Technical information supporting the 2023 Murray Mouth barrage outflow and dredging environmental trend and condition report card

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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.

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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 Murray Mouth barrage outflow and dredging report card. The reliability of information sources used in the report card is also described.

The Murray Mouth barrage outflow and dredging report card sits 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
- 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 Murray Mouth openness, barrage outflow and dredging

An open Murray Mouth provides a connection between the Southern Ocean, the Coorong, and the Lower Lakes of the River Murray, allowing for exchange of water between the estuarine and marine environments. This connection allows for the export of salt, nutrients, and sediments to the marine environment and provides a range of ecosystem benefits. Schedule 5 of the Basin Plan (Enhanced environmental outcomes requires that *the mouth of the River Murray is open without the need for dredging in at least 95% of years, with flows every year through the Murray Mouth Barrages*. Refer to DEW (2020) for a more detailed description of the Murray Mouth.

For this assessment, the diurnal tide ratio for Goolwa (DTR) is a direct indicator of Murray Mouth openness, with annual barrage outflow and dredging activity as secondary indicators. Murray Mouth openness refers to the extent to which there is exchange of water through the Murray Mouth between the Coorong estuary and the Southern Ocean. Water is exchanged in both directions through the Murray Mouth, driven on the freshwater side mainly by discharge through the barrages; and on the ocean side, by tides and wind set up.

The Murray Mouth stays open when there is sufficient barrage outflow from the River Murray. An annual barrage outflow of at least 730 GL (or 2 GL/d from Tauwitcherie Barrage) could potentially minimise sand ingress, although higher barrage flows are required to maintain an open mouth and prevent sand build up (BMT WBM 2009). This is reflected in the historical record of barrage discharge and corresponding diurnal tide ratio, where dredging has occurred during periods when the equivalent annual discharge was above 730 GL, suggesting that the actual minimum discharge required without dredging is likely to be into the range of 730–1,090 GL as per MDBA (2014).

2 Methods

The data analysis carried out for this assessment was generally consistent with the analysis for the prior trend and condition reporting for Murray Mouth openness as documented in DEW (2020).

2.1 Indicators

Three indicators of Murray Mouth openness are assessed: diurnal tide ratio; annual barrage outflow; and dredging in the vicinity of the Murray Mouth.

The Goolwa diurnal tide ratio (DTR), as described in DWLBC (2008) is a direct measure of Murray Mouth openness. The DTR ranges from zero, indicating that the mouth is completely closed; up to one, when the mouth would be considered completely open, with the tidal response in the estuary being equivalent to the ocean tide.

The threshold values for the DTR are adopted as per the prior trend and condition reporting (DEW 2020). If the DTR is below 0.3, then the mouth is constricted and requires dredging. If it falls below 0.2, it is critically constricted. Conversely, DTR values between 0.7 and 0.9 indicate the mouth is 'open' and occur after periods after high flows.

Annual barrage outflow is an indirect indicator of Murray Mouth openness. High annual barrage outflows will scour sand out of the Murray Mouth, increasing connectivity between the estuary and the ocean (raising the DTR). Low outflows will allow the ingress of sand into the Murray Mouth and estuary, thus reducing connectivity (lowering the DTR).

With sufficient freshwater barrage outflows from the River Murray, sand ingress through the Murray Mouth is minimised. Modelling suggests that an annual Tauwitcherie barrage outflow of 730 GL, or 2 GL/day could minimise sand ingress, although higher barrage flows are required to maintain an open mouth and prevent sand build up (BMT WBM 2009). Thus, this secondary indicator of Murray Mouth openness is the annual barrage outflow relative to the 730 GL/year threshold.

Annual barrage outflow data were used to assess the trend in Murray Mouth openness. Ideally the primary indicator DTR could be used to assess trend if there were no dredging. Dredge operations to maintain the DTR above 0.3 in more than 1 in 20 years indicates that the Murray Mouth is in poor condition.

2.2 Data sources

The same data sources were used as for the prior assessment documented in DEW (2020), except a more direct measure of barrage outflows from the 2012 to 2022 water years (ending) has been used. For years up to 2012, the same data as for DEW (2020) was used. From 2012 onwards, calculated total daily barrage outflow data (A4261002, Water Data SA) were exported from the Barrage Calculator (DEW 2021). The Barrage Calculator uses continuously monitored upstream and downstream water levels across the barrages, barrage operating configurations, and calibrated weir equations to calculate total discharge through the barrages and associated fishways.

DTR and dredge operation data were sourced directly from SA Water.

2.3 Data analysis and methods to assign trend, condition and reliablity

2.3.1 Trend

Diurnal tide Ratio

The proportion of days per year for which the Murray Mouth was not constricted (Goolwa DTR exceeded 0.3) and the proportion for which the DTR was below 0.2 (constricted) were both assessed.

Barrage outflows

Consistent with prior reporting on Murray Mouth openness (DEW 2020), a Bayesian analysis was carried out to identify any trend in annual barrage outflow threshold (730 GL/year) exceedance. The trend classes used are defined in Table 2.1.

There is a pronounced increase in exceedance of the barrage outflow threshold due to the Millennium Drought in the first decade of the assessment period. For consistency, a Bayesian analysis has been performed using the method described in DEW (2020) with the barrage outflow dataset extended to June 2022.

Table 2.1. Definition of trend classes used

Likelihood of outcome	IPCC Classification	Report card trend	Description
> +99 to +100%	Virtually certain increase	Getting better	Over a scale relevant to tracking change in the indicator it is improving in status with good confidence
> +95 to +99%	Extremely likely increase		
> +90 to +95%	Very likely increase		
> +66 to +90 %	Likely increase		
-66 to +66%	Stable	Stable	Over a scale relevant to tracking change in the indicator it is neither improving nor declining in status
< -66 to -90%	Likely decrease	Getting worse	Over a scale relevant to tracking change in the indicator it is declining in status with good confidence
< -90 to -95%	Very likely decrease		
< -95 to -99%	Extremely likely decrease		
< -99 to -100%	Virtually certain decrease		
-	-	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

The trend is then summarised for the period of the assessment as:

- Getting better: The indicator is improving
- Stable: The indicator is neither improving nor declining
- Getting worse: The indicator is declining
- Unknown: Data are not sufficient to determine any trend in the status of this indicator.

Dredging

Daily dredging data were provided by SA Water, indicating daily operation of zero, one, or two dredges.

2.3.2 Condition

Table 2.2 shows the DTR thresholds and criteria used to determine the condition of the Murray Mouth. Note that the condition of the Murray Mouth is considered poor if dredging is required to keep the mouth open.

Table 2.2. Definition of condition classes used

Condition	Criteria
Very good	DTR >0.4 without the use of dredges over the past 5 years.
Good	0.3 < DTR ≤ 0.4 without the use of dredges over the past 5 years.
Fair	0.2 < DTR ≤ 0.3 without the use of dredges over the past 5 years.
Poor	DTR ≤ 0.2 or the use of dredges over the past 5 years.

2.3.3 Limitations

Input data for the Barrage calculator includes the head difference across the barrages, measured as the difference between upstream and downstream water level. For calculating barrage discharge, the accuracy of this measurement is high. The other input is the physical configuration of the barrages, such as the number of barrage gates open. This is provided by the operator, and therefore the accuracy of this input may also be considered high. These two inputs are used in the calibrated weir equations to generate a flow estimate at an hourly timestep. Despite the difficulty in flow gauging the barrages to verify the flow calculations, confidence in the barrage discharge estimates is high when upstream water level is less than 0.83 m Australian Height Datum (AHD). Above 0.83 m AHD, the spillways engage and flow paths not accounted for in the equations commence, resulting in a likely under-estimation of barrage outflow.

2.3.4 Reliability

Information is scored for reliability based on the minimum of subjective scores (1 [worst] to 5 [best]) given for information currency, applicability, level of spatial representation and accuracy. Definitions guiding the application of these scores are provided in Table 2.3 for currency, Table 2.4 for applicability, Table 2.5 for spatial representation and Table 2.6 for accuracy.

Table 2.3. Guides for applying information currency

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

Table 2.4. Guides for applying information applicability

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

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

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

Table 2.6. Guides for applying accuracy information

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

2.4 Data transparency

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

3 Results

3.1 Trend

Diurnal tide ratio

The proportion of days that the Murray Mouth was open with a DTR greater than 0.3 has generally increased in the last decade compared with the Millennium Drought period between 2001 and 2010 (Figure 3.1). Conversely, the proportion of days for which the mouth was constricted has reduced markedly over the same period. The increasing trend in the DTR over the last decade can be seen in Figure 3.2, with the DTR increasingly above the mouth-open threshold of 0.3. To note, this has been achieved primarily due to continuous dredging since 2015.

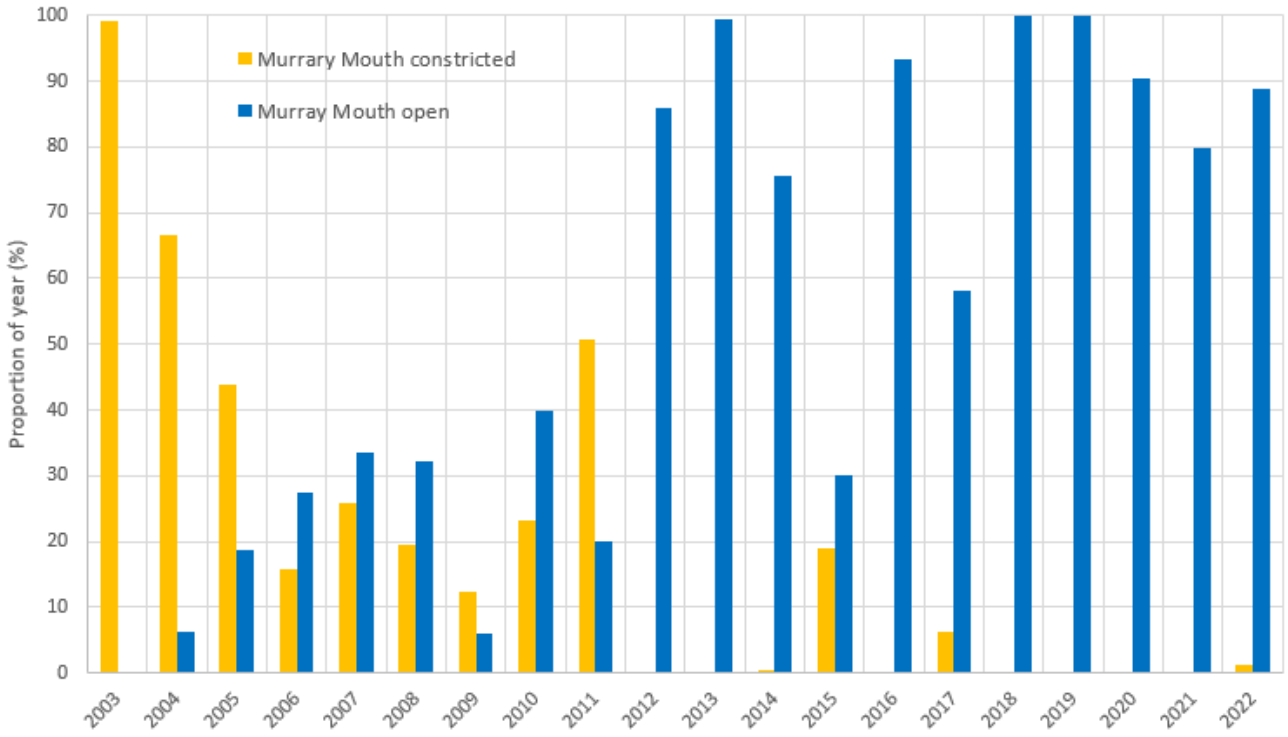


Figure 3.1. Proportion of time each year that the Murray Mouth was open (DTR > 0.3) or critically constricted (DTR ≤ 0.2)

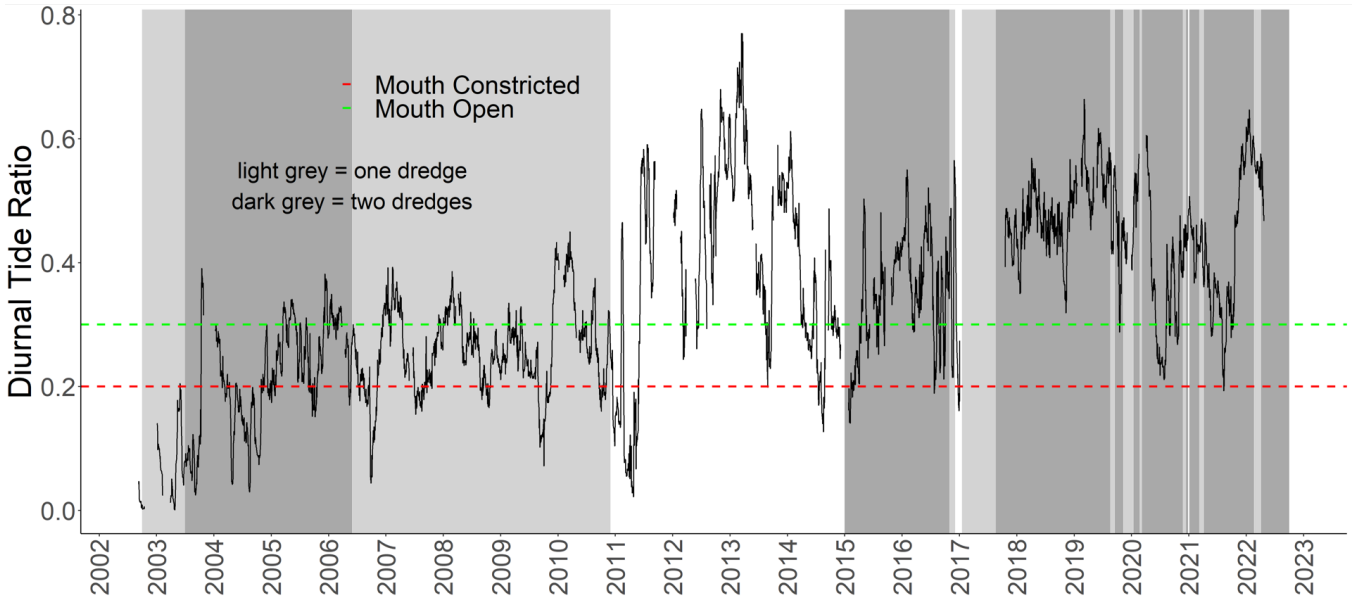


Figure 3.2. Diurnal Tide Ratio at Goolwa and Murray Mouth dredging activity

Barrage outflows

Figure 3.3 shows that the barrage outflow threshold of 730 GL/year has been exceeded in all but two years since 2010. Two of the three additional years added to the dataset since the previous trend analysis in 2020 exceed the 730 GL/year barrage outflow threshold. Thus, the probability that there is an increasing trend in the annual exceedance of the threshold over the assessment period remains very high at 0.91.

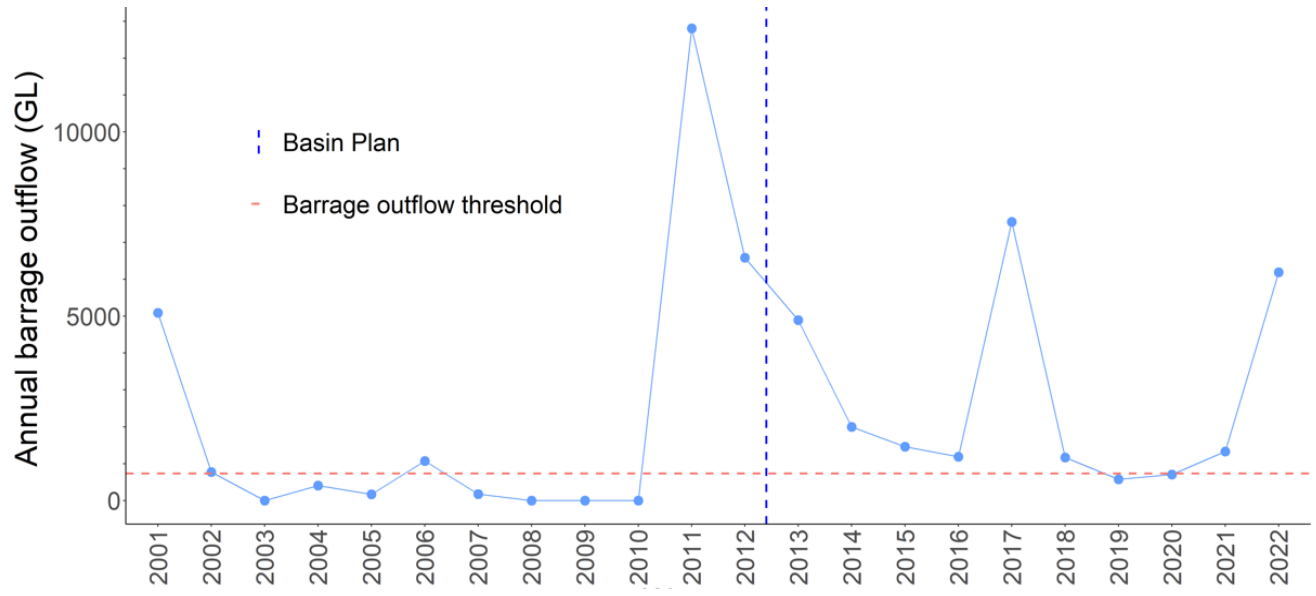


Figure 3.3. Annual total barrage outflow relative to the barrage outflow threshold (730 GL/y)

3.2 Condition

The condition of the Murray Mouth is rated as poor, as dredging has been required since 2015 to maintain the DTR above 0.3.

3.3 Reliability

The reliability score for each indicator and for each reliability criterion is provided in Table 3.1 based on the guiding definitions provided in Tables 2.3 to 2.6.

The overall reliability score for this report card is 4 out of 5, which is a reliability of 'very good'. The overall reliability score was based on the minimum of the reliability scores for the three indicators.

Table 3.1. Information reliability scores for the three Murray Mouth barrage outflow and dredging indicators

Indicator	Applicability	Currency	Spatial	Accuracy	Total reliability
Diurnal tide ratio	5	5	5	5	5
Annual barrage outflows	4	5	5	4	4
Dredge operation	5	5	5	5	5

3.3.1 Notes on reliability

The information reliability scores are based on:

- Information applicability assessed as 5 for the DTR and dredge operation data because all data are based on direct indicators of the measure. Information applicability assessed as 4 for annual barrage outflows because, while the Barrage Calculator is potentially a more direct measure of barrage outflows than the prior Lower Lakes water balance method (which the Barrage Calculator is calibrated against), it is still an indirect measure.
- Information currency assessed as 5 for each indicator as most recent information is up to 3 years old for all 3 indicators.
- Spatial representation assessed as 5 for each indicator as the data has been collected at the locations of interest and therefore reliability is not affected by this criterion.
- Information accuracy assessed as 5 for diurnal tide ratio, the water level measurements are made using surveyed and calibrated instruments, the precision of which would be high relative to the parameter being measured. Dredge operation is recorded by SA Water and is therefore also considered accurate at the daily time-step used for this assessment. Annual barrage outflows are based on accurate water level measurements upstream and downstream from the barrages, and accurate barrage operation data supplied by SA Water. However, while the barrage calculator has been calibrated to the Lower Lakes water balance, gaugings have not been carried out to verify the weir equations used for the various gate configurations.

Only two of the annual barrage outflow criteria (out of 12 shown in Table 3.1) are marked down from the top data reliability rating across the three indicators. The trend identified from this dataset is clear, so it is unlikely that systematic error could affect the result.

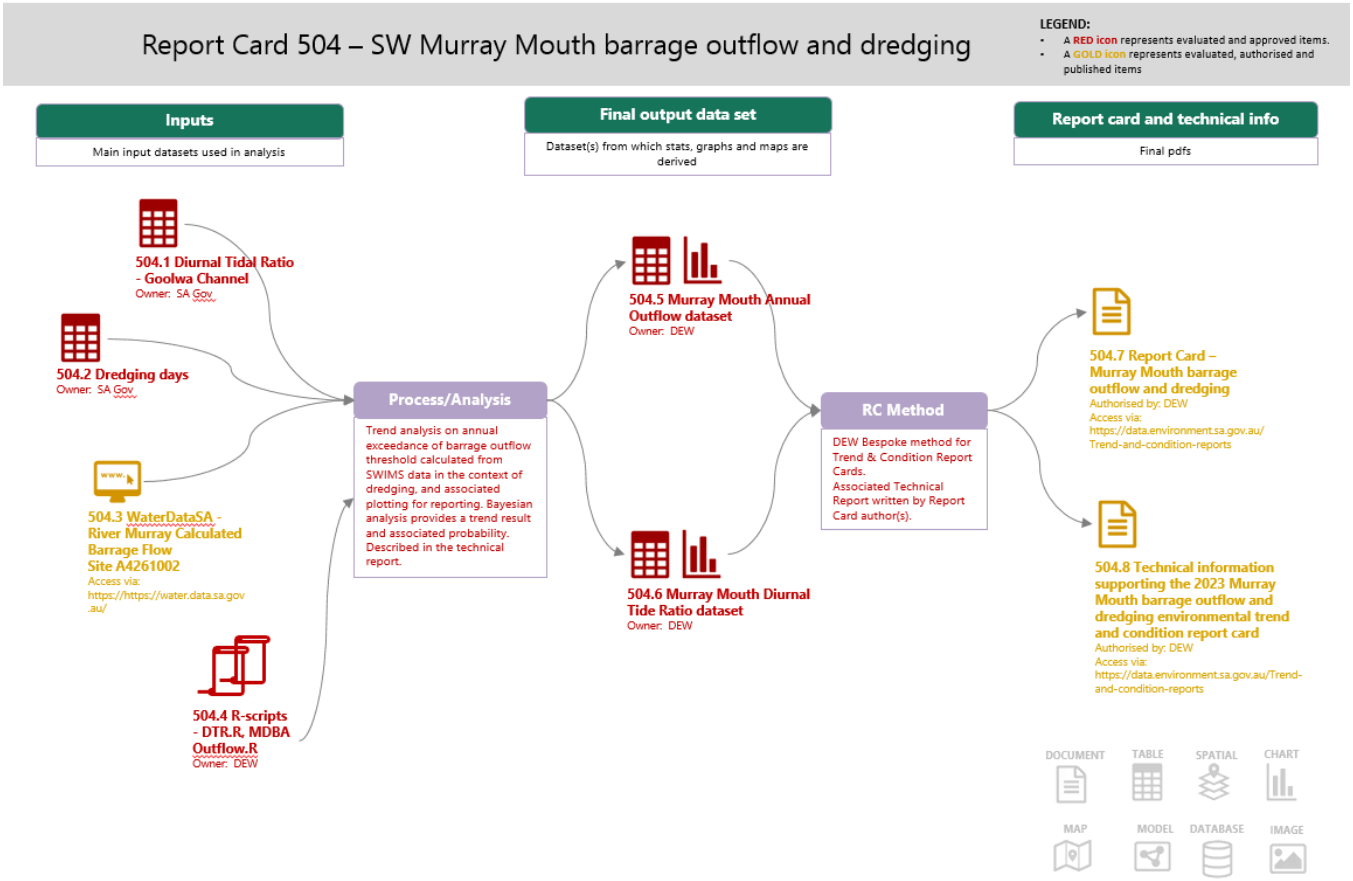
4 Discussion

Despite the barrage outflow in most recent years exceeding the 730 GL/year threshold, the DTR as an indicator of Murray Mouth openness, has been improving only with continued dredging. This suggests that the barrage outflow threshold may need to be increased toward the upper value of 1,090 GL/year (MDBA 2014) to maintain an open mouth, which is also supported by SA Water operations staff observations (G. Fyfe, pers. comms, April 2023). Additionally, the threshold could be refined through more detailed examination of DTR response to intra-annual barrage outflows and dedicated modelling.

There is a trend towards improvement in barrage outflows since implementation of the Basin Plan. However, the trend analysis is dominated by the influence of the Millennium Drought (2001–2010) in the early years of the assessment period. Although the minimum annual outflow threshold of 730 GL has been met 44% more often since 2012 following the Millennium Drought and the delivery of water for the environment through the Basin Plan, continuous dredging has been required to maintain the condition of the Murray Mouth since 2015. The condition of the Murray Mouth is considered poor while dredging is required to maintain openness.

5 Appendices

A. Managing environmental knowledge chart for Murray Mouth barrage outflow and dredging



6 References

BMT WBM (2009). Review of schemes for maintaining an open Murray Mouth, report to SA MDB NRM, BMT WBM Pty Ltd, Brisbane.

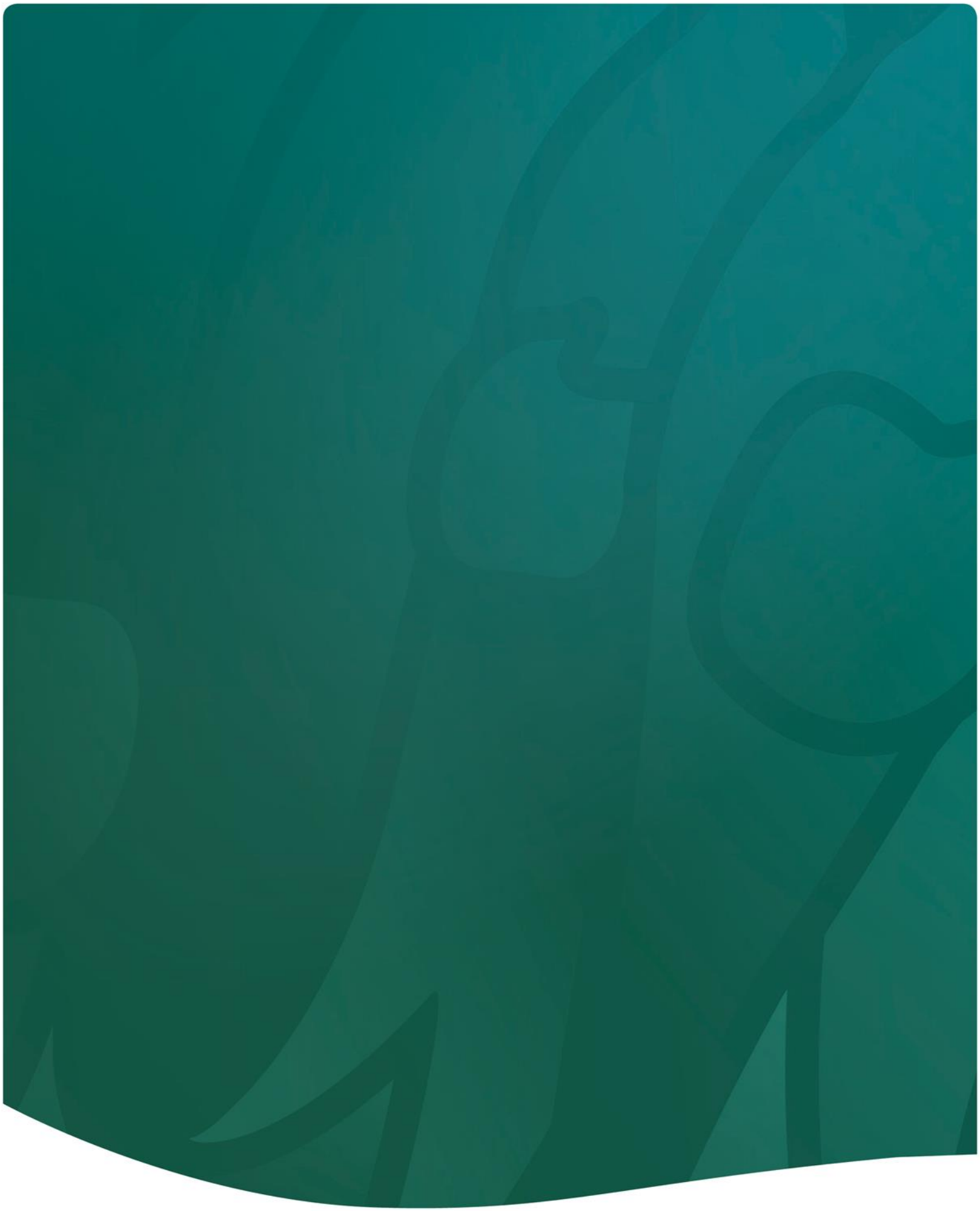
DEW (2020). South Australian River Murray Basin Plan Environmental Outcome Evaluation: Coorong, Lower Lakes and Murray Mouth (CLLMM) Priority Environmental Asset, DEW Technical report 2020/18, Government of South Australia, Department for Environment and Water, Adelaide.

DEW (2021). Methodology for calculating flow through the River Murray barrages, DEW Technical report 2021/04, Government of South Australia, Department for Environment and Water, Adelaide.

DWLBC (2008). Murray River Mouth Sand Pumping Program - Progress Report 2002 to 2008. South Australia. Department of Water, Land and Biodiversity Conservation, April 2009.

McBride G (2019). 'Has water quality improved or been maintained? A quantitative assessment procedure', *Journal of Environmental Quality*, 48, 412–420.

MDBA (2014). *Lower Lakes Coorong and Murray Mouth Environmental Water Management Plan*, Australian Government, Murray Darling Basin Authority, May 2014.



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