Technical information supporting the 2023 Rainfall 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

This document was prepared by Graham Green (DEW) and Susan Sweeney (DEW) and technically reviewed by Dan Rogers (DEW). Improvements were made to this report and associated report card based on reviews by Amy Ide (DEW), Di Favier (DEW), and Fi Taylor (DEW).

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

The Rainfall report card sits within the report card Climate 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 Climate change in Australia

Climate affects almost every part of our lives. Communities, industries, landscapes and ecosystems all develop with a tolerance for a range of climate variation. If the climate changes beyond that range of tolerance, then they must either adapt, migrate, transform or decline.

According to the Australian Academy of Science (2015), "Earth's climate has changed over the past century. The atmosphere and oceans have warmed, sea levels have risen, and glaciers and ice sheets have decreased in size. The best available evidence indicates that greenhouse gas emissions from human activities are the main cause. Continuing increases in greenhouse gases will produce further warming and other changes in Earth's physical environment and ecosystems."

The Bureau of Meteorology (BoM) and other science agencies employ a range of air, land and marine sensors to track climatic trends across Australia. The BoM's biennial State of the Climate report draws on the latest national and international climate research, encompassing observations, analyses and future projections to describe year-to-year variability and longer-term changes in Australia's climate (Bureau of Meteorology 2022).

1.4 Rainfall

The Climate: Rainfall report card reports on the decadal timescale trends in rainfall change observed in South Australia over more than 30 years. The information presented represents BoM observed rainfall data from 1990 to 2021.

The report card provides textual comments on the trends in observed rainfall in two figures presented in the card. These figures show 1) a colour-coded contour map of trends in observed April to October rainfall in South Australia over the period 1990–2021, and 2) a colour-coded contour map of trends in observed November to March rainfall in South Australia over the period 1990–2021.

2 Methods

2.1 Indicator

The indicator used for the Rainfall report card is the trend in spatially averaged wet season (April to October) and dry season (November to March) rainfall, interpolated from the Australian Gridded Climate Data (AGCD), which uses observed rainfall data combined with statistical modelling and the latest in scientific techniques to provide accurate information on monthly, seasonal and annual rainfall conditions across the country.

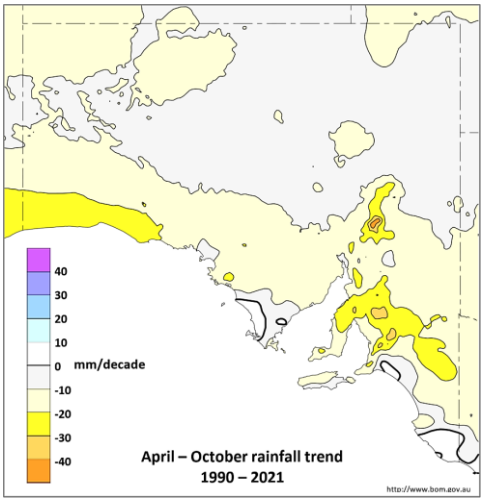
2.2 Data sources, collection and analysis

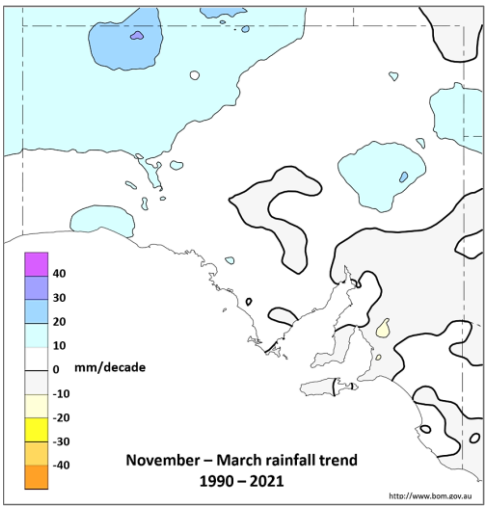
The content of the Rainfall report card includes a combination of elements of textual information, graphical figures, trend and condition ratings, and summary statements about the observed rainfall trends in South Australia. The information sources and analyses applied to derive each element of the report card content are summarised in Table 2.1. The method of selection of the trend, condition and information reliability ratings is described in Section 2.3.

The rainfall trend contour maps, showing zones of decadal rainfall trends covering the whole of South Australia, were provided by the BoM Business Solutions Group. The rainfall trends in the maps show the change in mean rainfall over a 32-year period using the Australian Gridded Climate Data (AGCD), which is the BoM's official dataset for monthly gridded rainfall analysis. AGCD combines available rainfall data with state-of-the-art statistical modelling and the latest in scientific techniques to provide accurate information on monthly, seasonal and annual rainfall conditions across the country (Bureau of Meteorology 2023a). These are based on observed rainfall from BoM monitoring stations across Australia from 1900 to the present.

Table 2.1. Summary of information sources and analysis

Report card element	Content	Information sources / analysis
Trend quote	Over more than 30 years, significant regional variation can be seen in seasonal rainfall trends across South Australia with summer rainfall increasing in the north of the state and winter rainfall decreasing in the south.	This comment is based on an observation of the maps in the top and bottom figures of the report card.
Trend text	Significant drying trends are seen across much of South Australia's southern agricultural areas in April to October (top figure). Rainfall totals across many southern areas of the state have been very much below average compared to all previous 30-year periods since 1900. With April to October rainfall typically averaging 300–500 mm in southern South Australia, declines of 10–40 mm per decade since 1990 are significant. These rainfall declines are consistent with climate change projections and are also seen in other mid-latitude areas in Australia such as south-west Western	The trend text is based on observations of the rainfall trend maps within the top and bottom figures of the report card. The top figure, showing the trend in April to October rainfall, indicates that there is a trend of decline in many parts of the southern half of South Australia in the winter months. The bottom figure, showing the trend in November to March rainfall, indicates that there is a trend of increase in much of the northern half of South Australia in the summer months.

Report card element	Content	Information sources / analysis
	Australia and Victoria. Pastoral areas in north-western South Australia are seeing increased tropically influenced rainfall during November to March (bottom figure). Trends were determined from the latest Bureau of Meteorology data based on observed rainfall across Australia.	
Condition quote	The condition is rated as fair because there are significant declines in April to October rainfall in southern South Australia.	The condition rating was applied according to the criteria for a 'fair' condition: '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).' This rating was selected as the current condition of rainfall, having shown a trend of decline in many of the southern agricultural areas, does not consistently meet environmental, economic and social expectations in many areas.
Condition text	The persistent drying trend in southern South Australia has the potential to affect future water security, reduce agricultural yields, increase fire risk, and impact ecosystems. Wetlands and water dependent ecosystems, particularly in the south-east of the state, have experienced a reducing duration of surface water inundation during the drier months of each year, resulting in encroachment of dryland terrestrial vegetation.	The commentary in the condition text column regarding the impact of drying conditions on water dependent ecosystems, particularly in the south-east of the state is based on the findings of a number of DEW technical investigations, including DEWNR (2015) https://www.waterconnect.sa.gov.au/Content/Publications/DEW/DEWNR-TR-2015-01.pdf and DEW (2018) https://www.waterconnect.sa.gov.au/Content/Publications/DEW/Temporal%20changes%20in%20wetland%20hydrology%20using%20WOfS.pdf
Quote	Rainfall is declining in April to October in South Australia's southern agricultural areas and increasing in November to March in the north-west.	This comment is based on observation of the trends of rainfall decline and increase in the maps in the top and bottom figures of the report card.
Top figure		The top figure of the report card is a map of the change (mm per decade) in average April to October rainfall in South Australia. The map, provided by the BoM South Australia Business Solutions Group, provides a spatial interpolation of the trend of change in the mean rainfall timeseries using the Australian Gridded Climate Data (AGCD), the BoM's official dataset for monthly gridded rainfall analysis (Bureau of Meteorology 2023a). These datasets are based on observed rainfall from BoM monitoring stations across Australia combined with state-of-the-art statistical modelling. The trend values calculated here using past observations should not be used to imply future rates of change. Due to the complex interactions between the natural and human drivers of climate change and variability, the climate of any location is always changing. Future rates of change will depend on how these drivers interact in future, which will not necessarily be the same as in the past (Bureau of Meteorology 2023b).

Report card element	Content	Information sources / analysis
		http://www.bom.gov.au/climate/change/about/rain_trendmaps.shtml
Bottom figure		The bottom figure of the report card is a map of the change (mm per decade) in November to March rainfall in South Australia. The map, provided by the BoM South Australia Business Solutions Group, provides a spatial interpolation of the trend of change in the mean rainfall timeseries using the Australian Gridded Climate Data (AGCD), the BoM's official dataset for monthly gridded rainfall analysis (Bureau of Meteorology 2023). These datasets are based on observed rainfall from BoM monitoring stations across Australia combined with state-of-the-art statistical modelling. The trend values calculated here using past observations should not be used to imply future rates of change. Due to the complex interactions between the natural and human drivers of climate change and variability, the climate of any location is always changing. Future rates of change will depend on how these drivers interact in future, which will not necessarily be the same as in the past (Bureau of Meteorology 2023b). http://www.bom.gov.au/climate/change/about/rain_trendmaps.shtml
Rationale	Climate affects almost every part of our lives. Communities, industries, landscapes and ecosystems all develop with a tolerance for a range of climate variation. If the climate changes beyond that range of tolerance, then they must either adapt, migrate, transform or decline. One example of the impact of a warming climate is declining rainfall in mid-latitudes (including South Australia), which will follow a widening of the tropics in a warmer planet. Declining rainfall impacts water security, agricultural yields, fire risk, and ecosystem function.	This is a general comment on the rationale for providing a report on the trend and condition of rainfall in South Australia. The comment on the influence of a warming global climate affecting the decline in rainfall in mid-latitudes following a widening of the tropics is founded by a range of research papers, for example, Cai et al. (2012), Rainfall reductions over Southern Hemisphere semi-arid regions: the role of subtropical dry zone expansion, Nature Scientific Reports 2/702: https://www.nature.com/articles/srep00702
Drivers	According to the Australian Academy of Science, "Earth's climate has changed over the past century. The atmosphere and oceans have warmed, sea levels have risen, and glaciers and ice sheets have decreased in size. The best available evidence indicates that greenhouse gas emissions from human activities are the main cause. Continuing increases in greenhouse gases will produce further warming and other changes in Earth's physical environment and ecosystems."	This statement from the Australian Academy of Science was selected to describe this pressure as it encapsulates a statement of the primary cause of warming, the effects on the Earth's physical environment in the past and future. The statement is drawn from Australian Academy of Science (2015) www.science.org.au/climatechange
What is being done	The Government of South Australia supports a wide range of initiatives to reduce greenhouse gas emissions and help the state to adapt to the changing climate. These include supporting renewable energy generation and storage, carbon	Information on the Government of South Australia's climate change response initiatives are drawn from DEW's Climate Change web page: SA Government action on climate change

Report card element	Content	Information sources / analysis
	sequestration, land use planning reforms, climate related hazard risk reduction, coastal protection, greening to cool urban environments, circular economy initiatives, and regional adaptation projects. The government provides downscaled climate projections information and tools for South Australia.	

2.3 Methods to assign trend, condition and reliablity

2.3.1 Trend

Table 2.2. Definition of trend classes used

Trend	Description
Getting better	Over a scale relevant to tracking change in the indicator it is improving in status with good confidence
Stable	Over a scale relevant to tracking change in the indicator it is neither improving nor declining in status
Getting worse	Over a scale relevant to tracking change in the indicator it is declining in status with good confidence
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

2.3.2 Condition

Table 2.3. 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

2.3.3 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 2.4 for currency, Table 2.5 for applicability, Table 2.6 for spatial representation and Table 2.7 for accuracy.

Table 2.4. 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 2.5. 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 2.6. 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 2.7. 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

2.4 Data transparency

Data transparency for this report card is represented in Appendix A.

3 Results

3.1 Trend

The trend rating for rainfall was determined to be 'getting worse' based on the trend class definitions in Table 2.2. A trend of decline in wet season (April to October) rainfall over parts of the most populous and agriculturally significant parts of South Australia has been observed over the 32 years from 1990 to 2021 (Figure 3.1). The increases in dry season (November to March) rainfall in some areas (Figure 3.2) do not offset the declines observed in wet season rainfall as the dry season increases are occurring in different parts of the state to the wet season declines, affecting different ecological and hydrological environments. The decline in wet season rainfall is assessed to be a trend that is 'getting worse' due to the increased risk to water security and potential impacts to agriculture and ecosystems that may result from a drying climate.

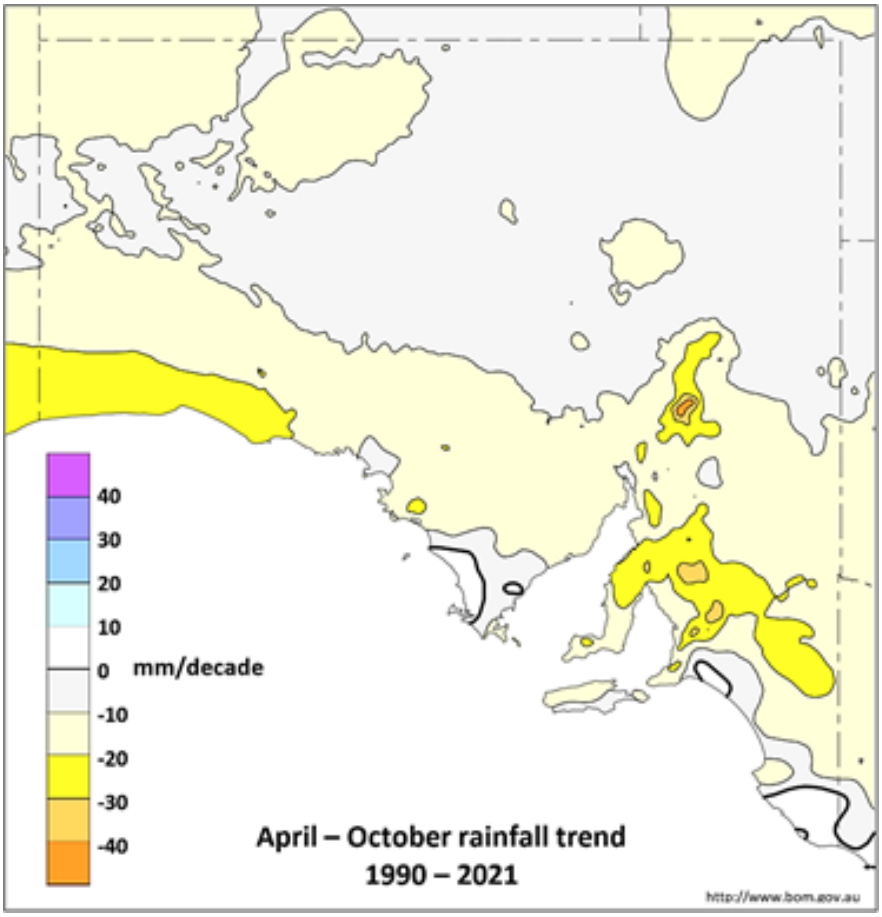


Figure 3.1. April to October observed rainfall trend for South Australia, 1990–2021. Source: Bureau of Meteorology

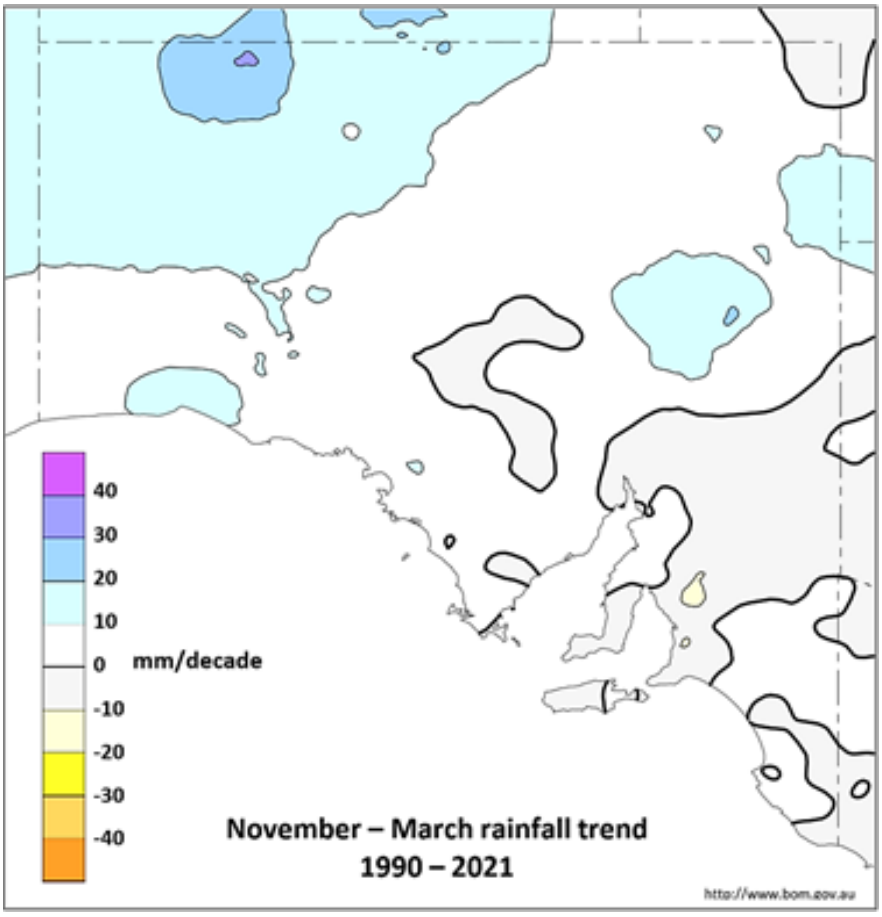


Figure 3.2. November to March observed rainfall trend for South Australia, 1990–2021. Source: Bureau of Meteorology

3.2 Condition

The condition rating assigned is 'fair' because, while wet season rainfall has declined over much of the most populous and agriculturally significant parts of South Australia, the changes in rainfall across South Australia have been manageable. This aligns with the condition definition of 'Fair' (Table 2.3), i.e. "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). If the declining winter rainfall trend in the southern half of South Australia continues into the future, such that it fails to meet the majority of environmental, economic and social needs, the condition assigned to the state's rainfall will likely be revised to 'poor'.

3.3 Reliability

The overall reliability score for this report card is 3 out of 5, based on the minimum of the score for the reliability rating criteria (Table 3.1.) Based on definitions in Section 2.3.3, this translates to an overall reliability rating of 'Good'.

Table 3.1. Information reliability scores for rainfall

Indicator	Applicability	Currency	Spatial	Accuracy	Reliability
Rainfall data	5	5	3	4	3

3.3.1 Notes on reliability

The information has a currency score of 5 as measured rainfall data up to 2021 has been used in the maps of the April to October and November to March rainfall trends.

The information has an applicability rating score of 5 because the data is based on rainfall gauge measurements, which are direct indicators of rainfall amounts.

A spatial representation score of 3 has been assigned because the data is from rain gauges that are distributed throughout the area of the state, however, each one is representative of rainfall over a limited area within the vicinity of the gauge. Hence, the whole extent of the state is represented by the rain gauge network, however the measurements represent less than half the spatial variation of the rainfall within the state.

The observed changes in rainfall are based on direct measurements of rainfall at calibrated rainfall gauging stations distributed across South Australia. However, the coverage of these gauging stations is variable across the state, with the more remote areas having a sparse distribution of stations. As a result, the accuracy of the data, for the purpose of the report card, has been ascribed a score of 4.

4 Discussion

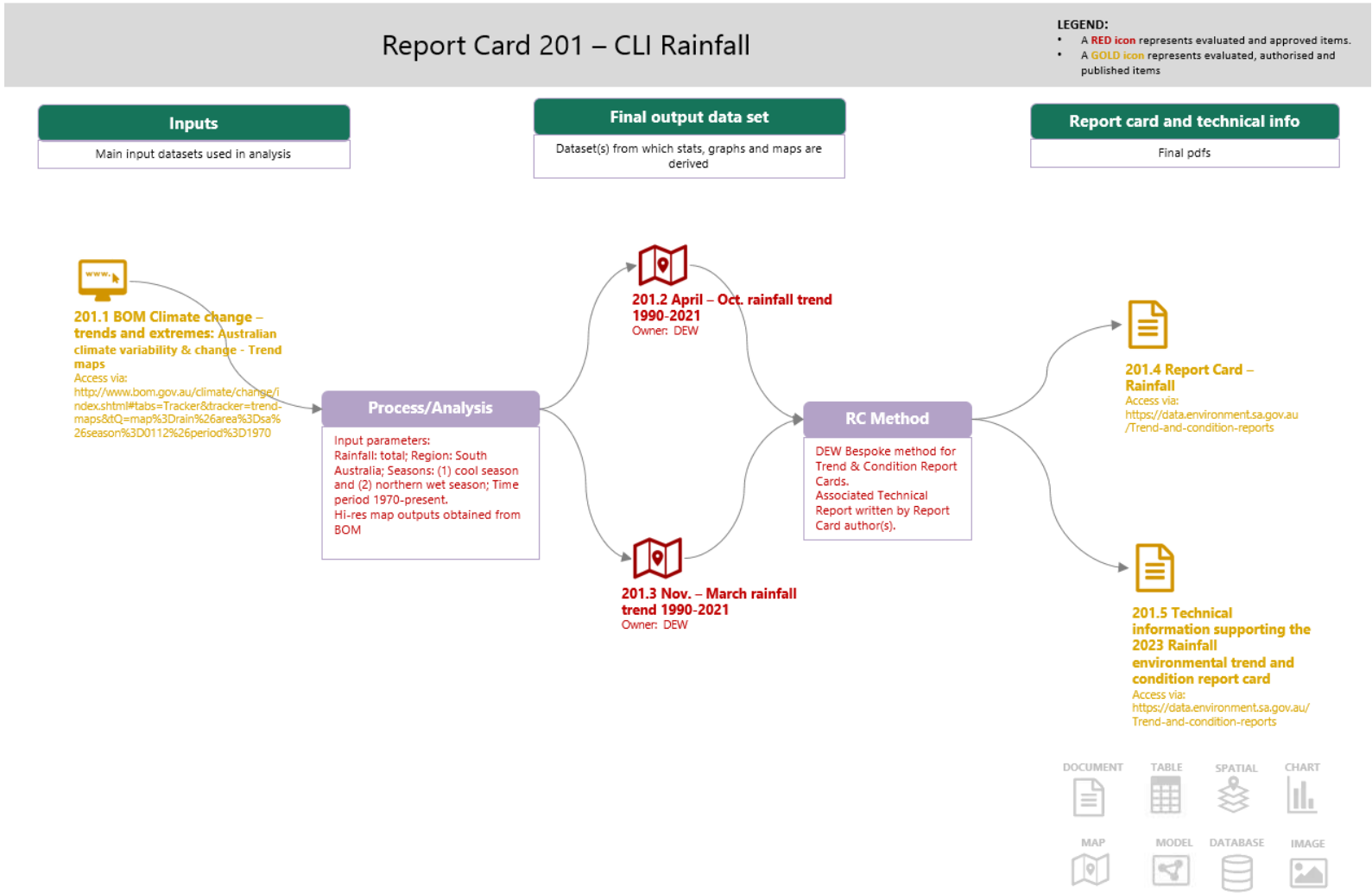
4.1 Trend

The trend rating for rainfall was determined to be 'Getting worse' as the observed changes over the 32 years from 1990 to 2021 show a decline in wet season rainfall in many of the most populous and agriculturally significant parts of South Australia.

4.2 Condition

The condition rating assigned is 'Fair' because, while wet season rainfall has declined over much of the most populous and agriculturally significant parts of South Australia, the changes in rainfall across South Australia have been manageable.

5 Appendix A: Managing environmental knowledge chart for Rainfall



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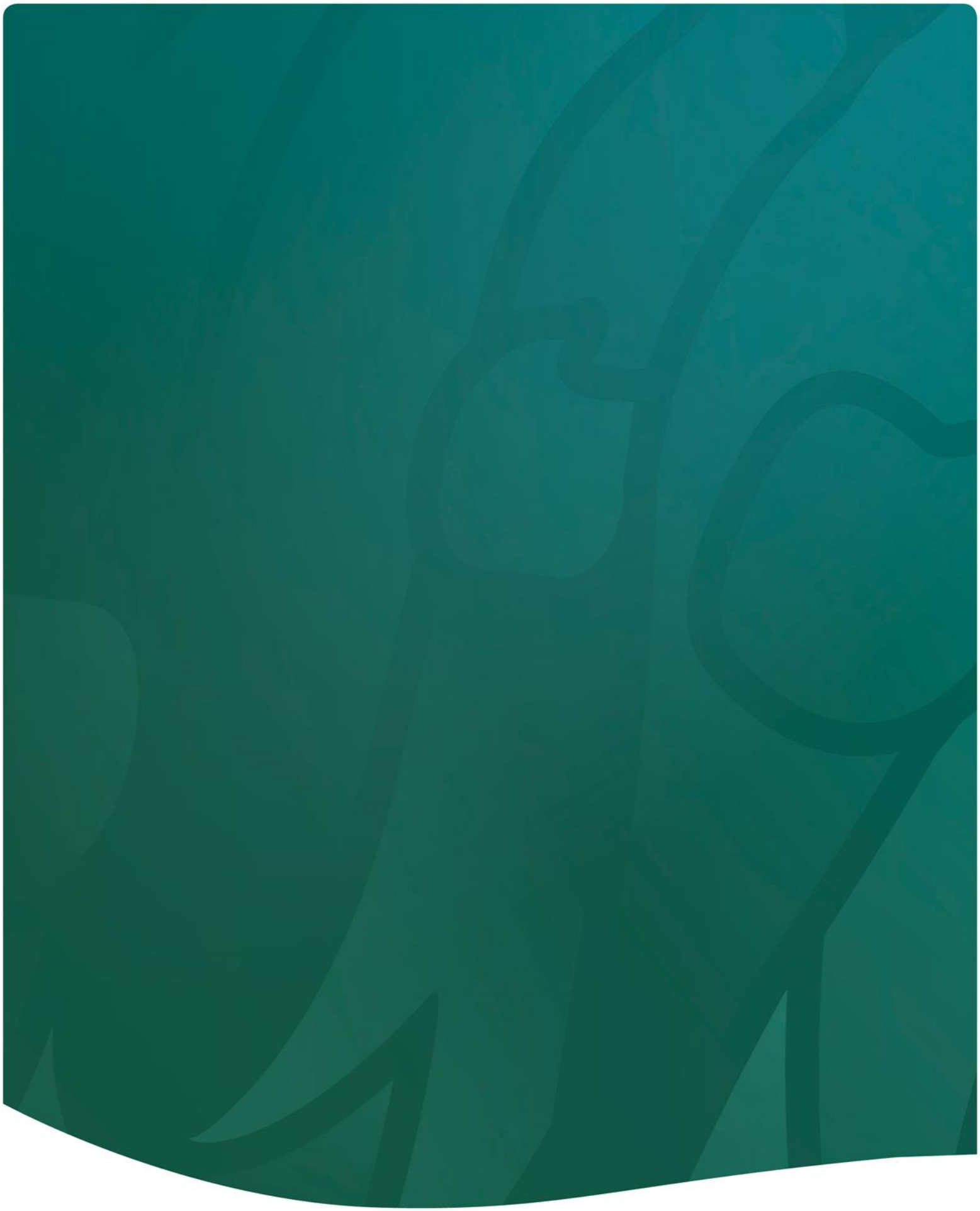

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