recent year on record (2021–22).

The streamflow data used for the trend and condition analysis are presented in the Appendix 5.3 Streamflow data - Prescribed areas and 5.45.4 Streamflow data - Non-prescribed areas.

Table 3.8. **Summary of the condition assessment for the most recent year with available data for streamflow at the site, landscape region, and state scales.**

Landscape region	Area	Site	Year	Annual flow (ML)	Percentile	Site condition	Landscape condition	State condition
EP	Eyre P	A5120500	2021–2022	9,913	87.5	Good	Good	Good
HF	EMLR	A4260503	2021–2022	3,347	54.2	Good	Good	
HF	EMLR	A4260504	2021–2022	20,860	48.5	Good		
HF	EMLR	A4260530	2021–2022	3,774	31.4	Good		
HF	EMLR	A4260533	2021–2022	12,676	57.1	Good		
HF	WMLR	A5010503	2021–2022	7,898	54.2	Good		
HF	WMLR	A5011006	2021–2022	3,739	37.1	Good		
HF	WMLR	A5020502	2021–2022	10,348	80	Good		
HF	WMLR	A5030502	2021–2022	3,193	54.2	Good		
HF	WMLR	A5030503	2021–2022	3,257	42.8	Good		
HF	WMLR	A5040512	2021–2022	335	31.4	Good		
HF	WMLR	A5040523	2021–2022	5,135	37.1	Good		
HF	WMLR	A5040525	2021–2022	2,174	42.8	Good		
KI	KI	A5130501	2021–2022	29,086	97.1	Very Good	Good	
KI	KI	A5131002	2021–2022	8,494	74.2	Good		
KI	KI	A5131015	2021–2022	10,082	68.5	Good		
LC	LC	A2390519	2021–2022	4,580	34.2	Good	Fair	
LC	LC	A2390534	2021–2022	51	17.1	Fair		
LC	Morambro Creek	A2390531	2021–2022	80	34.2	Good		
MR	Marne Saunders	A4260605	2021–2022	208	22.8	Fair	Fair	
MR	Marne Saunders	A4261174	2021–2022	13	17.1	Fair		
NY	Barossa	A5050502	2021–2022	4,293	42.8	Good	Fair	
NY	Clare	A5060500	2021–2022	634	8.5	Poor		
NY	NY	A5070500	2021–2022	-	0	Poor		
NY	NY	A5070501	2021–2022	269	16.6	Poor		
NY	NY	A5070503	2021–2022	4,812	13.8	Fair		
SAAL	SAAL	A0020101	2021–2022	1,384,289	68.5	Good	Good	
SAAL	SAAL	A0030501	2021–2022	412,850	60	Good		
SAAL	SAAL	A5090502	2021–2022	1,854	48.5	Good		

3.2.2 Flow regime

Across the state there was considerable variability in the classification of the condition of the flow regime (Table 3.9). At the individual site scale the percentile ranged from lowest on record through to highest on record. All but one of the sites that recorded highest on record were perennial sites where the number of flowing days is capped by the number of days in a year. The only site to record highest on record that was not perennial was Middle River on Kangaroo Island. Two sites were classed as lowest on record (Hill River in the NY region and Tod River in the EP region). The Hill River site recorded no days of flow during the 2021–22 year. The Penrice site in the NY region recorded one day of flow which was considered very much below average.

The condition assessment for the landscape regions defined in **Error! Reference source not found.** showed the full condition spectrum with EP classed as 'poor', while SAAL, HF and NY were classed as 'good' while Kangaroo Island was classed as 'very good'. (Table 3.5). The overall condition for the State was classed as 'good'.

Table 3.9. Summary of the condition assessment for the most recent year with available data for the flow regime at the site, landscape region, and state scales.

Landscape region	Area	Site	Year	Flowing days	Percentile	Site condition	Landscape condition	State condition
EP	Eyre P	A5120500	2019–2020	199	0	Poor	Poor	Good
HF	EMLR	A4260503	2021–2022	365	100	Very good	Good	
HF	EMLR	A4260504	2021–2022	365	100	Very good		
HF	EMLR	A4260530	2021–2022	365	100	Very good		
HF	EMLR	A4260533	2009–2010	194	23	Fair		
HF	WMLR	A5010503	2021–2022	365	100	Very good		
HF	WMLR	A5011006	2021–2022	287	57	Good		
HF	WMLR	A5020502	2021–2022	365	100	Very good		
HF	WMLR	A5030502	2021–2022	365	100	Very good		
HF	WMLR	A5030503	2021–2022	232	22	Fair		
HF	WMLR	A5040512	2021–2022	189	39	Good		
HF	WMSLR	A5040523	2021–2022	365	100	Very good		
HF	WMLR	A5040525	2021–2022	204	64	Good		
KI	KI	A5130501	2021–2022	365	100	Very good	Very good	
KI	KI	A5131002	2021–2022	305	50	Good		
KI	KI	A5131015	2021–2022	294	100	Very good		
LC	LC	A2390519	2021–2022	48	22	Fair	Fair	
LC	LC	A2390534	2021–2022	128	20	Fair		
LC	Morambro Creek	A2390531	2021–2022	32	12	Fair		
MR	Marne Saunders	A4260605	2021–2022	109	33	Good	Fair	
MR	Marne Saunders	A4261174	2021–2022	51	18	Fair		
NY	Barossa	A5050502	2021–2022	215	19	Fair	Good	
NY	Clare	A5060500	2021–2022	365	100	Very good		
NY	NY	A5070500	2021–2022	0	0	Poor		
NY	NY	A5070501	2021–2022	174	32	Good		
NY	NY	A5070503	2021–2022	365	100	Very good		
SAAL	SAAL	A0020101	2021–2022	300	90	Good	Good	
SAAL	SAAL	A0030501	2021–2022	280	58	Good		
SAAL	SAAL	A5090502	2017–2018	365	100	Very good		

3.3 Reliability

The reliability score for each indicator and for each criterion in the report cards is provided in Table 3.10 and are based on the guiding definitions provided in Table 2.4.

The overall reliability score for the Streamflow report card is 2 out of 5, which is a reliability of 'fair'. The reliability score for the Flow regime (zero flow days) report card is 2 out of 5, which is a reliability of 'fair'.

Table 3.10. Information reliability scores for streamflow and flow regime

Indicator	Applicability	Currency	Spatial	Accuracy	Reliability
Streamflow	5	5	2	5	2
Flow regime	5	5	2	5	2

3.3.1 Notes on reliability

The information reliability scores for both the streamflow and the flow regime report cards are identical as the base data used to undertake the assessment are the same. Therefore, these notes provided here are applicable to both report cards. The information reliability scores are based on:

- Information applicability had an overall rating of 5 as the metrics used are based mostly on a direct measure of the flow (streamflow and flow regime) recorded from monitoring sites across the state.
- Information currency rated as 5 as all monitoring sites assessed for the different indicators had data less than 3 years old
- Spatial representation had an overall rating of 2 as the areas covered by the assessment cover less than 25% of the regions/State.
- Information accuracy rated as 5 as the monitoring sites are all calibrated to be greater than 90% expected by chance.

4 Discussion

With most of the streams across South Australia being seasonal, surface water is a limited resource in the state. Surface water is vital for meeting environmental needs by maintaining water dependent ecosystems and is equally essential for supporting the cultural and economic needs of communities. The main uses of surface water across the state are for stock and domestic consumption and agriculture. Due to the high variability and uncertainty in rainfall and surface water generated, tens of thousands of private farm dams were constructed across the catchments in South Australia as a water security measure. These farm dams capture surface water generated from the landscape and provide for the consumptive needs of the local community during the drier summer months. In years of very low rainfall, when the surface water collected in these dams is insufficient to meet demand, the supply is supplemented from groundwater resources where available. Reduced availability of surface water has adverse impacts on water quality and ecosystems conditions.

Ensuring that the State's scarce surface water resources are managed sustainably is key to achieve the water security goals to provide, "***an acceptable quantity and quality of water for people, communities, industry, agriculture and the environment, now and into the future.***" – Annual Water Security Statement 2023 (DEW 2023). Aligned to the state water security goals, regional programs have been developed and implemented across the state through Water Allocation Plans (WAP, for prescribed areas) and Landscape Management Plans (for non-prescribed areas) under the *Landscape South Australia Act 2019*. These plans adopt sustainable water use practices with the aims of reducing the impacts of land management activities on surface water quality and the environment while supporting economic productivity and social wellbeing (www.landscape.sa.gov.au).

The quality of water resources across the state is regularly monitored and annually assessed, including through a series of annual water resource assessments for all the PWRAs (www.waterconnect.sa.gov.au). These monitoring and reporting efforts are a key provision to inform the sustainability goals of water management in South Australia as they support the science behind the WAPs and NRMs plans (which are reviewed and updated as required). A robust science-based understanding of the trend and condition of the state's surface water resources is vital to meet the water security goals and for developing the strategies to adapt and meet the challenges in the face of a changing climate.

4.1 Trend

The trend for streamflow (surface water quantity) and the flow regime (number of flowing days per year) was analysed using a Bayesian modelling approach and classed following a simplified version of the IPCC classification.

Surface water systems are highly variable across South Australia. They are characterised by differing landscapes, climate patterns and hydrological processes. To account for this variability, the trend analysis and classification was undertaken at multiple spatial scales from individual sites, prescribed and non-prescribed areas, landscape regions and the whole state. Data from representative sites across the prescribed and non-prescribed areas, landscape regions and the state were combined to provide an area level assessment. The River Murray is excluded and reported in a separate assessment.

The majority of the streams in South Australia (across landscape regions and prescribed and non-prescribed areas) are ephemeral or seasonal with many streams predominately only flowing through the winter and spring months, with patterns of variability in streamflow being primarily driven by rainfall patterns. That is, generally above average annual rainfall results in above average annual streamflow volumes and vice versa.

The observed trends for streamflow and flow regime (as represented by the number of flowing days), have been classed as getting worse for all landscape regions and state-wide. Further analysis also indicates that since the 1990s the frequency of subsequent years with above-average streamflow has decreased while the frequency of below-average streamflow years has increased. This drying pattern of streamflow follows a north–south gradient, with sites further north showing stronger declines. This does not include the far north that operates on a different rainfall driver outside South Australia.

Due to the high reliance on rainfall patterns, seasonal and ephemeral waterways are particularly sensitive to the impacts of climate change (Nabih, et al., 2021; Cudennec, Leduc, & Koutsoyiannis, 2007; Gutierrez-Jurado, Partington, & Shanafield, 2021). Studies suggest that the shifting climate patterns predicted by hydroclimatic models are likely to result in seasonal and ephemeral streams to experience significant drying (Milly et al. 2005) and an alteration of waterway flow regimes. This link between the streamflow trend results and the flow regime are evident from the analysis presented in this report and suggest an overall worsening trend for surface water resources across the state.

The flow regime has been identified as a key link between the physical environment and the ecological community associated with it (Poff et al. 1997). In particular, the number of flowing days has been identified as the 'master variable' for ephemeral and intermittent streams, the predominant type of waterways in South Australia (Datry et al. 2014). The results suggest that the flow regime will put pressure on the aquatic ecosystems associated with these river systems, increasing the risk of ecosystem condition decline. This will be particularly evident on the flow sensitive species of fish and macroinvertebrates who are adapted and depend on flow levels that may no longer be experienced.

The link between the flow regime results and the results from the aquatic ecosystem condition report card are not comparable due to the different time scales used for each analysis. While the aquatic ecosystem condition report card suggests that ecosystem conditions are getting better across the state, this is due to the relatively short period used for the assessment, from 2008 to 2022, which aligns with the recovery from the Millennium Drought. There are no statewide long-term datasets looking at aquatic ecosystem condition that go back to the 1980s to compare to the flow data presented in this report.

If the current trends in flow regime continue, it is likely that the decline in flowing days will begin to adversely impact the recovery of aquatic ecosystems from the drought and reverse the improving trend observed in the ecosystem data.

4.2 Condition

The condition analysis for streamflow and the flow regime (number of flowing days per year) was based on the analysis of their annual percentile for the most recent year (2021–22). For these two metrics, the condition analysis was undertaken at the same multiple spatial scales as for the trend analysis (Section 4.1).

The average to above average annual rainfall experienced throughout the state in 2021–22 resulted in the streamflow and flow regime condition across the state being rated as 'good'. Nevertheless, a full range of condition scores were observed across the state at the different spatial scales for all metrics. At the site scale, the condition results suggest that the drivers of streamflow and flow regime are highly spatially variable across the state and therefore need to be viewed with this in mind.

At the site scale, the condition results are spatially consistent with the trend analysis results. The weakest conditions for streamflow are observed for the northern catchments in the NY and MR regions.

The good rating for flow regime condition suggests that, at the state scale, the flow regime experienced for 2021–22 should have been able to support the water dependent ecosystems associated with the river systems as the number of flowing days was above the long-term average for the period 1986 to 2022.

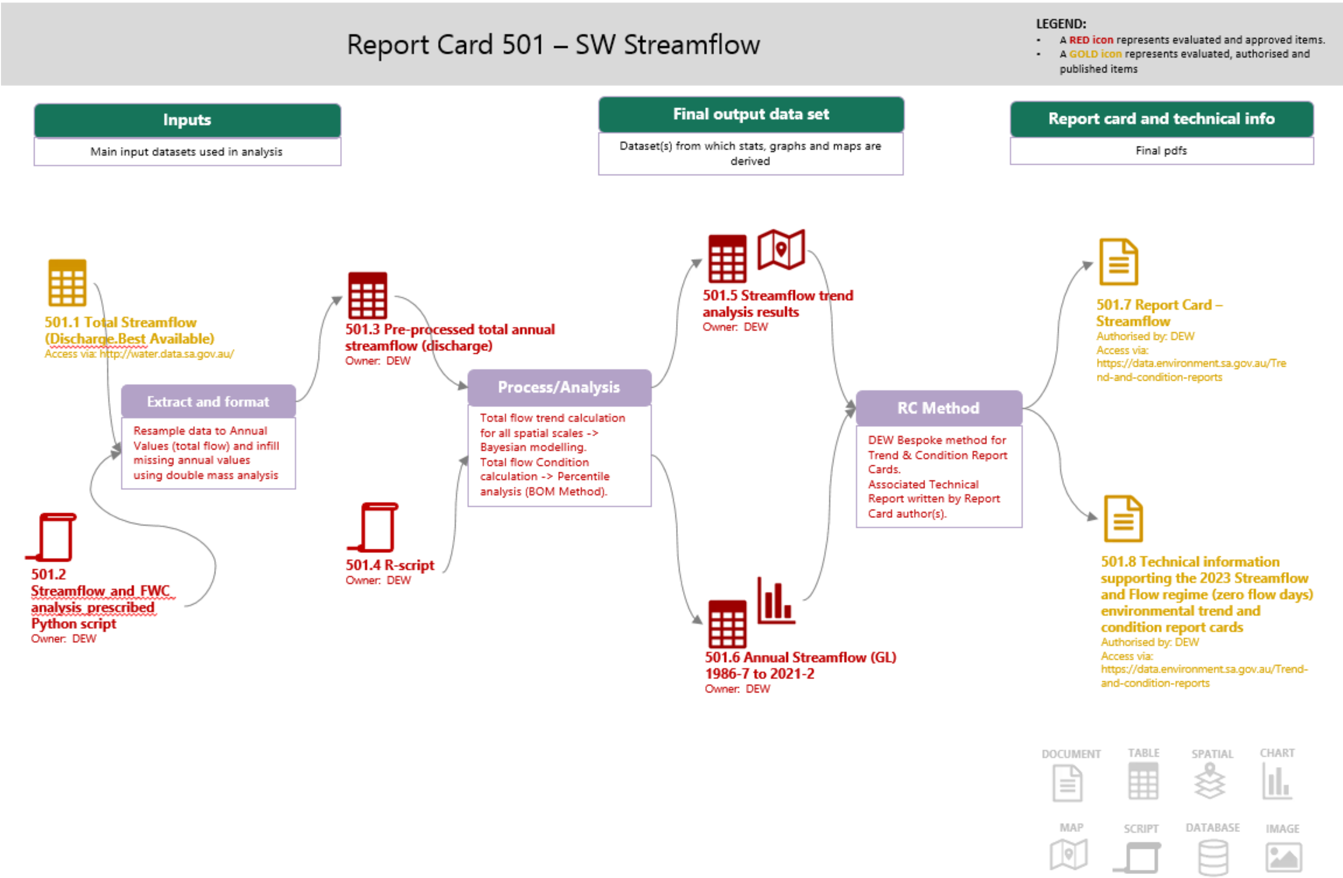
Eyre Peninsula was given a condition rating of poor for flow regime condition and was the only region given this rating. This is despite the higher than average rainfall for the same period. This suggests that there is a lag effect between rainfall and runoff in situations where streamflow has been below average for a prolonged period. The same effect is observed in the Barossa, and to a lesser extent in the Clare Valley, with sites showing poor condition despite above average or near average rainfall. Based on the connection between the flow regime and ecosystem condition, it is expected that the aquatic ecosystems associated with these areas will be at a high level of risk of degradation of condition.

The contrasting results between the overall state trend (looking at the long-term period) and condition (for the most recent year, 2021–22) across all metrics highlight the highly uncertain and variable nature of the (mostly) seasonal and ephemeral waterways in South Australia. This uncertain and variable nature is likely to be exacerbated by the impacts of a changing climate.

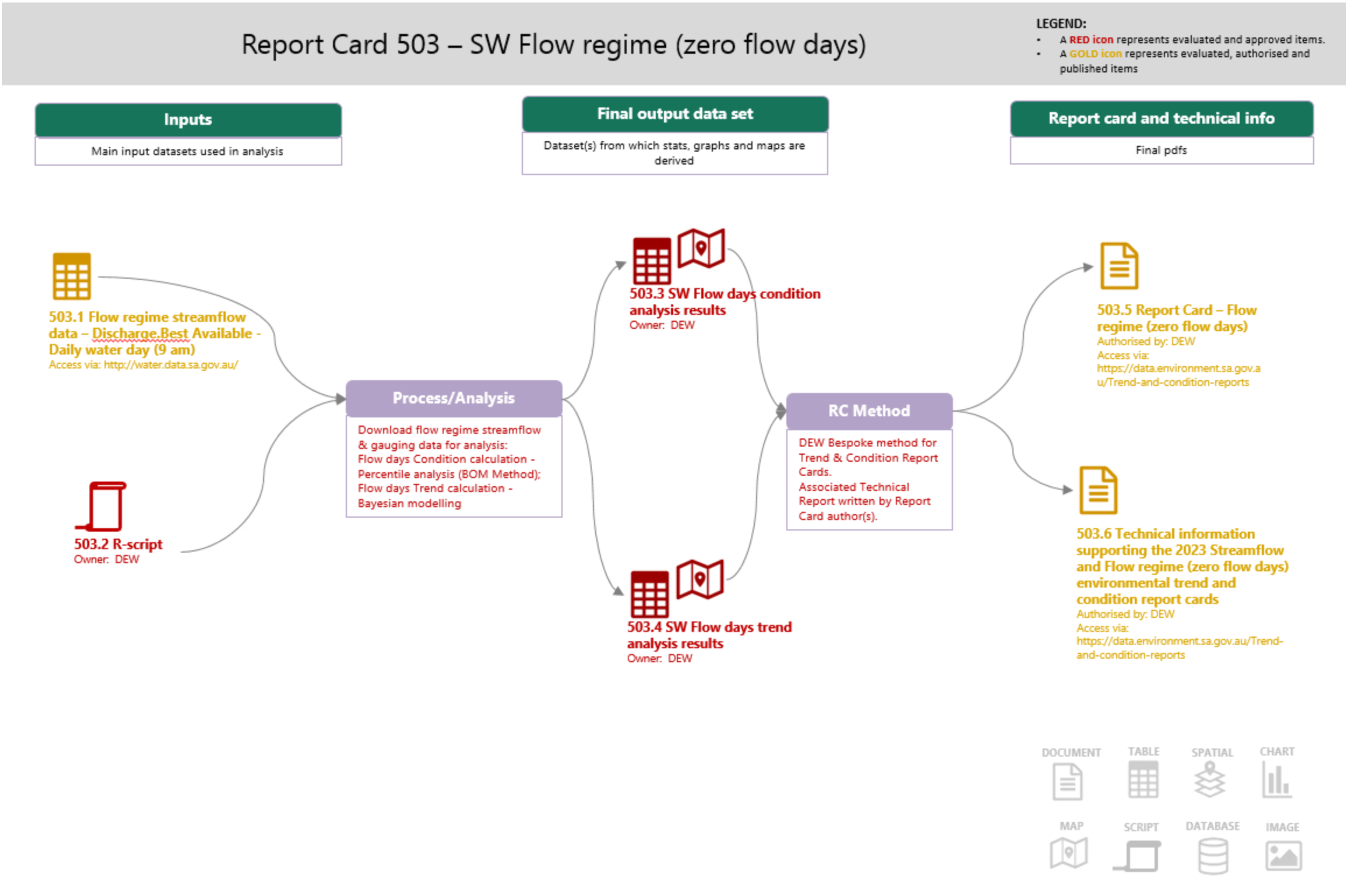
The current streamflow and flow regime trend and condition assessment and results provide an opportunity to anticipate the challenges that could emerge if the current trends continue. As suggested by Milly et al. (2005), with the predicted impacts of hydroclimatic change in water resources, it has become imperative to consider the trend in availability of water resources for water management, as well as for ecological and economic assessment and planning.

5 Appendices

5.1 Managing environmental knowledge chart for Streamflow



5.2 Managing environmental knowledge chart for Flow regime (zero flow days)



5.3 Streamflow data - Prescribed areas

5.3.1 Barossa PWRA

The annual streamflow from 1986 to 2022 for the Yaldara streamflow monitoring site (A5050502) is shown in Figure 5.1. The average annual streamflow at the site is 10,772 ML and 9 of the last 10 years (shaded area) are classified as 'average' or 'below average' (Table 3.3). The trend at the site scale was classified as 'extremely likely decrease', while for the area scale, the trend was classified as 'very likely decrease' (Table 3.1 and Table 3.2). The difference between the site scale and the area scale results are explained by the random factor of site used in the area scale models which introduces a level of uncertainty by assuming not all sites within an area can be accounted for.

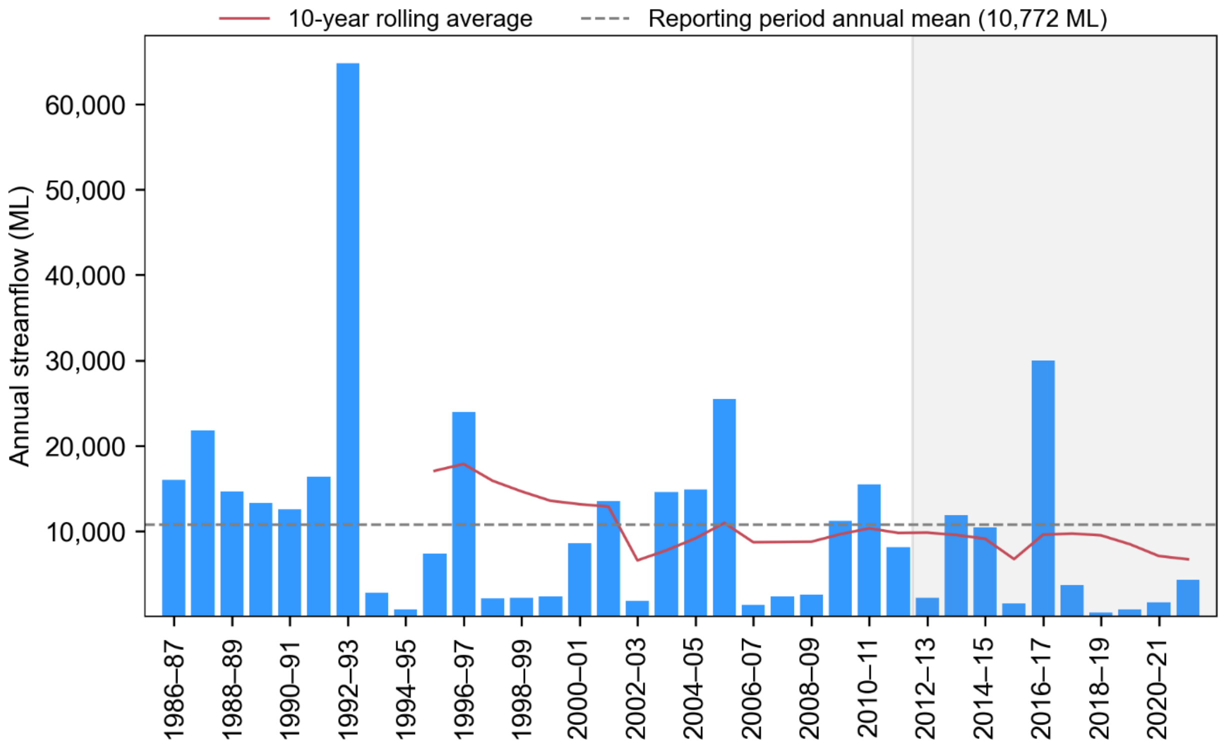


Figure 5.1. Annual streamflow showing the 1986 to 2022 annual mean and 10-year rolling average for the Barossa PWRA (Yaldara A5050502). The last decade is shaded in grey.

5.3.2 Clare PWRA

The annual streamflow from 1986 to 2022 for the Wakefield River streamflow monitoring site (A5060500) is shown in Figure 5.2. The average annual streamflow at the site is 6,485 ML and 8 of the last 10 years (shaded areas) are classified as 'average' or 'below average' (Table 3.3). The trend at the site and area scales were both classified as 'likely decrease' (Table 3.1 and Table 3.2).

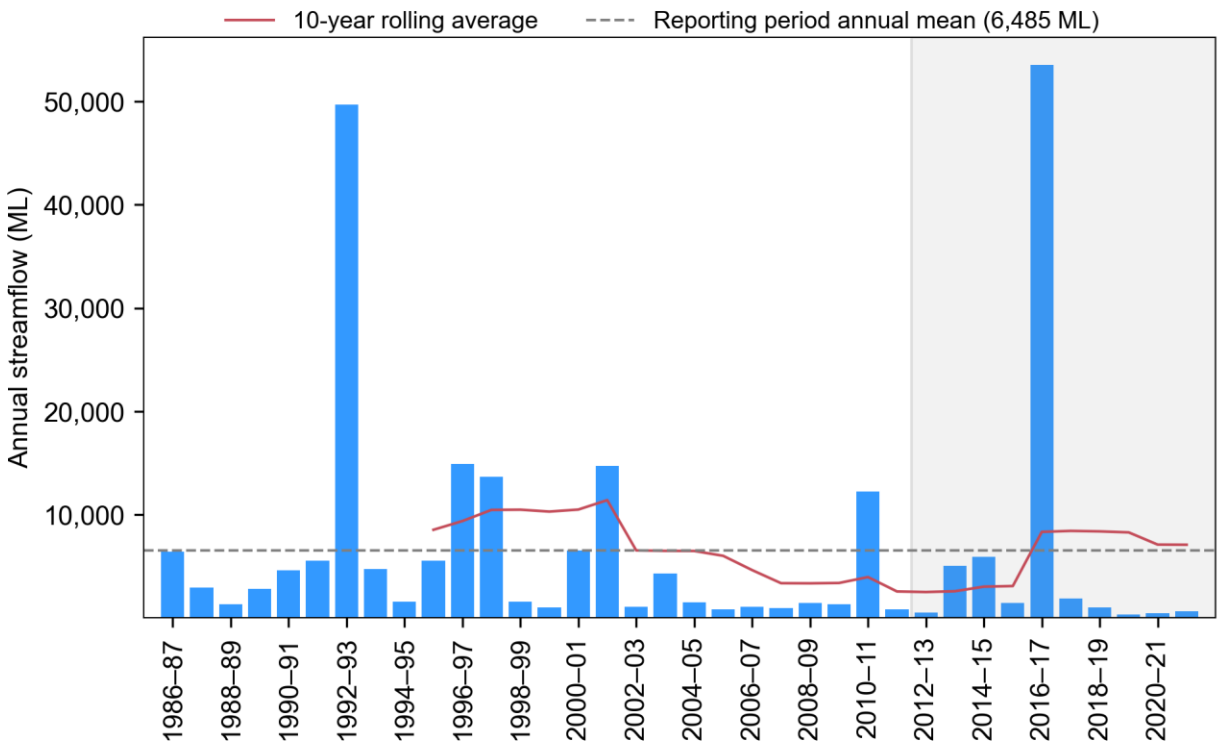
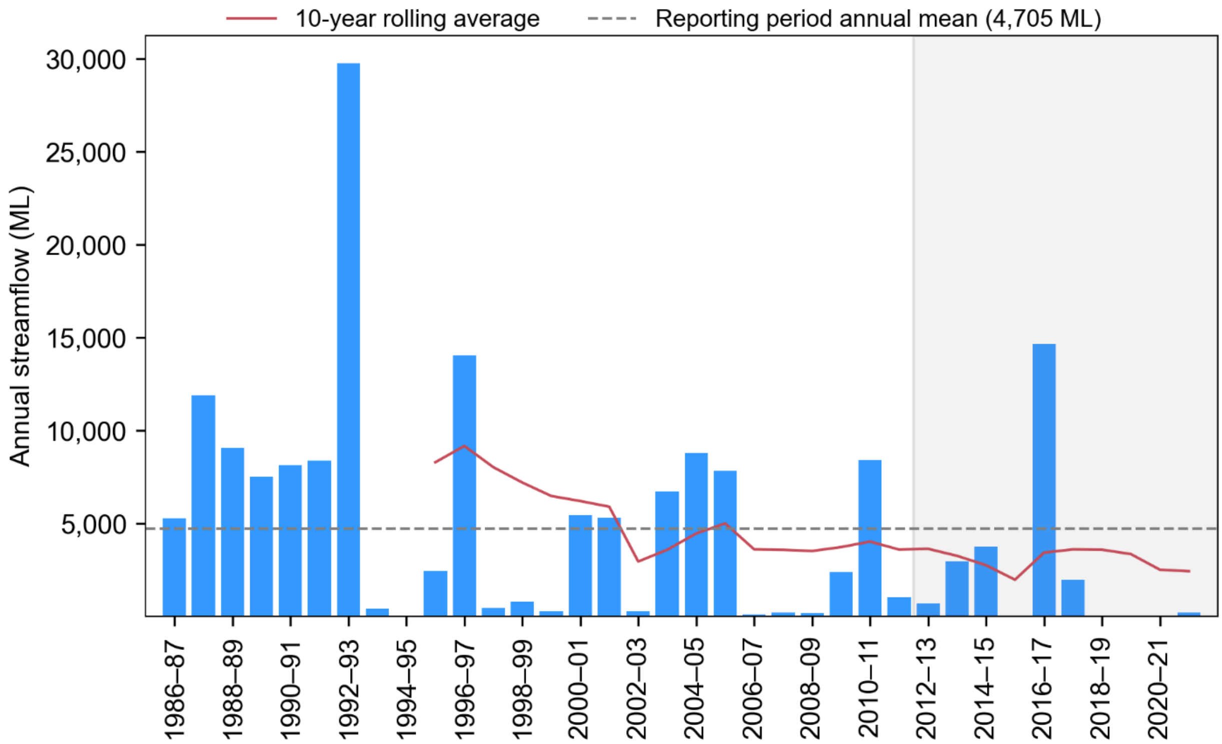


Figure 5.2. Annual streamflow showing the 1986 to 2022 annual mean and 10-year rolling average for the Clare Valley PWRA (Wakefield River A5060500). The last decade is shaded in grey.

5.3.3 Marne-Saunders PWRA

The annual streamflow from 1986 to 2022 showing the combined flow of the Marne Gorge (A4260605) and Saunders Creek (A4261174) streamflow monitoring sites is presented in Figure 5.3. The combined average annual streamflow for Marne-Saunders is 4,705 ML and 9 of the last 10 years (shaded area) are classified as 'average' or 'below average' (Table 3.3). At the site scale, the trends were classified as 'virtually certain decrease' for Marne Gorge and 'extremely likely decrease' for Saunders Creek (Table 3.1). At the area scale the trend for Marne-Saunders was classified as 'likely decrease' with 79.2% of slopes being negative (Table 3.2)



)

Figure 5.3. Annual streamflow showing the 1986 to 2022 annual mean and 10-year rolling average for the Marne-Saunders PWRA (Marne Gorge A4260605 and Saunders Creek A4261174). The last decade is shaded in grey.

5.3.4 Morambro Creek PSWA

The annual streamflow from 1986 to 2022 for the Morambro Creek streamflow monitoring site (A2390531) is shown in Figure 5.4. The average annual streamflow for the site is 3,107 ML and 8 of the last 10 years (shaded area) are classified as 'average' or 'below average' (Table 3.3). The trend for the site scale was classified as 'extremely likely decrease", while for the area scale, the trend was classified as 'likely decrease' (Table 3.1 and Table 3.2). The difference between the site scale and the area scale results are explained by the random factor of site used in the area scale models which introduces a level of uncertainty by assuming not all sites within an area can be accounted for.

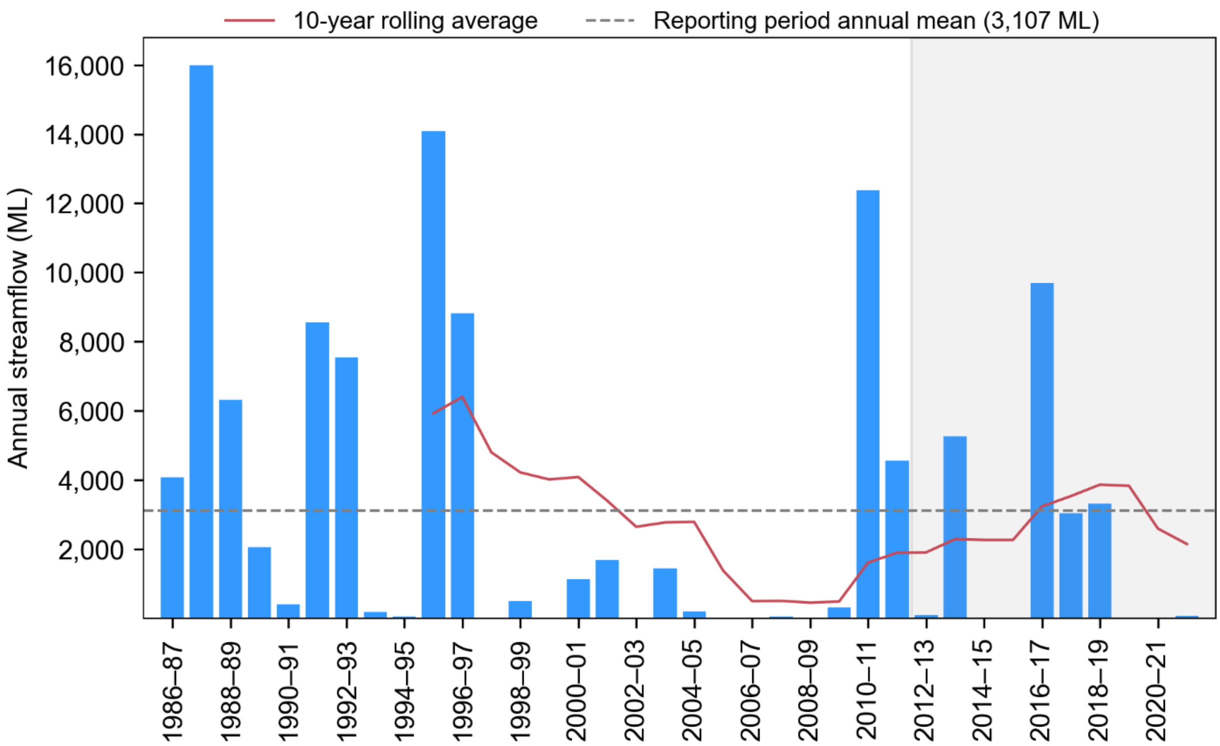


Figure 5.4. Annual streamflow showing the 1986 to 2022 annual mean and 10-year rolling average for the Morambro Creek PSWA (Morambro Creek A2390531). The last decade is shaded in grey.

5.3.5 Eastern Mount Lofty Ranges PWRA

The annual streamflow from 1986 to 2022 showing the combined flow of the Finniss River (A4260504), Currency Creek (A4260530), Angas River (A4260503) and Bremer River (A4260533) streamflow monitoring sites is presented Figure 5.5. The combined average annual streamflow for these sites is 48,657 ML and 8 of the last 10 years (shaded area) are classified as 'average' or 'below average' (Table 3.3). At the site scale, the trends ranged from 'very likely decrease' to 'virtually certain decrease' (Table 3.1). At the area scale the trend for the EMLR was classified as 'likely decrease' with 82.5% of slopes being negative (Table 3.2).

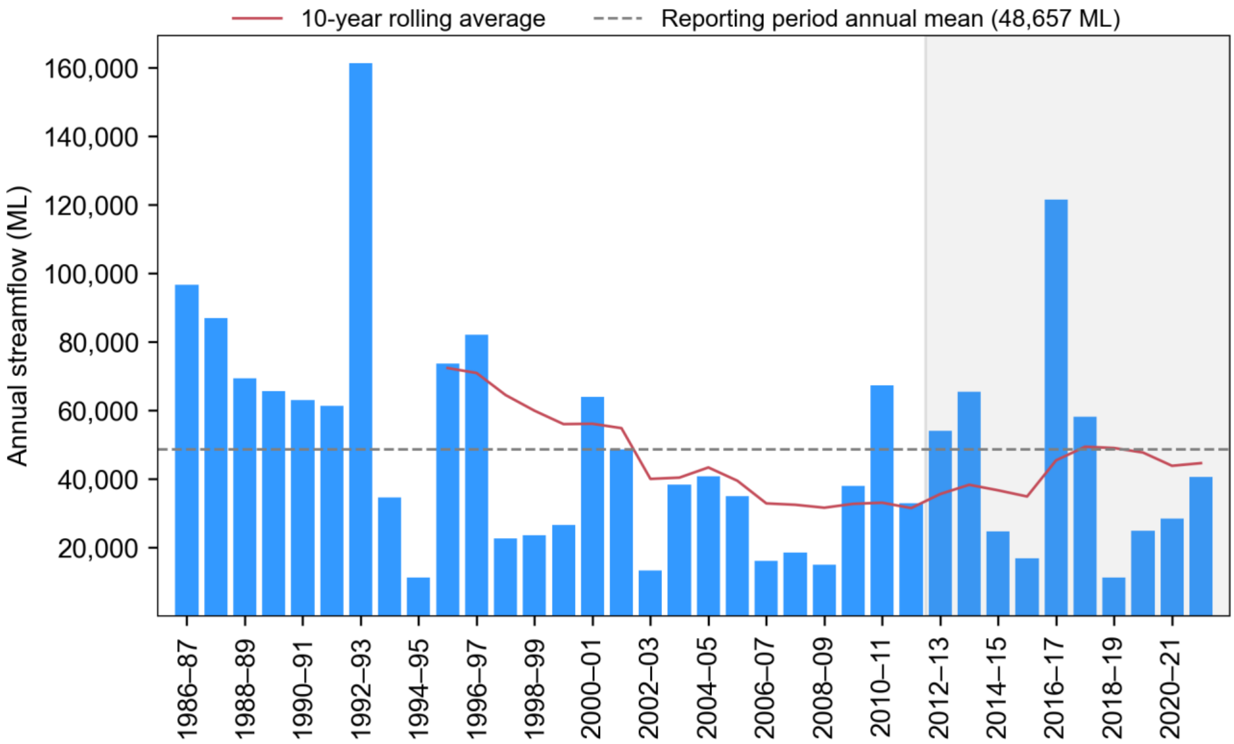


Figure 5.5. Annual streamflow showing the 1986 to 2022 annual mean and 10-year rolling average for the Eastern Mount Lofty Ranges PWRA (Finniss River A4260504, Currency Creek A4260530, Angas River A4260503, and Bremer River A4260533). The last decade is shaded in grey.

5.3.6 Western Mount Lofty Ranges PWRA

The annual streamflow from 1986 to 2022 showing the combined flow of the Kersbrook Creek (A5040525), Sixth Creek (A5040523), Yankalilla River (A5011006), Myponga River (A5020502), Bakers Gully (A5030503), Mount Pleasant (A5040512), Inman River (A5010503) and Scott Creek (A5030502) streamflow monitoring sites is presented in Figure 5.6. The combined average annual streamflow for these sites is 42,879 ML and 8 of the last 10 years (shaded area) are classified as 'average' or 'below average' (Table 3.3). At the site scale, the trends ranged from 'likely decrease' to 'extremely likely decrease' for all sites (Table 3.1). At the area scale trend for the WMLR was classified as 'likely decrease' with 85.9% of slopes being negative (Table 3.2).

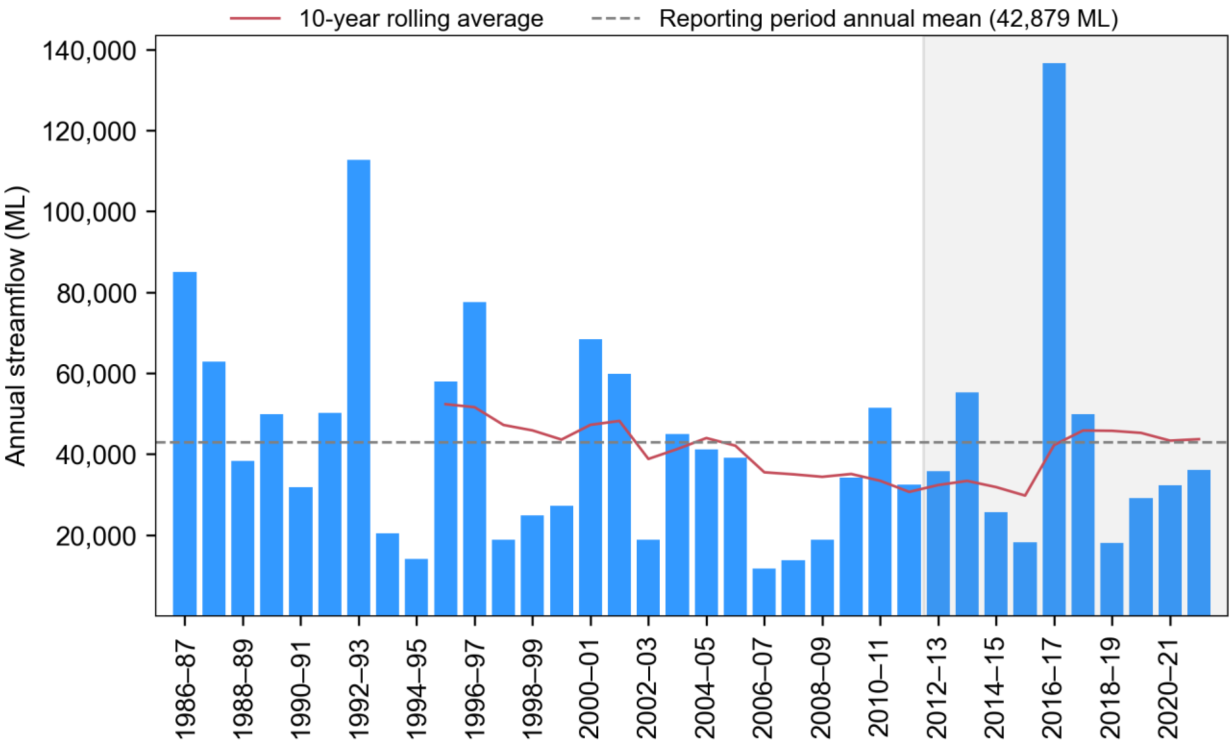


Figure 5.6. Annual streamflow showing the 1986 to 2022 annual mean and 10-year rolling average for the Western Mount Lofty Ranges PWRA (Kersbrook Creek A5040525, Sixth Creek A5040523, Yankalilla River A5011006, Myponga River A5020502, Bakers Gully A5030503, Mount Pleasant A5040512, Inman River A5010503 and Scott Creek A5030502). The last decade is shaded in grey.

5.3.7 Combined PWRAs

The annual streamflow from 1986 to 2022 showing the combined flow for the PWRAs streamflow monitoring sites is presented in Figure 5.7. The combined average annual streamflow for the PWRAs sites is 116,605 ML and 8 of the last 10 years (shaded area) are classified as ‘average’ or ‘below average’.

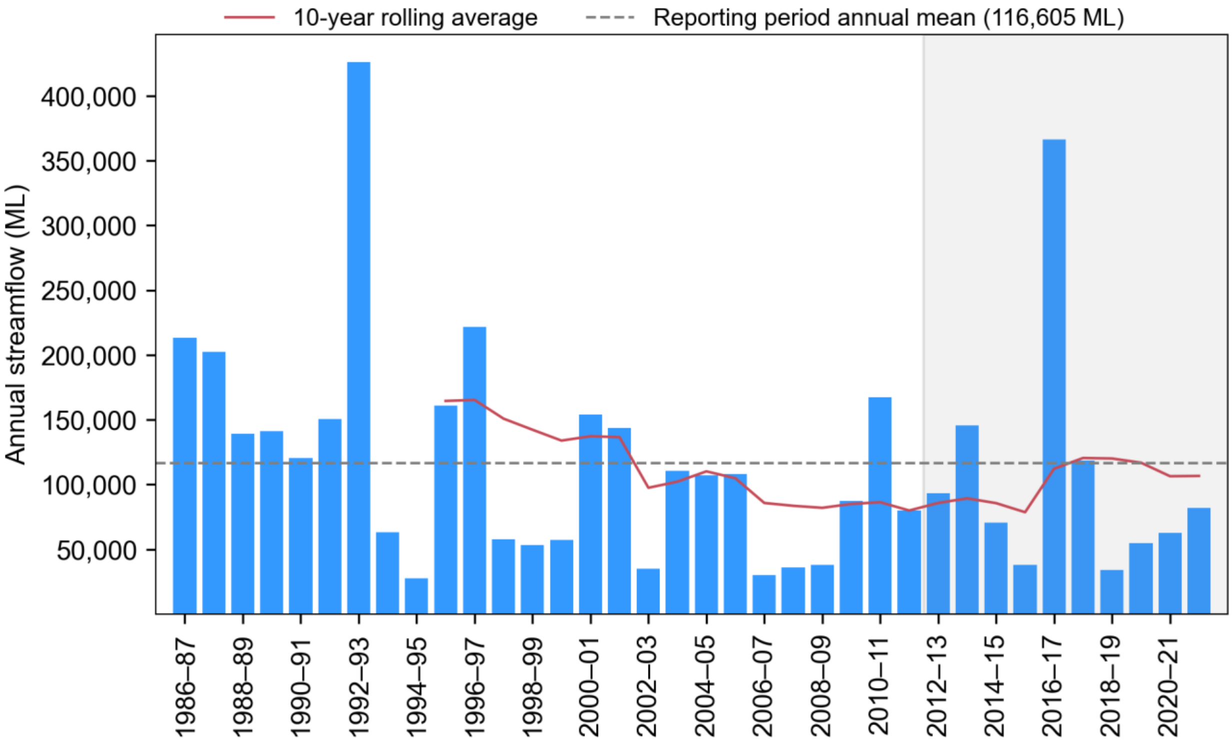


Figure 5.7. Annual streamflow showing the 1986 to 2022 annual mean and 10-year rolling average for the combined PWRAs. The last decade is shaded in grey.

5.4 Streamflow data - Non-prescribed areas

5.4.1 Kangaroo Island Landscape region non-PWRAs

The annual streamflow from 1986 to 2022 showing the combined flow of the Rocky River (A5040525), Middle River (A5131015), and Timber Creek (A5131002) streamflow monitoring sites is presented in Figure 5.8 The combined average annual streamflow for these sites is 27,074 ML and 7 of the last 10 years (shaded area) are classified as 'average' or 'below average' (Table 3.3). At the site scale, the trends were classified as 'likely decrease' for Rocky River and Timber Creek and 'very likely decrease' for Middle River (Table 3.1). The trend at the area scale was classified as 'likely decrease' with 82.4% of slopes being negative (Table 3.2).

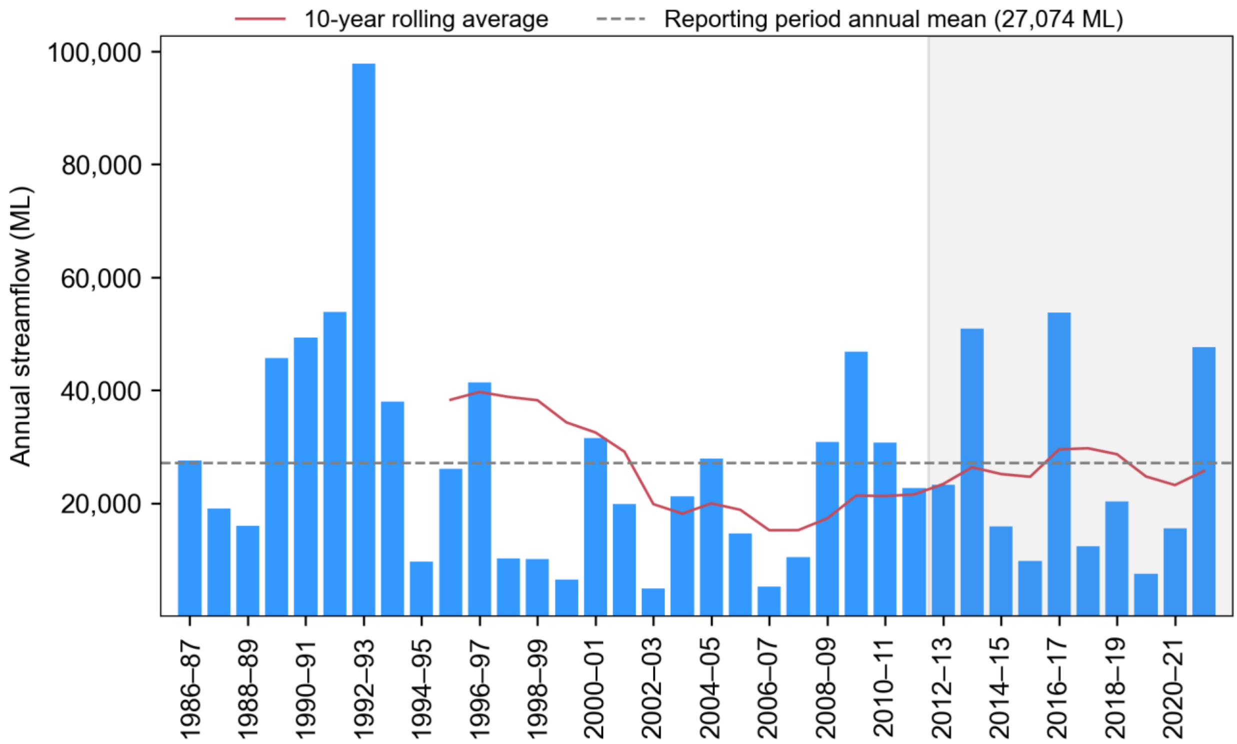


Figure 5.8. Annual streamflow showing the 1986 to 2021 annual mean and 10-year rolling average for the Kangaroo Island Landscape region non-PWRAs (Rocky River A5040525, Middle River A5131015, and Timber Creek A5131002). The last decade is shaded in grey.

5.4.2 Limestone Coast Landscape region non-PWRAs

The annual streamflow from 1986 to 2021 showing the combined flow of the Mosquito Creek (A2390519) and Tatiara Creek (A2390534) streamflow monitoring sites is presented in Figure 5.9. The combined average annual streamflow for these sites is 19,511 ML and 8 of the last 10 years (shaded area) are classified as 'average' or 'below average' (Table 3.3). At the site scale, the trends were classified as 'virtually certain decrease' for Tatiara Creek and 'extremely likely decrease' for Mosquito Creek (Table 3.1). The trend at the area scale was classified as 'likely decrease' with 80.3% of slopes being negative (Table 3.2).

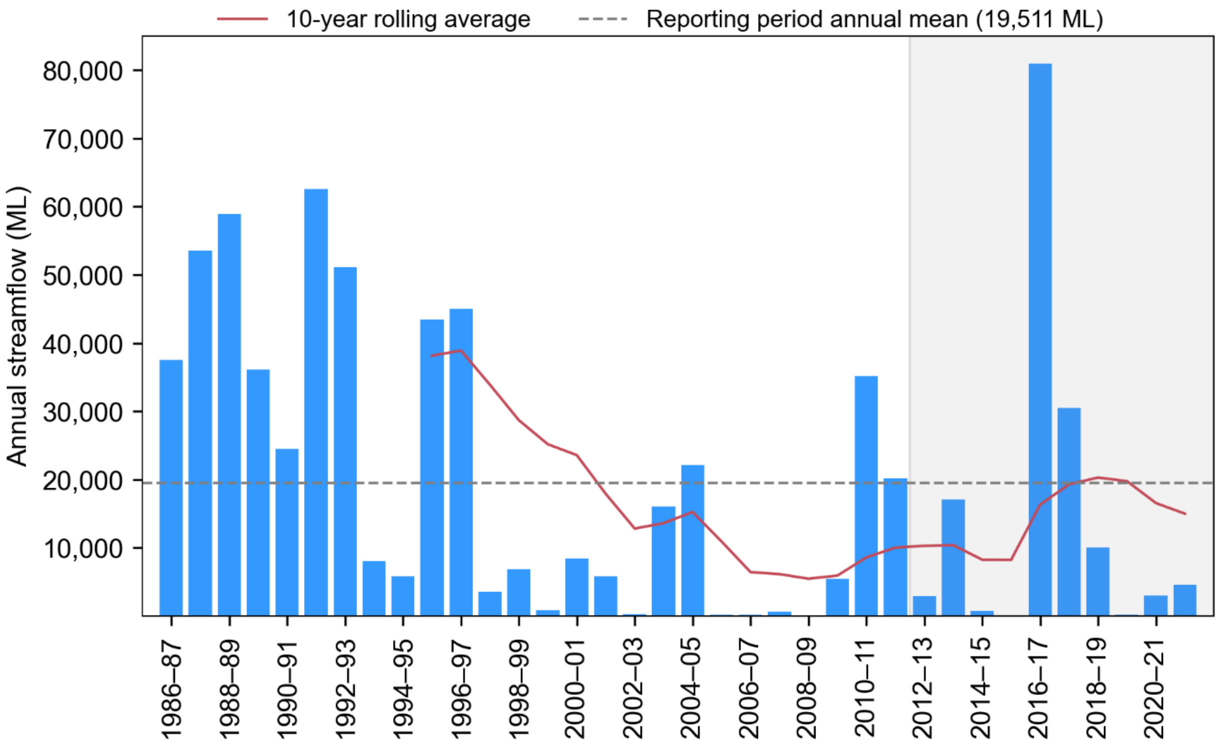


Figure 5.9. Annual streamflow showing the 1986 to 2021 annual mean and 10-year rolling average for the Limestone Coast Landscape region non-PWRAs (Mosquito Creek A2390519 and Tatiara Creek A2390534). The last decade is shaded in grey.

5.4.3 Northern and Yorke Landscape region non-PWRAs

The annual streamflow from 1986 to 2021 showing the combined flow of the Broughton River (A5040525), Hill River (A5040523), and Hutt River (A5011006) streamflow monitoring sites is presented Figure 5.10. The combined average annual streamflow for these sites is 26,960 ML and 7 of the last 10 years (shaded area) are classified as 'below average' (Table 3.3). At the site scale the trends were classified as 'extremely likely decrease' for Broughton and Hill rivers and 'very likely decrease' for Hutt River (Table 3.1). At the area scale the trend was classified as 'likely decrease' with 82.1% of slopes being negative (Table 3.2).

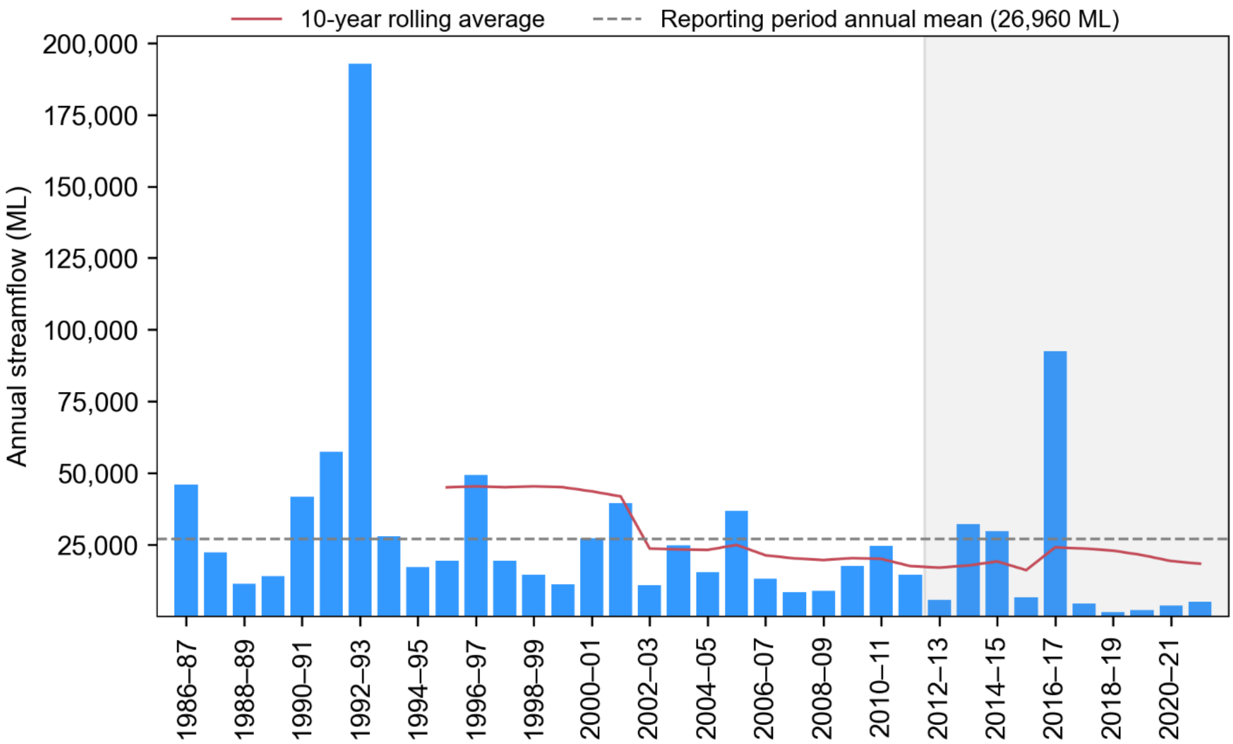


Figure 5.10. Annual streamflow showing the 1986 to 2021 annual mean and 10-year rolling average for Northern and Yorke Landscape region non-PWRAs (the Broughton River A5040525, Hill River A5040523, and Hutt River A5011006). The last decade is shaded in grey.

5.4.4 Eyre Peninsula Landscape region non-PWRAs

The Tod River streamflow monitoring site (A5120500) is the only available long-term monitoring site on the Eyre Peninsula region. The annual streamflow from 1986 to 2021 is shown in Figure 5.11. Streamflow data for this site is not available between 1990–91 to 1998–99 and 2006–07 to 2007–08 (areas shaded in red). Infilled annual streamflow values are not possible to be calculated for this site since there are not nearby monitoring sites to develop a double mass relationship. The average annual streamflow for the available data at the site is 6,424 ML and 5 of the last 10 years (grey shaded area) are classified as 'average' or 'below average' (Table 3.3). The trend at the site scale was classified as 'very likely increase', while for the area scale the trend was classified as 'very likely decrease' (Table 3.1 and Table 3.2). The contrasting difference between the site and area trends are the explained by how the Bayesian linear models calculate the trends at different scales. For the site scale the model it assumes the provided data is the complete representation of the system, therefore the model does not include a level of uncertainty on its trend prediction. In the case of the Tod River, the data for the site scale model is missing a significant portion of the period and therefore the trend analysis includes a high degree of uncertainty which is not accounted in the results. At the area scale however, the model includes the random factor of site to introduce a level of uncertainty by acknowledging not all sites within an area can be accounted. Moreover, the model 'looks' at the rest of the dataset in order to assess the impact of the missing data and the uncertainty level and confidence of the model based on the data and trend for the rest of the sites. In this case, the model for EP predicted a decreasing trend due to the high level of uncertainty by only including one site with a significant period of unavailable data all while the rest of the areas show decreasing trends.

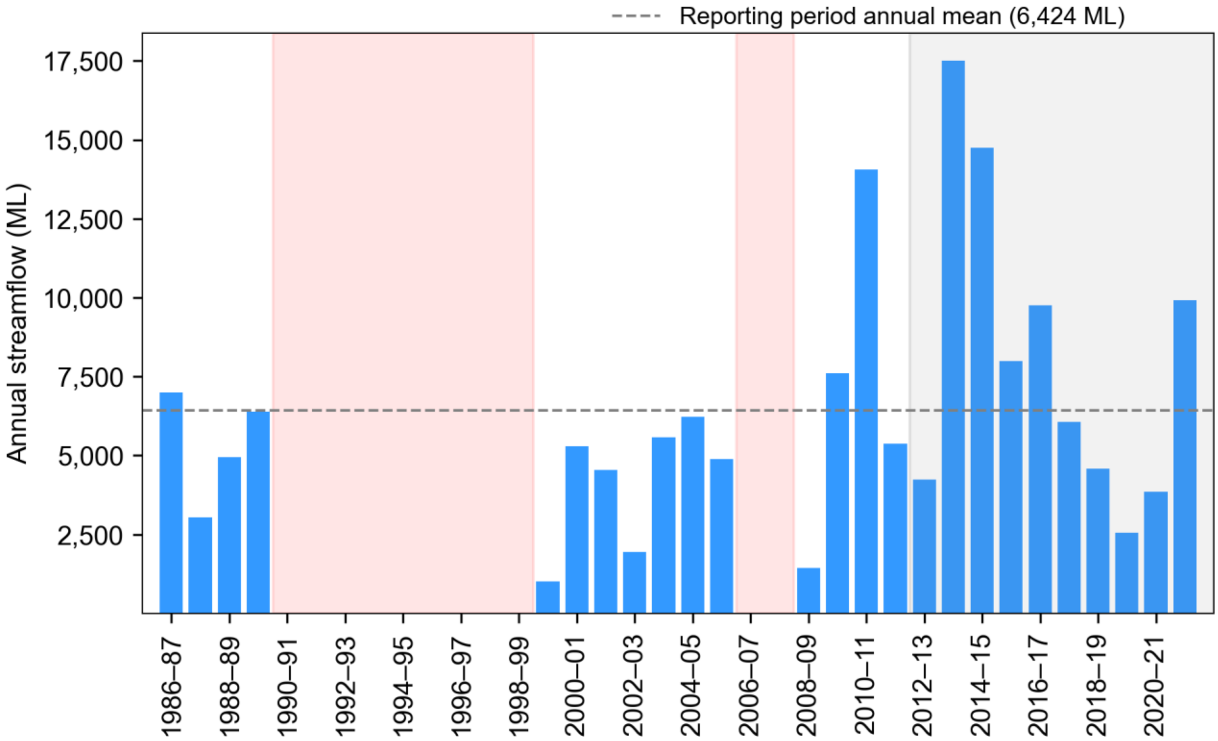


Figure 5.11. Annual streamflow showing the 1986 to 2021 annual mean for Eyre Peninsula region non-PWRAs (Tod River A5120500). Missing data period is shaded in red and the last decade is shaded in grey.

5.4.5 SA Arid Lands Landscape region non-PWRAs

The annual streamflow from 1986 to 2021 showing the combined flow of the Diamantina River (A0020101), Cooper Creek (A0030501), and Willochra Creek (A5090502) streamflow monitoring sites is presented in Figure 5.12. The combined average annual streamflow for these sites is 2,496,391 ML and 9 of the last 10 years (shaded area) are classified as 'average' or 'below average' (Table 3.3). At the site scale, the trends were classified as 'likely decrease' for Diamantina River, 'very likely decrease' for Cooper Creek and 'virtually certain increase' for Willochra Creek (Table 3.1). At the area scale the trend was classified as 'extremely likely decrease' with 97.2% of slopes being negative (Table 3.2).

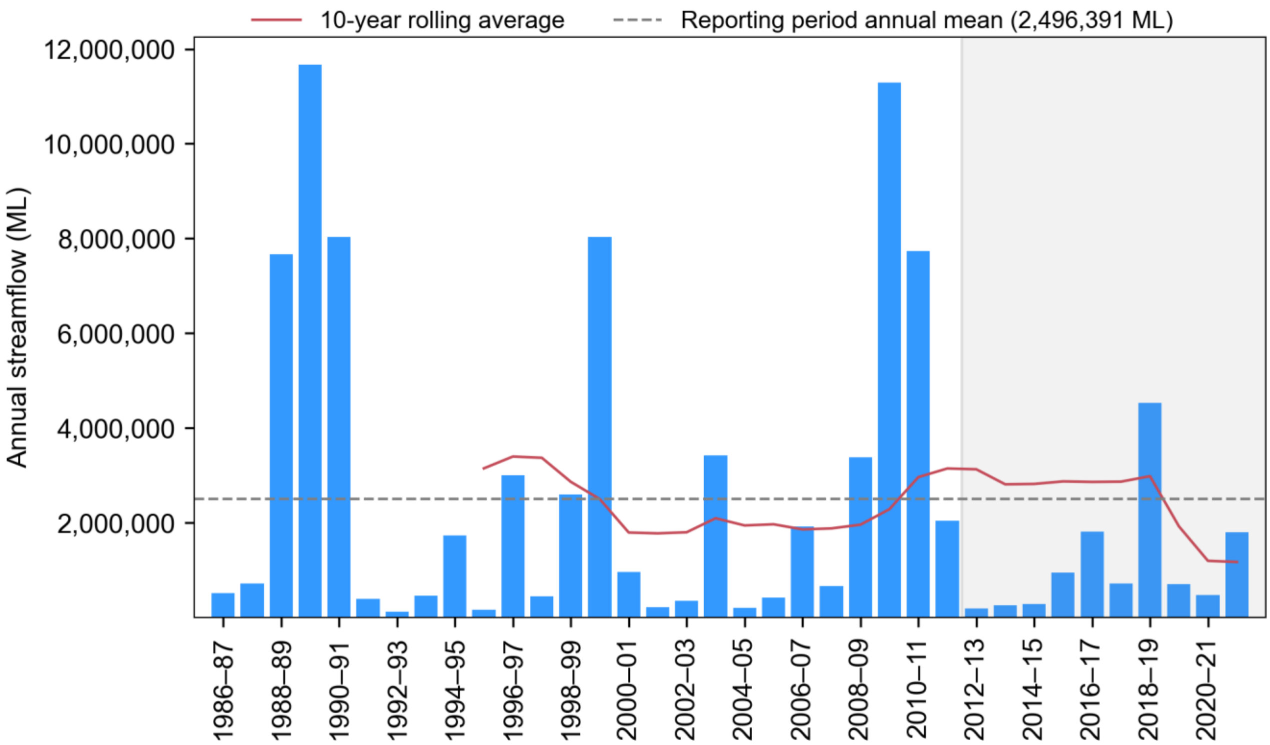


Figure 5.12. Annual streamflow showing the 1986 to 2022 annual mean and 10-year rolling average for SA Arid Lands Landscape region non-PWRAs (Diamantina River A0020101, Cooper Creek A0030501, and Willochra Creek A5090502). The last decade is shaded in grey.

5.4.6 Combined Non-PWRAs

The annual streamflow from 1986 to 2022 showing the combined flow for the non-PWRAs streamflow monitoring sites is presented in Figure 5.13. The combined average annual streamflow for the non-PWRAs sites is 2,569,936 ML and 9 of the last 10 years (shaded area) are classified as 'average' or 'below average'.

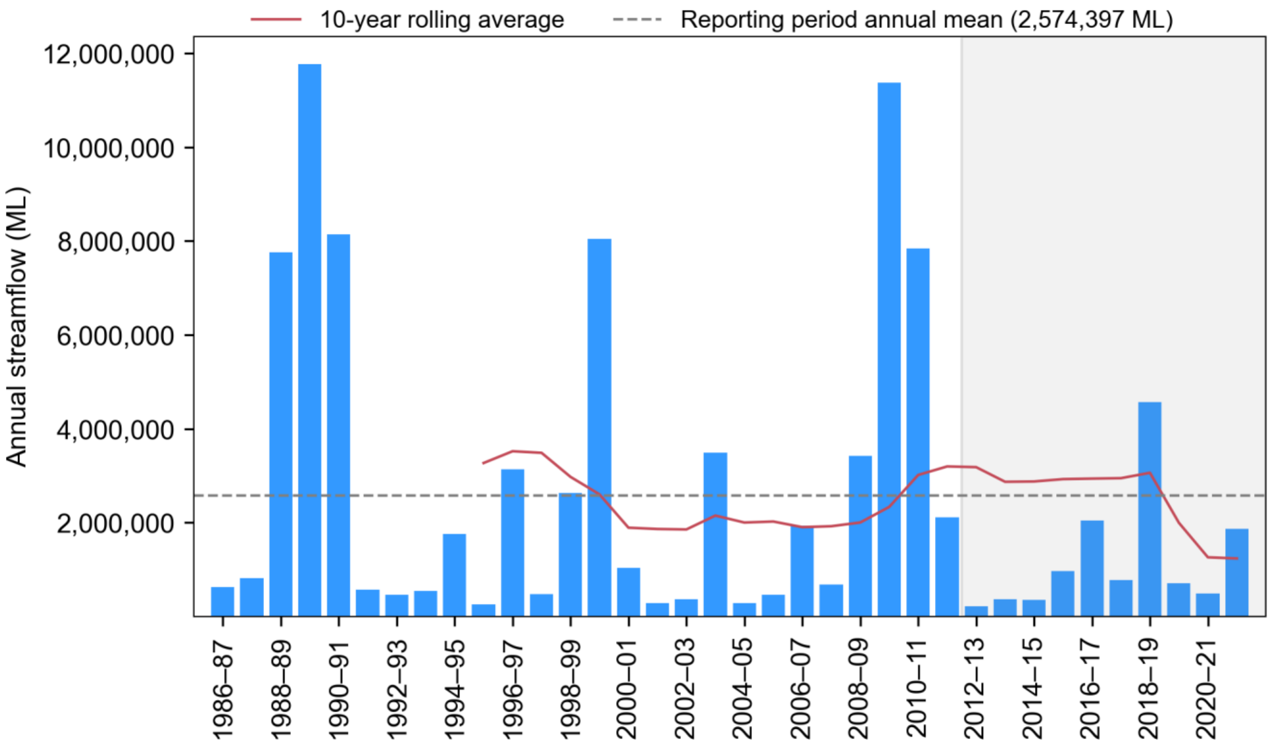


Figure 5.13. Annual streamflow showing the 1986 to 2022 annual mean and 10-year rolling average for the combined non-PWRAs. The last decade is shaded in grey.

6 References

Bureau of Meteorology (2018). Gridded rainfall data. Available at: http://www.bom.gov.au/index.php

Cudennec, C., Leduc, C., and Koutsoyiannis, D. (2007) Dryland hydrology in Mediterranean regions – a review, Hydrol. Sci. J., 52, 1077–1087, https://doi.org/10.1623/hysj.52.6.1077

Datry, T., S. T. Larned, K. M. Fritz, M. T. Bogan, P. J. Wood, E. I. Meyer and A. N. Santos (2014). Broad-scale patterns of invertebrate richness and community composition in temporary rivers: effects of flow intermittence. Ecography 37(1): 94-104.

DEW (2018). Trend and Condition Report Cards for South Australia's Environment and Natural Resources. Report. Department of Environment, Water and Natural Resources, Government of South Australia. Available at: https://data.environment.sa.gov.au/Trend-and-condition-reports/Pages/default.aspx

DEW (2020). Barossa PWRA 2018-19 Water Resource Assessment report, Government of South Australia, through Department for Environment and Water, Adelaide. Draft.

DEW (2020). Clare PWRA 2018-19 Water Resource Assessment report, Government of South Australia, through Department for Environment and Water, Adelaide. Draft.

DEW (2020). Eastern Mount Lofty Ranges PWRA Water Resource Assessment report 2018-19, Government of South Australia, through Department for Environment and Water, Adelaide. Draft.

DEW (2020). Marne-Saunders PWRA Water Resource Assessment report 2018-19, Government of South Australia, through Department for Environment and Water, Adelaide. Draft.

DEW (2020). South East PWRAs Water Resource Assessment report 2018-19, Government of South Australia, through Department for Environment and Water, Adelaide. Draft.

DEW (2020). Western Mount Lofty Ranges PWRA Water Resource Assessment report 2018-19, Government of South Australia, through Department for Environment and Water, Adelaide. Draft.

DEW (2023). Annual Water Security Update 2023, Government of South Australia, through Department for Environment and Water, Adelaide. Draft.

Government of South Australia (1993). Environment Protection Act 1993.

Government of South Australia (2004). Natural Resources Management Act 2004.

Government of South Australia (2020). Landscape South Australia Act 2020.

Gutierrez-Jurado, K. Y., Partington, D., & Shanafield, M. (2021). Taking theory to the field: streamflow generation mechanisms in an intermittent Mediterranean catchment. Hydrology and Earth System Sciences, 4299–4317. https://doi.org/10.5194/hess-25-4299-2021

Hobbs TJ, Neumann CR, Meyer WS, Moon T & Bryan BA (2016). Models of reforestation productivity and carbon sequestration for land use and climate change adaptation planning in South Australia, Journal of Environmental Management, 181, 279-288. http://dx.doi.org/10.1016/j.jenvman.2016.06.049.

Mastrandrea, M.D., C.B. Field, T.F. Stocker, O. Edenhofer, K.L. Ebi, D.J. Frame, H. Held, E. Kriegler, K.J. Mach, P.R. Matschoss, G.-K. Plattner, G.W. Yohe, and F.W. Zwiers (2010). Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties. Intergovernmental Panel on Climate Change (IPCC).

McCullough DP, Montazeri M & Esprey L (2016). SARFIIP – Pike Floodplain hydraulic modelling: Managed inundation options assessment scenarios – 2015-16, DEWNR Technical note 2016/12, Government of South Australia, Department of Environment, Water and Natural Resources, Adelaide.

McIntyre S & Hobbs RJ (2000). Human impacts on landscapes: matrix condition and management priorities, In: Nature Conservation 5: Nature Conservation in Production Environments: Managing the Matrix (eds J.L. Craig, N. Mitchell, D.A. Saunders), pp. 301–07, Surrey Beatty & Sons, Chipping Norton, NSW.

Milly, P. C. D., Dunne, K. A., and Vecchia, A. V. (2005) Global pattern of trends in streamflow and water availability in a changing climate, Nature, 438, 347–350, https://doi.org/10.1038/nature04312

Nabih, S., Tzoraki, O., Zanis, P., Tsikerdekis, T.; Akritidis, D.; Kontogeorgos, I.; Benaabidate, L. Alteration of the Ecohydrological Status of the Intermittent Flow Rivers and Ephemeral Streams due to the Climate Change Impact (Case Study: Tsiknias River). Hydrology 2021, 8, 43. https://doi.org/10.3390/ hydrology8010043

Poff, N. L., J. D. Allan, M. B. Bain, J. R. Karr, K. L. Prestegaard, B. D. Richter, R. E. Sparks and J. C. Stromberg (1997). The natural flow regime. Bioscience 47(11): 769-784.

SAMDB NRM Board (2013). Water allocation plan for the eastern Mount Lofty Ranges, Government of South Australia, Department of Environment, Water and Natural Resources, South Australian Murray-Darling Basin Natural Resources Management Board, Adelaide, www.naturalresources.sa.gov.au/files/c2293324-4e9f-407c-b9c4-a2970101f410/emlr-wap-plan.pdf (accessed 31/12/15).

SILO climate data, Queensland Government. Available at: https://legacy.longpaddock.qld.gov.au/silo/

Stan Development Team (2016). RStan: the R interface to Stan. R package version 2.14.1. Available at: http://mc-stan.org/

R Core Team. (2013). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.

7 Units of measurement

7.1 Units of measurement commonly used (SI and non-SI Australian legal)

Name of unit	Symbol	Definition in terms of other metric units	Quantity
day	d	24 h	time interval
gigalitre	GL	10^6 m^3	volume
gram	g	10^{-3} kg	mass
hectare	ha	10^4 m^2	area
hour	h	60 min	time interval
kilogram	kg	base unit	mass
kilolitre	kL	1 m^3	volume
kilometre	km	10^3 m	length
litre	L	10^{-3} m^3	volume
megalitre	ML	10^3 m^3	volume
metre	m	base unit	length
microgram	µg	10^{-6} g	mass
microlitre	µL	10^{-9} m^3	volume
milligram	mg	10^{-3} g	mass
millilitre	mL	10^{-6} m^3	volume
millimetre	mm	10^{-3} m	length
minute	min	60 s	time interval
second	s	base unit	time interval
tonne	t	1000 kg	mass
year	y	365 or 366 days	time interval

8 Glossary

Catchment — That area of land determined by topographic features within which rainfall will contribute to runoff at a particular point.

DEW — Department for Environment and Water.

DEWNR — Department of Environment, Water and Natural Resources (Government of South Australia).

EMLR — Eastern Mount Lofty Ranges.

Ephemeral streams or wetlands — Those streams or wetlands that usually contain water only on an occasional basis after rainfall events. Many arid zone streams and wetlands are ephemeral.

Flow regime — The character of the timing and amount of flow in a stream.

NRM — Natural Resource Management Plan..

Prescribed water resource — A water resource declared by the Governor to be prescribed under the Act and includes underground water to which access is obtained by prescribed wells. Prescription of a water resource requires that future management of the resource be regulated via a licensing system.

PWRA — Prescribed Water Resources Area.

Surface water — (a) water flowing over land (except in a watercourse), (i) after having fallen as rain or hail or having precipitated in any another manner, (ii) or after rising to the surface naturally from underground; (b) water of the kind referred to in paragraph (a) that has been collected in a dam or reservoir.

WAP — Water Allocation Plan; a plan prepared by a water resources planning committee and adopted by the Minister in accordance with the Act.

Watercourse — A river, creek or other natural watercourse (whether modified or not) and includes: a dam or reservoir that collects water flowing in a watercourse; a lake through which water flows; a channel (but not a channel declared by regulation to be excluded from this definition) into which the water of a watercourse has been diverted; and part of a watercourse.

Water-use year — The period between 1 July in any given calendar year and 30 June the following calendar year; also called a licensing year.

WMLR — Western Mount Lofty Ranges.

Government
of South Australia

Department for
Environment and Water