Technical information supporting the South Australian Basin Plan Environmental Outcome Evaluation & Reporting

South Australian Murray Region

Department for Environment and Water
October, 2024

DEW Technical report 2024/14

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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

The Department for Environment and Water (DEW) would like to acknowledge that Burra Creek and its catchment are on the traditional lands of the Ngadjuri people. We wish to acknowledge their custodianship of this land since time immemorial and pay our respects to their elders, past, present and emerging.

The Department would like to acknowledge the staff of the Department, together with staff from the Northern and Yorke, and Murraylands and Riverlands Landscape Boards, both past and present, who have contributed data, advice and information that have been critical in the development of this report.

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Summary

South Australia has assessed the achievement of environmental outcomes in the SA Murray Region Water Resource Plan Area (WRPA) based on: 1) the Long-term Watering Plan (LTWP) environmental objective of 'aquatic fauna and flora supported within permanent pools'; and 2) the environmental water requirements (EWRs) for the Northern Mount Lofty Ranges Watercourses (NMLRW) Priority Environmental Asset (PEA). For this purpose, the assessment is based on the Burra Creek catchment, with the achievement of outcomes considered in relation to the water-dependent ecosystems associated with the permanent pools in Burra Creek Gorge.

An assessment of environmental outcomes has been undertaken for each environmental water requirement (flow band) between 2008–2023. The assessment of environmental outcomes presents the trend for each indicator along with an evaluation of the changes, contribution of the Basin Plan and other influences on the achievement of these outcomes. A summary of the assessment is shown below.

Theme/Information reliability	Indicator	Trend	Key finding
Theme: Flow & Ecosystem Function	Base flows	NA Trend Not Applicable	Baseflows to permanent pools have improved, with no cease to flow events since 2019.
Information reliability*	Higher flows: Freshes	Trend Stable	Freshes were observed every year since 2009–10, but this did not meet the flow requirement (all years).
Reliability Fair	Higher flows: Bankfull	Trend Improved	Bankfull flows have improved, but requirements have not been met in 3 of the last 5 years.
	Higher flows: Overbank	Trend Improved	Overbank flow requirements have been met across the assessment period, with flows detected across 2 of the last 6 years.

* Information reliability is only scored once as it is derived from a single data source for each indicator.

The following key messages have come from South Australia's assessment and evaluation of the achievement of environmental outcomes in the SA Murray Region:

- Baseflows into the permanent pools of Burra Gorge were near perennial throughout the assessment and have been sustained since 2019, helping to maintain aquatic ecosystem condition.
- Freshes have occurred every year since 2009–10 and remain stable over the assessment period.
- Although there have been improvements in the higher bankfull and overbank flows, the frequency of these flows required to support aquatic ecosystems were not met at times, due to a lack of rainfall producing sufficient runoff events.
- The key factors that have affected the achievement of environmental outcomes for baseflows and higher flows to permanent pools in Burra Gorge are rainfall, surface water and groundwater extraction and dam development levels; however, the relative impact of these drivers is currently a knowledge gap.

1 Introduction

1.1 Basin Plan Schedule 12

The reporting requirements outlined in Schedule 12 of the Basin Plan provide the Murray–Darling Basin Authority (MDBA) with the information necessary to evaluate the effectiveness of the Basin Plan against its objectives and outcomes (s13.05).

Matter 8 (achievement of environmental outcomes at an asset scale) is a state-based reporting obligation that is central to communicating the environmental outcomes achieved through the implementation of the Basin Plan. Basin states are required to report on Matter 8 on a 5-yearly basis, with the first round of reporting being submitted in October 2020. The next round of reporting (of which this report contributes to) is to be submitted in October 2024. Technical reports for the 2025 Matter 8 Evaluation were prepared and submitted a year earlier (four years after the 2020 Evaluation) in order to support the MDBA's Basin-scale evaluation in 2025. The MDBA is required to undertake an evaluation of the Basin Plan against its objectives in 2025, which will draw on the reporting undertaken by the MDBA, and reporting submitted by the Basin states under Schedule 12.

1.2 South Australia's approach to Basin Plan Environmental Outcome Evaluation and Reporting (Matter 8)

South Australia has identified the following objectives for Matter 8 environmental outcome reporting:

- To meet Basin Plan reporting obligations (Schedule 12, Basin Plan)
- To communicate Basin Plan outcomes to key stakeholders (including the community)
- To inform South Australia's, the Australian Government's, and other States' water for the environment delivery decision making and adaptive management capacity
- To make a meaningful contribution to MDBA's evaluation of the effectiveness of the Basin Plan (at Basin-scale) and South Australia's own evaluation of the effectiveness of the Basin Plan at a state-scale.

The South Australian Department for Environment and Water (DEW) has developed an approach to report on the achievement of environmental outcomes required for the Matter 8 reporting (Imgraben 2023). This approach recognises the linkages between the Basin Plan environmental objectives, environmental watering plans and strategies (State and Basin-wide) and asset-scale environmental outcome reporting (Matter 8). Four key evaluation questions guide South Australia's evaluation of environmental outcomes at an asset scale:

1. To what extent have outcomes been achieved?
2. If outcomes were not achieved, why not?
3. To what extent did the Basin Plan contribute to achieving outcomes?
4. Have there been any unanticipated outcomes?

Reporting for Matter 8 in South Australia is required for three Water Resource Plan (WRP) areas:

- South Australian River Murray
- Eastern Mount Lofty Ranges
- South Australian Murray Region

In line with the Basin Plan, South Australia has developed a Long-term Watering Plan (LTWP) for each of these WRPAs. These plans identify PEA together with environmental objectives, targets, and EWRs. The asset scale reporting of Matter 8 is therefore directly linked to the assets identified in the LTWPs and the objectives, targets, and EWRs for those assets.

2 South Australian Murray Region Water Resource Plan Area

2.1 Context

The SA Murray Region WRPA covers most of the Murray–Darling Basin in South Australia, and extends to the state border in the east, the coast in the south, and the edge of the Mount Lofty Ranges in the west, an area of approximately 63,509 km^2 (Figure 1). It incorporates all surface water and groundwater resources in this area excluding the surface water of the South Australian River Murray and Lakes (Lakes Albert and Alexandrina).

In the Basin Plan, the SA Murray Region includes the Coorong and Murray Mouth, however, for the purposes of Basin Plan reporting, the Coorong and Murray Mouth are reported along with the Lower Lakes as part of the Coorong, Lower Lakes and Murray Mouth PEA. This is because the SA River Murray LTWP includes objectives, targets and EWRs for this region in recognition of the intrinsic connection between the River Murray and Coorong.

The Basin Plan defines PEAs and priority ecosystem functions as environmental assets and ecosystem functions that can be managed with environmental water (s8.49 and s8.50). Environmental water consists of both 'held' and 'planned' environmental water. Held environmental water (HEW) is water available under a water access right or held on a water licence for the purpose of achieving environmental outcomes. There is no HEW in the SA Murray Region WRPA. Planned environmental water (PEW) is water that is committed or preserved for achieving environmental outcomes through a plan or legislation and cannot be used for any other purpose. The SA Murray Region WRP identifies the rules that provide protection to the PEAs and ecosystem functions together with rules for the protection of PEW.

The Basin-wide Environmental Watering Strategy identifies the Noora Evaporation Basin as an environmental asset for the purpose of supporting an abundance and diversity of waterbirds (MDBA 2020). Noora Evaporation Basin is kept artificially wet through the disposal of highly saline water from salt interception and drainage schemes along the River Murray. The drainage water delivered to the Noora Evaporation Basin is not PEW and as such the Noora Evaporation Basin is not considered a PEA in the LTWP.

In the Northern Mount Lofty Ranges in the north and northwest of the SA Murray Region WRPA, watercourses are characterised by occasional surface flows and the persistence of refuge pools. The largest and most well-known of these are Burra Creek, Olary Creek, Wiawera Creek, Yunta Creek and Manunda Creek. A single PEA, the Northern Mount Lofty Ranges Watercourses (NMLRW), has been identified in the SA Murray Region LTWP (DEW 2020).

The ecological objective for this asset is to provide critical refuge habitats for aquatic biota in the form of permanent pools and this is managed using PEW. The rules that provide protection to the asset are established through section 104(2) of the *Landscape South Australia Act 2019* (Landscape SA Act), stating that a person must not take water from a watercourse, lake or well that is not prescribed or take surface water from land that is not in a surface water prescribed area in contravention of a Water Affecting Activities (WAA) policy. Two WAA policies apply in the NMLRW.

2.2 Murraylands and Riverland Landscape Board Water Affecting Activities policy

Applicable general principles within the Murraylands and Riverland WAA Policy (Murraylands and Riverland Landscape Board, 2021) include the maintenance of natural hydrological and hydrogeological systems and EWRs (3.2.2; 1d) and preservation of water-dependent ecosystems (3.2.2; 1e).

In addition to the general principles, specific principles for the constructing, backfilling or repairing of wells state the activity should not adversely affect water-dependent ecosystems (3.3.2; 13).

Water collection or diversion mechanisms for surface water are to be sited, constructed and operated in a manner which protects the rights of downstream users (including the environment) to access those water resources (3.3.4; Ka). Catching dams that directly catch runoff and inhibit all flow until the dam is filled are generally not to be constructed or enlarged in or across watercourses with a stream order of three or higher (3.3.4; 29). To minimise the impact of water collection on runoff, sub-catchment and property runoff limits of 30% of May to November runoff apply (3.3.4; 33-35). To minimise the impact of water collection on the flow regime, new structures must include devices to ensure that any water present at, or below the threshold flow rate will not be collected or diverted (3.3.4; 41-42) (Murraylands and Riverland Landscape Board, 2021).

2.3 Northern and Yorke Landscape Board Water Affecting Activities policy

Applicable general principles include that a WAA must be undertaken so that, in both the short-term and long-term, it ensures a maintenance of natural hydrological and hydrogeological systems, and EWRs and the preservation of water-dependent ecosystems (2.3.1; 1). A WAA must not:

- be located in ecologically sensitive areas where the activity will, or is likely to have a significant detrimental impact
- have adverse impacts on water resources, other natural resources, or communities at both local and regional levels
- have adverse impacts on biodiversity and habitat preservation, water-dependent ecosystems, EWRs and migration of aquatic biota (2.3.1; 2)

The specific principles in the Northern and Yorke Landscape Board WAA policy mirror those in the Murraylands and Riverland Landscape Board WAA policy (section 2.2). In addition to the general principles, specific principles for the constructing, backfilling or repairing of wells in the SA Murray Region state the activity should not adversely affect water-dependent ecosystems (2.3.3; 13).

Water diversion and collection mechanisms for surface water are to be sited, constructed and operated in a manner which protects the rights of downstream users (including the environment) to access those water resources. Catching dams must not be constructed or enlarged in or across watercourses with a stream order of three or higher, expect in zone NY3 (relevant for Burra Creek; where this may be permitted in exceptional circumstances) (2.3.5; 29). To minimise the impact of water collection on runoff, sub-catchment and property runoff limits of 30% of May to November runoff apply (2.3.5; 33-35). To minimise the impact of water collection on the flow regime, new structures must include devices to ensure that any water present at, or below the threshold flow rate will not be collected or diverted (2.3.5; 41-42) (Northern and Yorke Landscape Board, 2020).

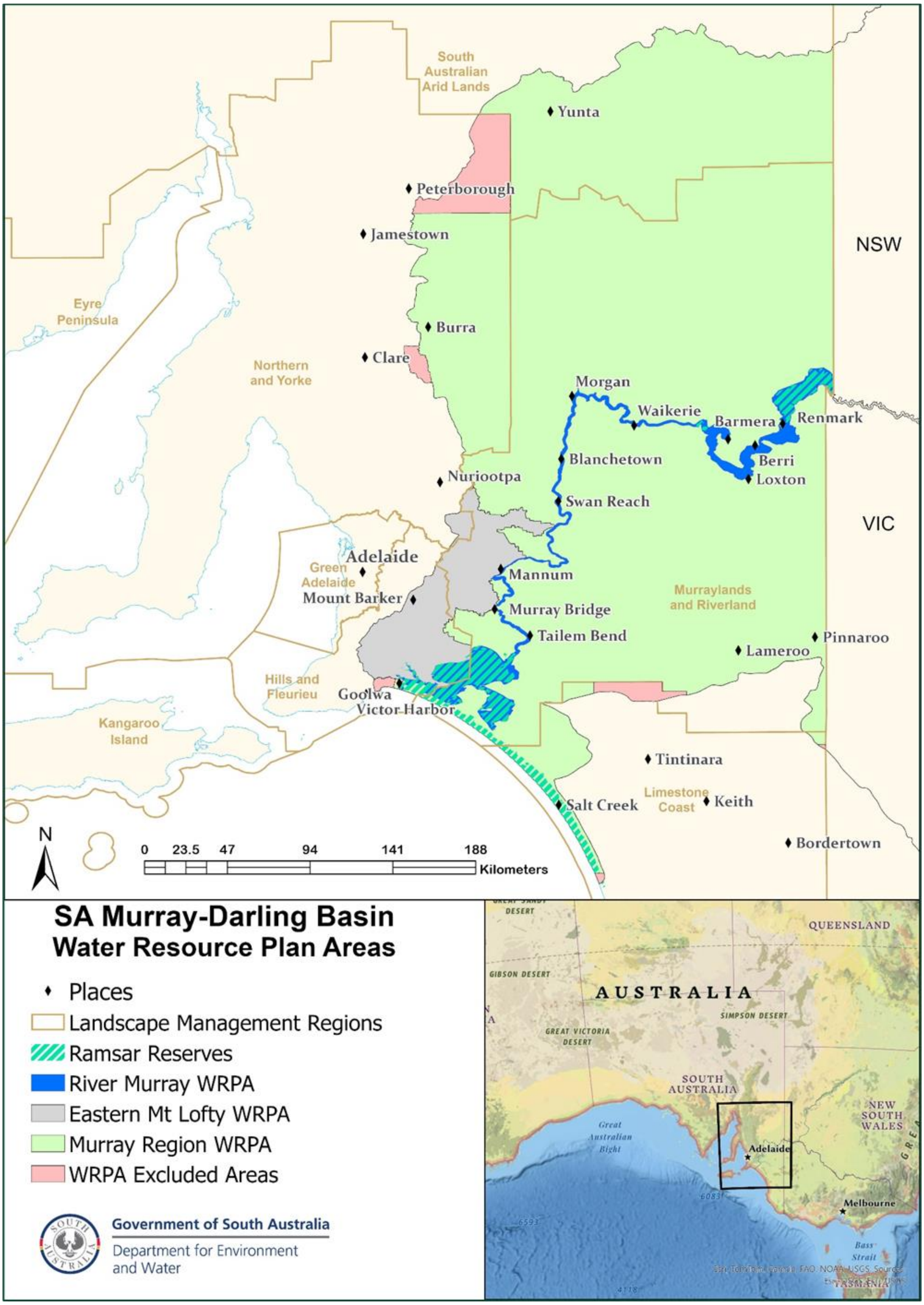

Figure 1. Extent of the South Australian Murray Region Water Resource Plan Area.

2.4 Burra Creek Catchment

The NMLRW are represented in this assessment of the Burra Creek Catchment. Burra Creek has the regionally most important permanent refuge pools and is the only catchment where surface water monitoring is undertaken in the SA Murray Region WRPA.

Surface water runoff generated within the catchment is extremely unreliable and highly influenced by extreme events. In effect there is no such thing as a ‘typical’ year as far as streamflow generated from surface runoff is concerned. In contrast, groundwater discharges (baseflow) to Burra Creek are extremely reliable and provide the constant flow maintaining the perennial reaches of the central catchment.

The Burra Creek Catchment is mostly represented by cleared and grazed land in the northwest section of the SA Murray Region WRPA (Figure 2). The headwaters of the catchment originate to the north of Mt Bryan before flowing east to Burra Creek. Approximately 10 km south of Burra township is a short reach (~17 km) of baseflow creek, containing numerous permanent refuge pools (scoured sections of stream channel), in the vicinity of Burra Gorge and Worlds End Gorge. These permanent refuge pools are sustained by the groundwater from the Skillogalee fractured rock dolomite aquifer and provide refugia and habitats for aquatic plants, macroinvertebrates, frogs and waterbirds (Deane et al. 2008). Recharge of the Skillogalee fractured rock dolomite aquifer occurs primarily in the head waters of the catchment by direct rainfall recharge or via the watercourses.

Groundwater salinities mean the pools are moderately saline, i.e., 2,000–3,000 mg L^{-1} (3,000–5,000 EC), which strongly influences the ecology by limiting the range of species that can persist (Deane et al. 2008). The riparian vegetation of Burra Creek is characterised by river red gum (*Eucalyptus camaldulensis*), native and introduced grasses and includes a number of vulnerable and/or threatened plant species (Deane et al. 2008).

Development of water resources, both groundwater and surface water, directly impacts the water availability, both in the watercourses in the upper parts of the catchment and via the volume of discharge from the aquifer to the gorge. The surrounding terrain is quite steep with hill sides covered by sparse low vegetation. These factors limit the agricultural potential of the area and allow higher recharge to groundwater from rainfall than would be experienced if the region was more heavily vegetated.

The low rainfall and paucity of freshwater in the landscape means that landholders seeking freshwater need to access water through dam construction and drilling of wells into the underlying aquifers. This is controlled through the Murraylands and Riverland Landscape Board’s and the Northern and Yorke Landscape Board’s WAA Policies (section 2.2 and 2.3).

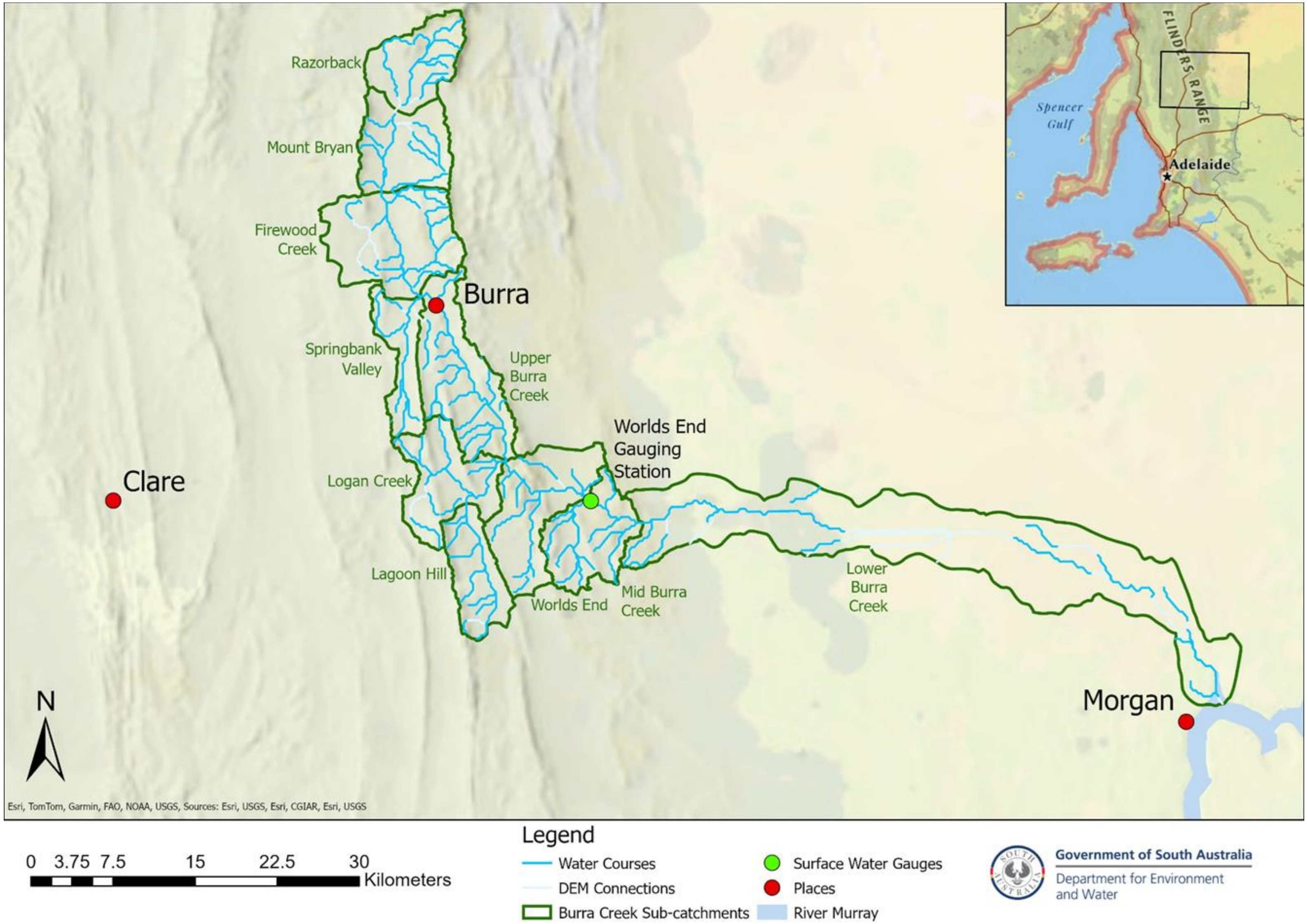

Figure 2. Location of the Burra Catchment, sub-catchments and watercourses (many of which are temporary) with respect to the Burra Township, Worlds End gauging station and the River Murray. DEM connections imply reaches that could be connected with stream flow, but rarely experience flows; flows typically disappear underground after Worlds End.

3 Objectives, environmental water requirements and environmental outcomes

The ecological objective for the NMLRW identified in the Long-term Watering Plan for the SA Murray Region Water Resource Plan Area is '*aquatic fauna and flora supported within permanent pools*' (DEW 2020) and the EWRs to support the PEA in a *healthy, functioning* state and at a low level of risk are outlined in Table 1.

A flow regime thought to support ecological processes in the Burra Creek Catchment was identified by Deane et al. (2008) and included flow bands and their associated return intervals (see Table 7 from the LTWP, DEW 2020). These flow bands have been adopted as EWRs in the LTWP as they describe the flow regime expected to maintain the current ecosystems in their current condition (Table 1).

In this report, the environmental outcome assessment focuses on the extent to which the flow bands reflective of the EWRs for Burra Creek Catchment have been met (Table 2).

Table 1. Environmental water requirements for the Northern Mt Lofty Ranges Watercourses from the LTWP for the SA Murray Region WRPA, adapted from previous work adapted from Deane et al. (2008).

Priority Environmental Asset	Ecological Objective	Environmental Water Requirement	Flow band
Northern Mount Lofty Ranges Watercourses	Aquatic fauna and flora supported within permanent pools	Maintenance of the existing baseflow to permanent pools.	• Permanent flow greater than 0.05 ML day^{-1}
		Maintenance of occasional overbank and higher flows to scour and maintain pool depths and assist in maintaining salinity levels.	• Freshes 1–3 times per year (flow greater than 3 ML day^{-1}) • Bankfull flows every 1–2 years (flow greater than 33 ML day^{-1}) • Overbank flows every 4–6 years (flow greater than 220 ML day^{-1})

4 Methods

The South Australian approach to the assessment and evaluation of environmental outcomes is based around the key evaluation questions and Table 2 provides a summary of the evaluation approach for the SA Murray Region, which includes:

- environmental outcome assessment
- trend assessment
- structured expert elicitation process

South Australia's key evaluation questions have been developed to directly align with the reporting guidelines for Matter 8 evaluation and reporting, the MDBA's Basin-scale evaluation questions and to ensure compatibility with the 2020 South Australian Matter 8 evaluation and consistency between rounds of South Australia's five-yearly reporting.

Table 2. Key evaluation questions used for this assessment of the evaluation of environmental outcomes for the SA Murray Region WRPA.

SA key evaluation questions	Evaluation method
To what extent have environmental objectives been achieved at the asset scale?	EWRs were quantitatively assessed and reported for each indicator at the asset scale. The data cut-off point for this assessment for all indicators was 30 June 2023. Trend and change will be assessed where possible: • All available data will be presented to provide a baseline for assessing and reporting trend. • Change since the 2020 evaluation will be assessed using data collected between July 2019 and June 2023.
If outcomes were not achieved, why not?	Qualitative evaluation of achievement of outcomes were undertaken using: • Contextual datasets and supplementary information • Expert judgement through a structured elicitation process • Assessment of documented assumptions, limitations and contributing factors for expected outcomes • Outcomes found in the 2020 Matter 8 report.
To what extent did the Basin Plan contribute to achieving outcomes?	As there is no water for the environment provided via an active mechanism (i.e. water for the environment is provided via a passive process), this question is not considered relevant for the Matter 8 evaluation and reporting for the SA Murray region.
Have there been any unanticipated outcomes?	Qualitative evaluation of potential unanticipated outcomes at the asset scale was undertaken using a structured expert elicitation process. There is no ecological data to support this process.

4.1 Environmental outcome assessments

The environmental outcome assessments focused on two indicators: baseflow to the permanent pools and higher and overbank flows (method for each is described in further detail below). Flow rates and the frequency of higher flows are critical to maintenance of the ecology of the Burra Creek and have been used as a surrogate for frequent, up-to-date ecological monitoring. It is acknowledged that the flow in these pools is via both surface water flows and groundwater discharge.

A summary of the indicators, measures and data sources used in the environmental outcome assessments are shown in Table 3 below.

Table 3. Indicators, measures and data sources identified to assess the achievement of environmental outcomes for the watercourses in the Northern Mount Lofty Ranges PEA.

Indicator	Measure	Data source	Data collector	Data owner
Baseflow to permanent pools	Daily flows	DEW station A4260536 Burra Creek at Worlds End, Water Data SA	DEW	DEW
Higher flows and overbank flow	Daily flows	DEW station A4260536 Burra Creek at Worlds End, Water Data SA	DEW	DEW
Additional contextual data				
Rainfall	Annual rainfall	BOM Station ID: 21077	BOM	BOM
Groundwater level	Depth to groundwater	DEW Monitoring Bore 6630-1456 (CLR051), Water Data SA	DEW	DEW
Groundwater development	Drilling activity	SA Geodata	DEW	DEW/DEM

4.1.1 Baseflows

The assessment of baseflow was undertaken on the premise that any surface water flow recorded at the Worlds End gauge represented a baseflow at the permanent pools in Burra Gorge. Therefore, days of zero flow were indicative of not achieving baseflow to the pools.

Baseflow was defined as flow greater than 0.05 ML day^{-1}, which is the lower sensitivity threshold of the gauging station instrumentation and assessed by examining the number of cease to flow days recorded at the Worlds End gauge station. This location's baseflow is generated by groundwater discharge across the break of slope of Burra Gorge combined with surface water flows from the upper catchment. It was assumed that the presence of baseflow at the Worlds End gauge would also mean the presence of baseflow at the permanent pool sites as the pools are between the main baseflow discharge section and the gauge location.

4.1.2 Overbank and higher flows

The assessment of overbank and higher flows was assessed by determining the number of days per water year (1 July – 30 June) where flow exceeded the lower threshold for each of the identified flow bands. The flow bands and the associated frequency thresholds are shown in Table 4.

Table 4. Descriptions of the overbank and higher flow bands and the flow frequency used in the assessment of environmental outcomes for Burra Creek.

Flow band	Discharge range (ML day^{-1})	Flow threshold used (ML day^{-1})	Flow band frequency (LTWP)	Flow band frequency
Freshes	3–33	3	1–3 pulses per year	once per year
Bankfull	33–220	33	every 1–2 years	At least every two years
Overbank	220–1500	220	Every 4–6 years	At least every six years

4.2 Hydrological data sources

The Worlds End gauging station is located ~6km downstream in Burra Gorge (Figure 2). The gauging station monitors daily surface water coming out of the gorge before the creek starts to lose water into the unconsolidated sediments of the Murray floodplain. The gauging station has been collecting data since 1974 (A4260536) but was upgraded in 2007 (A4261148, data available here, Water Data, DEW 2023c). While both of the gauges are in the same location, the construction of the controlling section of the new gauge is very different. This difference means that the data sets are not able to be linked. Therefore, the assessment of baseflows and higher flows were undertaken based on data from the updated gauge (A4261148) data alone, however, surface water flow data from the old gauge is also provided to give reference to long-term changes.

4.3 Trend assessment

4.3.1 Approach

A Bayesian modelling approach was used to assess trend in the time series flow data. This modelling approach was used as it provides more information surrounding the results and allowed for a more detailed assessment of trend based on variability inherent in the data. Bayesian models provide an estimate of the likelihood of the trend in the time series data assessed. Bayesian trend analysis was undertaken in R Studio (version 2022.02.2 Build 485, running R version 4.2.0, R Core Team, 2022) using Bayesian generalised linear models (using the stan-glm function in the rstanarm package, Goodrich et al. (2020), 4,000 iterations). Slope (trend) was estimated from the posterior distribution resulting from the Bayesian analysis. Trend direction was assessed using calculated probability and presented as degrees of certainty around the trend direction (Table 5), modified from Mastrandrea et al. 2010).

Table 5. Alignment of trend outcomes bases on the likelihood of an increase or decrease (modified from Mastrandrea et al. 2010) with the icons used for the evaluation.

Outcome	% positive slope results	% negative slope results	Icon
Virtually certain increase	99–100	0–1	Improved
Extremely likely increase	95–99	1–5	
Very likely increase	90–95	5–10	
Likely increase	66–90	10–33	
About as likely as not	33–66	33–66	Stable
Likely decrease	10–33	66–90	Declined
Very likely decrease	5–10	90–95	
Extremely likely decrease	1–5	95–99	
Virtually certain decrease	0–1	99–100	

This trend is summarised as the following:

- Improved: The indicator has improved over the period of assessment
- Stable: The indicator has neither improved nor declined over the period of assessment
- Declined: The indicator has declined over the period of assessment
- Unknown: Data were not sufficient to determine any tend in the status of this indicator

4.3.2 Baseflow and higher flow trend assessments

Trend assessment was considered for the two indicators outlined in Table 3. As there is a distinct lack of days where flow was under the baseflow threshold (≤0.05 ML day^{-1}), and an almost permanent baseflow for the majority of the assessment period (apart from three water years), no trend was performed for baseflow.

To assess the "higher flows and overbank flow" indicator, a trend analysis on the count of days per water year with each of the three flow bands (freshes, bankfull, and overbank flows; see Table 4) over the assessment period (July 2008 to June 2023) was performed. The trend used water year as the time step variable, assuming a negative binomial distribution. The (three) model specification(s) were:

Days with freshes flow ~ water year

Days with bankfull flow ~ water year

Days with overbank flow ~ water year

4.4 Information reliability

The reliability of data used to assess the achievement of environmental outcomes was assessed for each environmental indicator using a method modified from Battisti et al. (2014). This method scores answers to questions relating to the method used for data collection, representativeness and repetition. A scoring system as shown in Table 6 was used to determine a final score for information reliability that ranges between 0 and 12. Final scores are then converted into an information reliability rating that ranges between poor and excellent using the matrix in Table 7.

Table 6. **Scoring system for the reliability of data used to assess and analyse environmental outcomes and trend.**

Methods	Question	Scoring system		
		Yes	Partially	No
Methods used	Are the methods used appropriate to gather the information required for evaluation?	2	1	0
Standard methods	Has the same method been used over the sampling program?	2	1	0
Representativeness				
Space	Has sampling been conducted across the spatial extent of the PEA with equal effort?	2	1	0
Time	Has the duration of sampling been sufficient to represent change over the assessment period?	2	1	0
Repetition				
Space	Has sampling been conducted at the same sites over the assessment period?	2	1	0
Time	Has the frequency of sampling been sufficient to represent change over the assessment period?	2	1	0

Table 7. **Conversion of the final score (0–12) of information reliability to an information reliability rating that ranges from poor to excellent.**

Final score	Information reliability
12	Excellent
11	Very good
10	Good
9	Fair
≤8	Poor

4.5 Limitations and assumptions

4.5.1 Assessment of flow bands

An overarching limitation of the achievement of long-term environmental outcomes is the focus on surface water flow. It is well established that surface water flow in seasonally intermittent watercourses is the primary driver influencing ecosystem condition (Datry et al. 2014), but it is not the only driver of condition. Land-use, introduced predators, stock access and water quality among others are also important in determining ecosystem condition and may limit the ecosystem response to improved flow conditions and prevent the achievement of ecological objectives and targets in the longer term.

There is no regular ecological monitoring of Burra Creek. The last major assessment of the ecological condition of Burra Creek was undertaken in 2008. This assessment included identification of biotic groups present and their water requirements (Deane et al. 2008). Since this assessment, the only ecological assessment of Burra Creek was an aquatic ecosystem condition assessment undertaken by the EPA in 2010 (available here, EPA 2023; Goonan et al. 2018). This lack of ecological data means that there is no empirical method to assess or verify the EWRs developed for Burra Creek or the flow bands being assessed as part of this report. As a result, the assessment for this reporting of environmental outcomes is based on daily flow data alone. There is a significant body of literature that links flow in intermittent rivers such as Burra Creek with ecological condition (see Deane et al. 2016). In the case of Burra Creek, the achievement of the flow bands is suggested to be sufficient to achieve the ecological objective.

There is a lack of longer-term flow data that can be used for the assessment of the flow regime. While flow monitoring has been undertaken in Burra Creek since 1974, the physical structure of the monitoring location made the assessment of flow data difficult, especially at lower flows. The updated gauge began operating in 2008 and was a more accurate design, more capable of detecting low flows. There is little alignment between the two-gauge datasets and therefore direct comparison is inappropriate and the assessment is be based on data from the new gauge. While this does limit the timeframe of consistent data available, it is preferential to introducing unknowns into the assessment process by assessing the whole dataset.

4.5.2 Groundwater

Groundwater levels and volumes contributing to surface water flow in Burra Creek have not been assessed within this report. In systems such as Burra Creek where permanent pools and baseflow are maintained by groundwater discharge, the water levels (and by extension flow) serve as an indicator of the levels within the local connected aquifer. No attempt has been made in this report to decouple groundwater and surface water inputs to the achievement of the flow bands. However, as a general assumption, it is likely that the majority of baseflow over summer and early autumn would be groundwater dependent and higher flow bands would be surface water dependent.

4.5.3 Water extraction

At present there is no accounting of the volumes of extraction from the permanent pools for stock and domestic use. Therefore, the extent to which water extraction has impacted on the hydrology of Burra Creek is a knowledge gap.

4.5.4 Sub-catchment dam development levels

Sub-catchment dam development limits have been in place in the NMLR since 2009, prior to the commencement of the Basin Plan. These limits were set as a maximum dam development of 30% of average runoff across the sub-catchment areas during the May–November period. It is assumed that there would be an unacceptable risk to the environment if this limit was to be exceeded (DEWNR 2018).

Dam development levels were last assessed in 2008 based on the analysis of aerial imagery. All water resource development is assumed to be captured by the Murraylands and Riverland and Northern and Yorke Landscape Board's WAA Policies. Construction of dams of greater than 5 ML volume, or a dam wall height of greater than 3 metres requires development approval under the *Planning, Development and Infrastructure Act 2016*. Dams of a lesser volume and dam wall height do not require development approval, but require a WAA permit under Section 104 of the Landscape SA Act. Dam development levels determined by Deane et al. 2008 are currently the most accurate and reliable estimate available.

South Australia's Matter 19 report identified and outlined the current investigations from the Limestone Coast Landscape Board for updating aerial imagery of property dams in that region (DEW 2023a). This will be then used to assess any changes since 2019 in the surface water development levels relative to limits in their WAA policy. The Hills and Fleurieu Landscape Board is undertaking a number of initiatives to improve understanding of non-compliance in the region. This is recommended for the Burra Creek and Worlds End Gorge region.

5 Results

5.1 Environmental outcome assessment: Baseflows to permanent pools

Baseflows to permanent pools in Burra Creek improved across the assessment period (2008-09 to 2022-23) except for three major cease to flow events. The first recorded cease to flow event occurred in 2008–09 and lasted for a total of 23 days. In 2017–18 and 2018–19, there were further cease to flow events, which totaled 72 days (Figure 3). Therefore, since 2008–09, there have been significant cease to flow events, meaning that the environmental outcome, when considering continuous baseflow to permanent pools, has not been met overall. However, since the last assessment in 2019, there have been no cease to flow events recorded and therefore, baseflow has improved.

The former gauge that was in operation from 1974–2007 recorded no cease to flow events. As the former gauge (A4260536) was less accurate than the current gauge (A4261148) in measuring low flows, it is difficult to determine whether the frequency of cease to flow events has changed over the long-term (Figure 4). It is also noted that the cease to flow events in 2018 followed the highest flows recorded by this gauge and could therefore have also been caused by hydrological changes (blockages or sediment accumulation) or equipment/measurement issues.

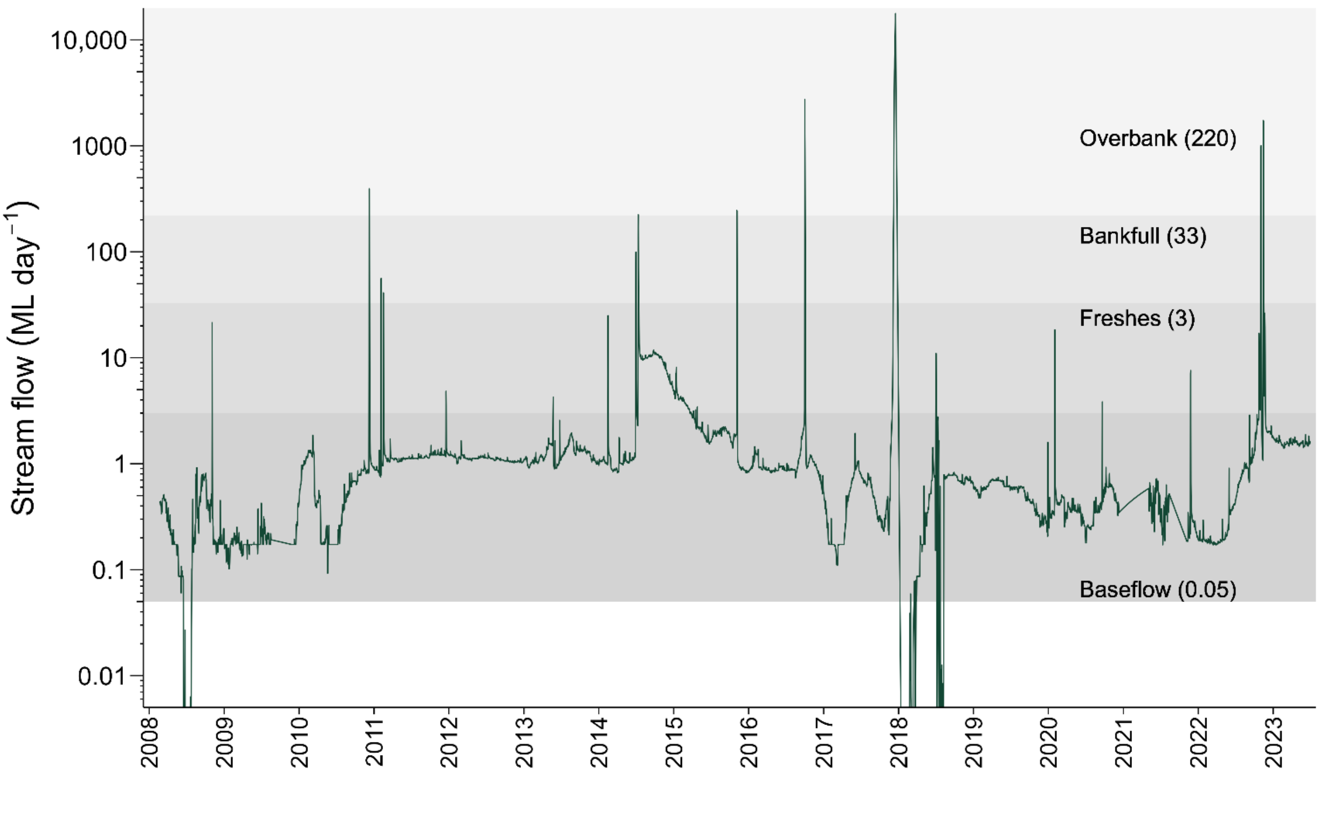

Figure 3. Daily flow from the updated Worlds End Gauge station (A4261148), transformed with logarithm10 for improved visualisation. The y-axis is truncated at 10,000 ML day^{-1}, removing three consecutive days in December 2017 of very high flow (10,619, 13,118 and 17,713 ML day^{-1}), as well as when stream flow is zero due to the logarithm transformation.

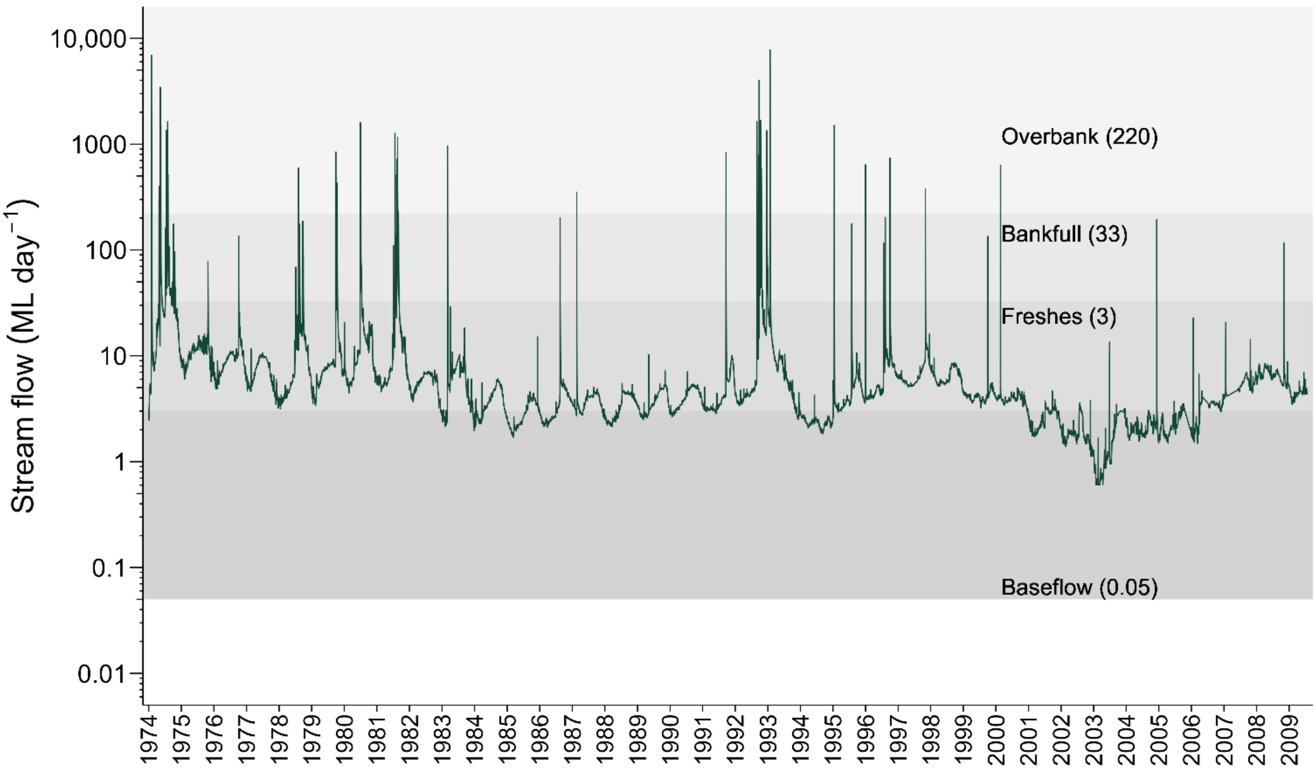

Figure 4. Daily flow from the previous Worlds End Gauge station (A4260536), transformed with logarithm10 for improved visualisation.

5.2 Environmental outcome assessment: Maintenance of occasional overbank and higher flows

The assessment of the higher flow bands since 2008–09 shows that only the overbank flow band has been consistently achieved since installation of the updated gauge (Table 8). The freshes flow band was not reached 1 year out of the 15 assessed (2009–10) while the bankfull flow band was not met four years across the 15-year period. There is no year that fails across all of the higher flow bands, noting that 2009–10 was not assessed for bankfull or overbank flow band as the return intervals prevents this.

Table 8. Number of days per water year of higher flow bands since 2008–09.

Year	Freshes flows (1–3 per year)		Bankfull flows (every 1–2 years)		Overbank flows (every 4–6 years)	
	Days	Flow requirement achieved	Days	Flow requirement achieved	Days	Flow requirement achieved
2008–09	1	Yes	0	NA*	0	NA*
2009–10	0	No	0	No	0	NA*
2010–11	8	Yes	4	Yes	1	Yes
2011–12	2	Yes	0	Yes	0	Yes
2012–13	1	Yes	0	No	0	Yes
2013–14	3	Yes	1	Yes	0	Yes
2014–15	264	Yes	7	Yes	1	Yes
2015–16	3	Yes	2	Yes	1	Yes
2016–17	6	Yes	3	Yes	2	Yes
2017–18	17	Yes	12	Yes	10	Yes
2018–19	2	Yes	0	Yes	0	Yes
2019–20	1	Yes	0	No	0	Yes
2020–21	1	Yes	0	No	0	Yes
2021–22	2	Yes	0	No	0	Yes
2022–23	26	Yes	8	Yes	3	Yes

* NA reflects that the window for achievement of this flow band extends beyond the availability of data and therefore was not assessed.

5.3 Trend: Maintenance of occasional overbank and higher flows

Both bankfull and overbank showed a likely increase in the number of flowing days with 81.23% and 88.9% of model runs showing a positive slope, respectively, while freshes was shown to be stable with 48.62% of model runs showing a positive slope (Table 9; Figure 5; Figure 6; Figure 7).

Table 9. Results from the trend assessment of the higher flow bands for Burra Creek from 2008–09 to 2022–23.

Metric	Positive slopes (%)	Negative slopes (%)	Median slope	90% confidence interval	Trend
Freshes	48.62	51.38	-0.005	-0.297 to 0.351	Stable
Bankfull	81.23	18.8	0.112	-0.152 to 0.419	Improved
Overbank	88.9	11.1	0.191	-0.137 to 0.591	Improved

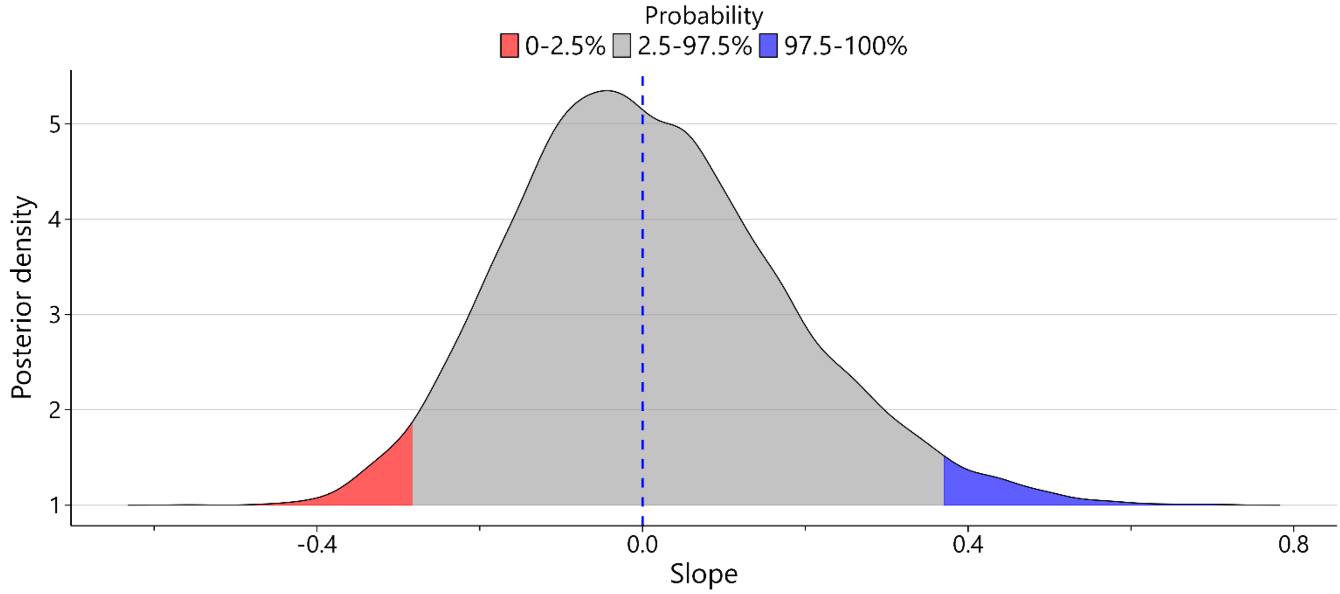

Figure 5. Estimated values for the slopes generated from Bayesian modelling of the number per year of fresh flow days (>3 ML day^{-1}) from 2008-09 to 2022-23. Posterior slope values >0 infer a positive trend (improved) and values <0 infer a negative trend (declined).

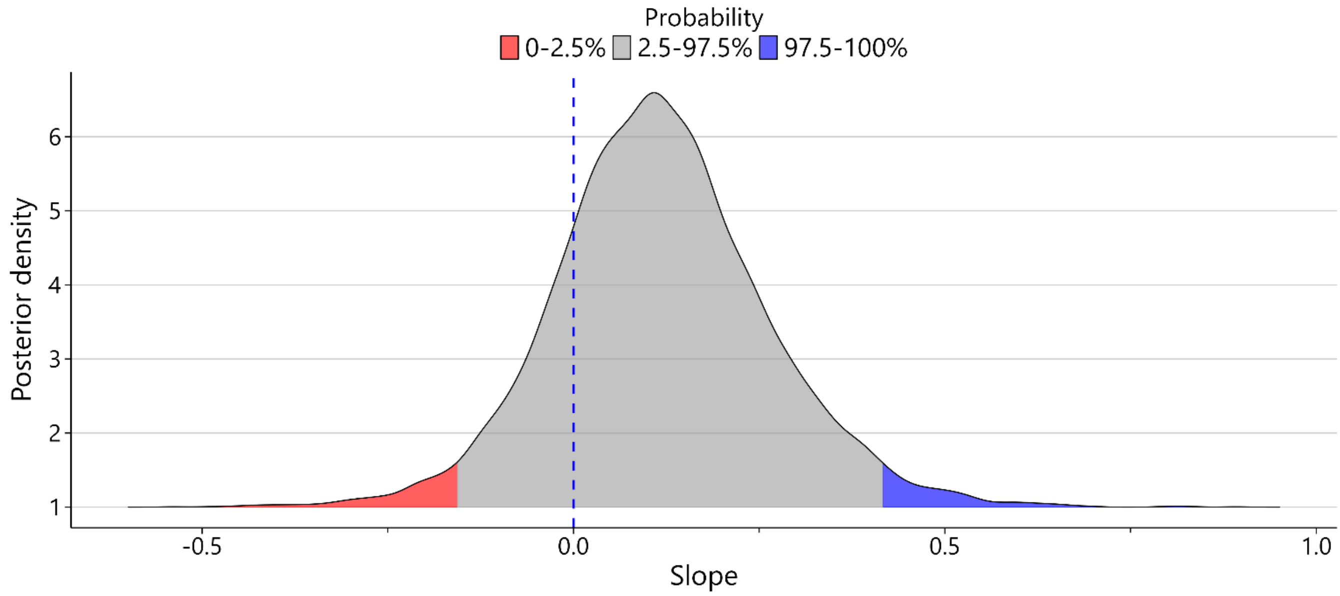

Figure 6. Estimated values for the slopes generated from Bayesian modelling of the number per year of bankfull flow days (>33 ML day^{-1}) from 2008-09 to 2022-23. Posterior slope values >0 infer a positive trend (improved) and values <0 infer a negative trend (declined).

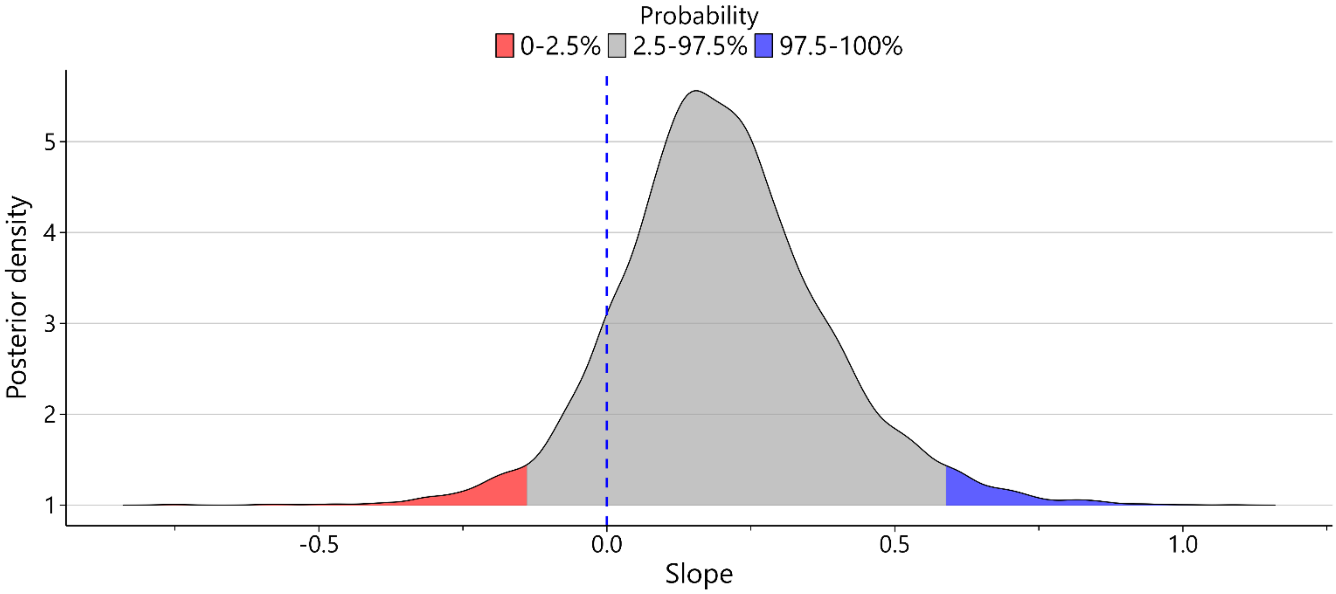

Figure 7. Estimated values for the slopes generated from Bayesian modelling of the number per year of overbank flow days (>220 ML day^{-1}) from 2008-09 to 2022-23. Posterior slope values >0 infer a positive trend (improved) and values <0 infer a negative trend (declined).

5.4 Information reliability

The information reliability for the assessments of flow outcomes was **fair** (final score of 9). As each assessment of flow was based on data from a single flow monitoring station at Worlds End (A4261148), a single assessment of information reliability was conducted. Justification for the scoring of flow data is provided in Table 10.

Table 10. Information reliability assessment for assessment of environmental outcomes for the Murray Region.

Methods	Question	Answer and justification	Score
Methods used	Are the methods used appropriate to gather the information required for evaluation?	**Partially**. Flow monitoring data collected nearby to permanent pools and is subjected to strict QA/QC. However, in lieu of ecological monitoring data, flow has been used as a proxy and does not provide a direct indication of ecological condition.	**1**
Standard methods	Has the same method been used over the sampling program?	**Yes**. Single flow monitoring station provided data for the whole assessment period.	**2**
Representativeness			
Space	Has sampling been conducted across the spatial extent of the SA Murray Region with equal effort?	**No**. Only a single flow monitoring gauge was used for the assessment. While this gauge is close to the permanent pools, it is only a single point within the catchment.	**0**
Time	Has the duration of sampling been sufficient to represent change over the assessment period?	**Yes.** Flow monitoring has occurred at a single site from 2008–2023, and therefore, has covered a range of climate phases and hydrological conditions.	**2**
Repetition			
Space	Has sampling been conducted at the same sites over the assessment period?	**Yes**. The same flow gauge has been sampled for the entire assessment period.	**2**
Time	Has the frequency of sampling been sufficient to represent change over the assessment period?	**Yes**. Telemetered data was collected continuously from the flow gauge.	**2**
Final score			**9**
Information reliability			**Fair**

6 Evaluation

Bankfull and overbank flows to permanent pools in Burra Gorge have improved over the assessment period (2008–09 to 2022–23). However, it is recognised that the start of the assessment period coincided with the Millennium Drought (1996–2010), where prolonged dry conditions occurred in the region and across the southern Basin more broadly, which significantly reduced flow in those catchments. Despite this, the environmental outcomes for continuous baseflow and higher flows were not consistently achieved across the assessment period (2008–09 to 2022–23).

Since adoption of the Basin Plan, baseflows in Burra Creek ceased for 91 days over two events in 2018. The duration of these cease to flow events likely had an impact on the instream fauna with rheophilic (flow sensitive) species negatively impacted (Datry et al. 2014). However, the permanent pools would have persisted through the cease to flow period continuing to provide habitat for all obligate aquatic flora and fauna (organisms that need to remain in water at all times). There is an inherent assumption in this assessment that the baseflow, defined as flow greater than 0.05 ML day^{-1}, is sufficient to maintain ecological processes within the permanent pools. The key ecological function of the baseflow to the pools is to maintain the water quality within the pools as opposed to any form of geomorphological or hydrological function. By maintaining water quality, it is assumed that ecological condition will be maintained.

Impacts of inadequate return intervals of high flows were observed to have impacted permanent pools of Burra Creek in 2010 when the EPA conducted its aquatic ecosystem condition assessment. During the assessment undertaken by the EPA, it was found that there were moderate to high amounts of nitrogen and phosphorus and that sediment samples were black, sulfidic and anaerobic, indicating that too much organic matter had entered and not been flushed from the creek in the past (EPA 2023). The EPA assessment also noted that the decreased frequency of high flows has also provided conditions favourable for increased establishment of *Typha domingensis* and *Phragmites australis*. These reed species prefer stable water levels and can outcompete other native flora species in the littoral zones of freshwater ecosystems, decreasing habitat complexity and diversity (Maxwell et al. 2015).

The key factors that can impact the environmental outcomes for baseflows and higher flows to permanent pools in Burra Gorge are rainfall (see section 6.1.1), groundwater discharge (see section 6.1.2) and groundwater and surface water development levels (see section 6.1.3). However, the relative impact of these drivers is currently a knowledge gap.

It is also recognised that land use, such as livestock access to watercourses, and limited riparian vegetation that provides minimal buffer protection from catchment land uses would impact on the condition of permanent pools and their capacity to support aquatic fauna and flora (EPA 2023). In late 2023, a 1000-hectare block of land containing several permanent pools in the Burra Gorge upstream of the EPA's monitoring site was gifted to the Department for Environment and Water for a new national park and improved protection of the existing ecological values (DEW 2023b).

6.1 Key factors contributing to environmental outcomes

6.1.1 Rainfall

Annual rainfall in the Burra catchment is highly variable, and although the recent trend across the assessment period (2009–2023) shows a relatively stable trend, inter-annual variability remains high (Figure 8). Outcomes for baseflow and higher flows are associated with changes in rainfall, e.g., the two cease to flow events in 2018 were associated with below average rainfall. As described in Deane et al. (2008), surface runoff in the catchment is highly variable and driven by extreme rainfall events. This was also evident in the environmental outcome assessment, with the high flow events in 2017–18 and 2021–22 having coincided with years (e.g., 2016–17 and 2022–23) of above average annual rainfall during which extreme rainfall events likely occurred.

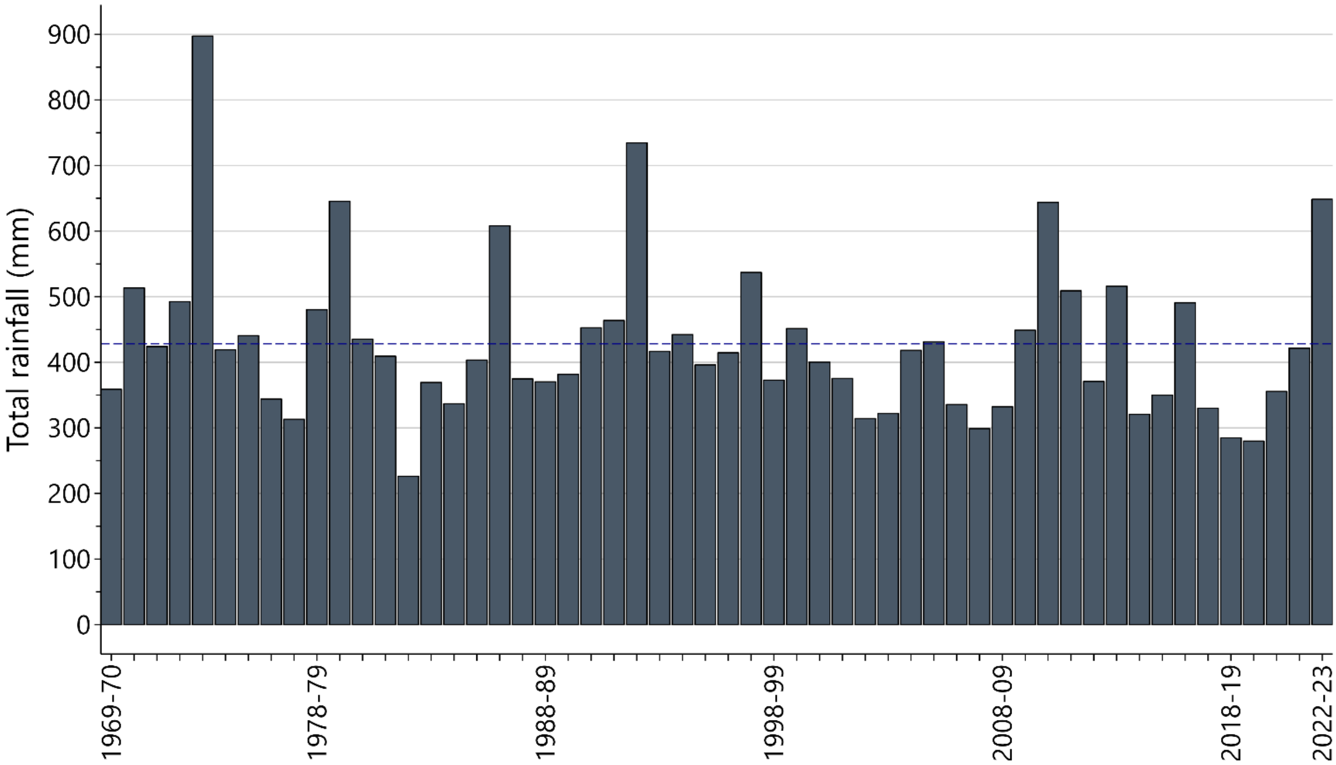

Figure 8. Rainfall (mm) per water year from the Burra Community School monitoring location (station 21077, BOM 2023). Blue line represents long-term mean rainfall from 1970–2023.

6.1.2 Surface water and groundwater dynamics

The presence of permanent pools in the Burra Gorge and the baseflow supporting these pools is linked to a complex system of groundwater and surface water interaction in the catchment upstream. Currently, there is little information available to quantify the relative contributions of surface or groundwater. It is assumed that the baseflow over the summer months is most likely derived from groundwater inputs to the pools, derived from the fractured rock aquifer that underpins much of the upstream catchment.

Both surface water and groundwater usage can likely have an impact on the baseflow through the permanent pools. The level of groundwater development in Burra Creek is not considered to be high enough to warrant prescription under the Landscape SA Act, though there are pockets of high development linked to individual developments. Due to the nature of fractured rock aquifers, the impact of the groundwater development is likely quite localised.

Surface water from permanent pools in Burra creek is extracted for stock and domestic use. The impact of extraction activities is unknown, as the number of extraction points and volumes of extraction are not measured or reported on.

Although there are no groundwater observation wells that are regularly monitored close to the gorge, those in the region typically display a close relationship with rainfall patterns (DEW 2021). This relationship is depicted in Figure 9, which shows data from the closest long-term groundwater monitoring site to the gorge (Well CLR051; 30 km to the west, in the Clare Valley). This gives an indication of the variability of local groundwater, which are important for baseflows in Burra Creek.

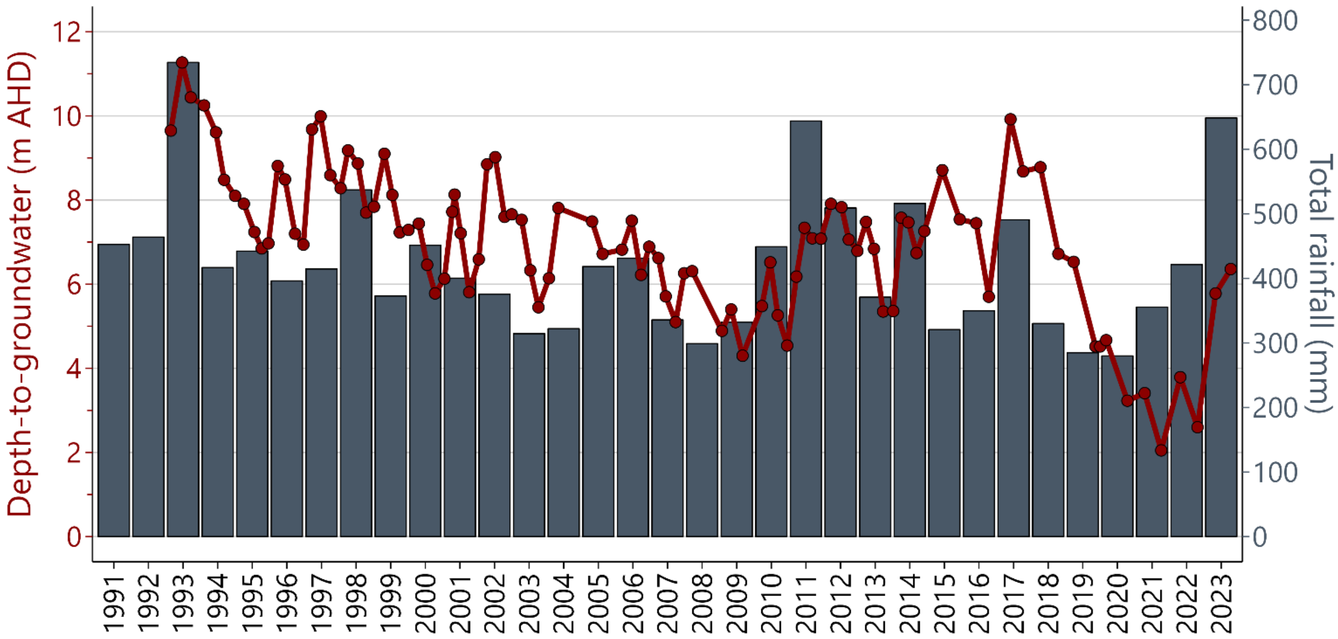

Figure 9. The daily depth to groundwater (line; left axis) at monitoring site CLR051, 30 kms to the west of the Burra Gorge, and rainfall (mm) per water year (columns; right axis) from the Burra Community School monitoring location (station 21077, BOM 2023).

6.1.3 Dam development levels

The most recent assessment of dam development levels in Burra Creek was last completed by Deane et al. (2008). Please refer to that report, as well as the 2020 Matter 8 Murray Region Technical Report, for that contextual information on surface water development.

6.1.4 Groundwater development levels

As outlined in section 6.1.2, an increasing depth to groundwater has likely been driven by patterns in annual rainfall. Similar to surface water development levels, the last assessment of groundwater development levels was completed by Deane et al. (2008). This demonstrated that there were approximately 456 either operational or with an unknown status drillholes across the Burra Creek sub-catchments, with drilling activity peaking in the late 1990s and early 2000s (see Figure 9 in Deane et al. 2008). Based on current data, no new operational groundwater drillholes (used for stock, domestic, irrigation, or municipal water supply) have been developed since 2008.

6.2 Unanticipated outcomes

There were no unanticipated outcomes in this evaluation.

6.3 Actions to achieve environmental outcomes

The level of water resource development in the Burra creek catchment was identified in the South Australian Water Resource Plan Area Risk Assessment as warranting further investigation to determine impact on water-dependent ecosystems (WDE) (DEWNR 2018). Ecological monitoring of the permanent pools of Burra Creek could ascertain whether current levels of water resource development under a drying climate are impacting these WDE.

Further investigations into levels of ground and surface water usage, and dam development within the Burra Creek catchment and Northern Mount Lofty Ranges, would assist in ascertaining how these activities impact flows and ecological condition.

7 Conclusion

The WRP for the SA Murray Region documents the controls and policies in place to ensure that take remains within the Sustainable Diversion Limits set under the Basin Plan. The WRP identifies the rules that provide protection to the PEAs and ecosystem functions together with rules for the protection of PEW.

The environmental objectives for the Murray Region were considered to have been achieved. Baseflows to permanent pools, and overbank and higher flows in Burra Gorge have improved over the assessment period (2008–09 to 2022–23). The frequency of baseflows, freshes and overbank flows (but not bankfull) have been sufficient since 2019 to meet the EWRs. The key factors that likely impacted the achievement of environmental outcomes for baseflows, overbank and higher flows to permanent pools in Burra Gorge were rainfall, surface and potentially groundwater extraction, and dam development levels; however, the relative impact of these drivers is currently a knowledge gap. The improvement in baseflow and higher flows over the assessment period, is assumed to translate positively to support aquatic flora and fauna within the permanent pools of Burra Creek.

The current ecological condition and abundance of the flora and fauna inhabiting the permanent pools of Burra Creek remains a knowledge gap, as the most recent ecological assessment (by the EPA) dates back to 2010. However, it is possible that potential cease to flow events in 2018-19 affected rheophilic (flow sensitive) instream fauna. It is recommended that ecological assessments be undertaken in the area to update the ecological information from the 2010 assessment, and a reassessment of surface water development levels and flow bands be undertaken to ensure flow regime targets are sufficient.

8 Abbreviations and Glossary

8.1 Abbreviations

DEW	Department for Environment and Water (South Australia)
EPA	Environment Protection Authority
EWR	Environmental Water Requirements
LTWP	Long-term Watering Plan
MDBA	Murray–Darling Basin Authority
NMLR	Northern Mt Lofty Ranges
NMLRW	Northern Mt Lofty Ranges Watercourses
PEA	Priority Environmental Assets
WRP	Water Resource Plan
WRPA	Water Resource Plan Area

8.2 Glossary

Anaerobic	Without oxygen
Aquatic plants	Plant species that grow partly or wholly within aquatic environments
Bankfull flows	Flows that fill the channel but do not spill on to the floodplain (can occur any time but more commonly associated with High Flow Season). Defined in the LTWP for the SA Murray Region as flows between 33 and 220 ML day^{-1}.
Baseflow	Minimum flows within a perennial waterbody. Defined in the LTWP for the SA Murray Region as flows between 0 and 3 ML/day. Due to gauging accuracy limits, for the purpose of this evaluation, minimum baseflow was defined at 0.05 ML day^{-1}.
Basin Plan	Adopted in 2012, the Basin Plan is a widespread, across governments, agreement to manage and protect water in the Murray–Darling Basin.
Cease to flow OR zero flow	No flows are recorded in the channel and during these periods, the stream may contract to a series of pools or ponds, or may dry completely.
Ecosystem	A group of living organisms that live in and interact with each other in a specific environment.
Freshes or fresh flows	Flows greater than base flow but less than Bankfull, defined in the LTWP for the SA Murray Region as flows between 3 and 33 ML day^{-1}.
Littoral zone	Part of the river that is close to shore.

Macroinvertebrate	An invertebrate that is large enough to be seen without a microscope.
Millennium Drought	From late 1996 to mid 2010, much of southern Australia (except parts of central Western Australia) experienced a prolonged period of dry conditions, known as the Millennium Drought. The drought conditions were particularly severe in the more densely populated southeast and southwest and severely affected the Murray–Darling Basin and virtually all of the southern cropping zones. The period from 2007–2010 was particularly extreme with extended periods of no flow through the barrages to the Coorong.
Murray–Darling Basin	An area of about 1 million km^2 in the south east of Australia, it is almost 1,400 km long and about 800 km wide.
Overbank flows	Flow that rises over the riverbank and connects the river to the surrounding floodplains and wetlands.
Riparian vegetation	Vegetation that grows in the transition zone between the aquatic and upland areas.
Water for the environment	Environmental water is 'held' or 'planned' environmental water, defined in the *Water Act 2007*. *Held* environmental water is available under a water access right for the purposes of achieving environmental outcomes; *planned* environmental water is committed to environmental outcomes and cannot be used for any other purpose unless required in emergency circumstances.

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