Technical information supporting the South Australian Basin Plan Environmental Outcome Evaluation

South Australian Murray Region

Department for Environment and Water
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Summary

The assessment of environmental objectives for the SA Murray Region water resource planning area was undertaken for the reporting period 2014–2019. The only priority environmental asset, identified in the long-term watering plan for the area (DEWNR, 2017), is Northern Mount Lofty Ranges Watercourses. These watercourses are represented by the Burra Creek Catchment, specifically the permanent pools of the gorge section of the catchment.

As identified in the long term watering plan, the environmental objective for the area is 'aquatic fauna and flora supported within permanent pools'. This is underpinned by two environmental water requirements (EWRs):

- Maintenance of the existing baseflow to permanent pools; and
- Maintenance of occasional overbank and higher flows to scour and maintain pool depths, and assist in maintaining salinity levels.

The environmental objective was evaluated by assessing the achievement of the environmental water requirements for the area using flow data from the Worlds End gauging station, located 4kms downstream of the permanent pools of the Burra Gorge. This data was supplemented by rainfall data from Burra Community School and ecological data collected by the South Australian Environment Protection Authority (EPA).

The baseflow EWR was considered to be met. There were two cease to flow periods between 2014 and 2019, both occurring in 2018 for a total of 101 days. The baseflow recovered quickly and has flowed perennially since. While there is a long term declining trend in flow, the last few years have seen an increasing trend.

The high flows EWR was not considered to be met with only 12 days recording flows over 20ML/day. Of these, 10 occurred in 2014 and two in 2015. There have been no high flow days since winter 2015 though this is not unexpected given the dry conditions experienced throughout the area since the beginning of 2017.

The latest ecological assessment of the area was undertaken by the EPA in 2010. They recorded the ecosystem being in "fair" condition noting the presence of two rare macroinvertebrate species and a mostly native vegetation community. However, they also noted issues with nutrient enrichment and siltation, suggesting that the lack of high flows is potentially starting to impact the ecosystem.

Despite not meeting the high flows EWR, the environmental objective was achieved, as the maintenance of baseflows ensured aquatic habitat was not lost. However, the cumulative effect of years without higher flows will need to be assessed in future rounds of reporting.

1 Introduction

In accordance with Chapter 8 of the Basin Plan, and consistent with the Basin-wide Environmental Watering Strategy, a long-term environmental watering plan (LTWP) was developed for the SA Murray Region water resource plan areas (WRPA). The LTWP identifies the priority environmental assets (PEAs) and priority ecosystem functions (PEFs) for the area and the associated environmental water requirements. The SA Murray Region Water Resource Plan (WRP) identifies the rules that provide protection to the priority environmental assets and ecosystem functions together with rules for the protection of planned environmental water.

1.1 Basin Plan

The Reporting requirements outlined in Schedule 12 of the Basin Plan provide the Murray-Darling Basin Authority (the Authority) 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.

1.2 Matter 8 – environmental oucome reporting

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

- To meet Basin Plan reporting obligations under Schedule 12;
- To communicate Basin Plan outcomes to key stakeholders (including the community);
- To inform South Australia's, the Australian Government's and other States' environmental water delivery decision-making and adaptive management capacity; and
- To make a meaningful contribution to the Authority's evaluation of the effectiveness of the Basin Plan (at Basin-scale), and our 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 reporting on the achievement of environmental outcomes required for the Matter 8 reporting. 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).

South Australia considers Matter 8 an evaluation of the achievement of environmental outcomes at an asset scale, and the reporting of that evaluation to the Authority.

This evaluation is guided by three key evaluation questions:

- To what extent are expected environmental outcomes being achieved?
- If expected environmental outcomes are not being achieved, why not?
- To what extent is the provision of environmental water contributing to the achievement of expected environmental outcomes?

This document presents the assessment of achievement of environmental outcomes for the Murray Region Water Resource Plan Area, and supporting data and information to evaluate why these outcomes have been met or not met since the adoption of the Basin Plan and actions to achieve environmental outcomes in the future.

2 South Australian Murray Region WRPA

2.1 Context

The SA Murray Region water resource plan area (WRPA) covers an area of approximately 63 509 km^2. It incorporates all surface water and groundwater resources in this area excluding the surface water of the South Australian River Murray and Lower Lakes (Lakes Albert and Alexandrina). The SA Murray Region WRPA covers most of the Murray-Darling Basin in South Australia from the state border in the east, to the edge of the plains of the Mount Lofty Ranges in the west and south-east to the coast. In the Basin Plan, the SA Murray Region also 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 priority environmental asset.

The SA Murray Region long-term watering plan (LTWP) identifies a single priority environmental asset, the Northern Mount Lofty Ranges Watercourses (NMLRW). This area was identified as a priority environmental asset due to the presence of critical refuge habitats in the form of permanent pools within the river channels, and the presence of 'planned environmental water'. The SAMDB Regional NRM Plan sets the maximum level for the development of water resources at 30% of May to November runoff, meaning that the remainder is protected for downstream users, including the environment (NR SAMDB 2015).

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. 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 considered to be planned environmental water and as such the Noora Evaporation Basin is not considered a priority environmental asset in the LTWP.

There is no held environmental water in the SA Murray Region WRPA and the area is not influenced by environmental water delivery in the South Australian River Murray WRPA (when excluding the Coorong and Murray Mouth). With the exception of the management of new development to ensure that the development limits are not exceeded and environmental water requirements are maintained to preserve water-dependent ecosystems, there is no active management of the water resource.

Watercourses in the northern and eastern sections of the SA Murray Region WRPA drain onto the flat Mallee country and rarely if ever reach the River Murray. Other minor watercourses with indistinguishable end points are also present in the landscape.

In the Olary Ranges and Northern Mount Lofty Ranges in the north and northwest of the SA Murray Region WRPA there are numerous watercourses that 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. Of these watercourses, Burra Creek is the only one that is monitored and is the best example of the permanent refuge pools noted in the LTWP.

2.2 Burra Creek Catchment

The Burra Creek Catchment is mostly represented by cleared and grazed land in the northwest section of the SA Region WRPA (Figure 1). The headwaters of the catchment originate to the north of Mt Bryan before flowing east to Burra Creek where a short reach (~17 km) of baseflow creek with large deep permanent refuge pools occurs in the vicinity of Burra to Burra Gorge/Worlds End Gorge. These permanent refuge pools are sustained by the groundwater from the Skillogalee fractured rock dolomite aquifer (Deane et al. 2008) and provide refugia and habitats for macroinvertebrates, frogs, waterbirds and aquatic plants (Deane et al. 2008). This section is characterised by riparian vegetation comprising of River Red Gum (*Eucalyptus camaldulensis*), native and introduced grasses, however, a number of vulnerable and/or threatened plants are also supported.

Apart from this section, few other permanent refuge pools (e.g. Redbanks) are maintained across the SA Murray Region WRPA.

As the permanent water in the catchment is groundwater dependent, salinities are moderately saline i.e. 2000-3000 mg/L (3000-5000 EC). This exerts a strong influence on the ecology limiting the range of possible species that can persist (Deane et al. 2008).

Due to the low rainfall and paucity of freshwater in the landscape, landholders seeking freshwater have needed to harvest and mine water. This has been through dam construction and drilling of wells into the underlying aquifers. There are approximately 600 dams along Burra Creek with the vast majority being for stock and domestic use (DEW, Unpublished data).

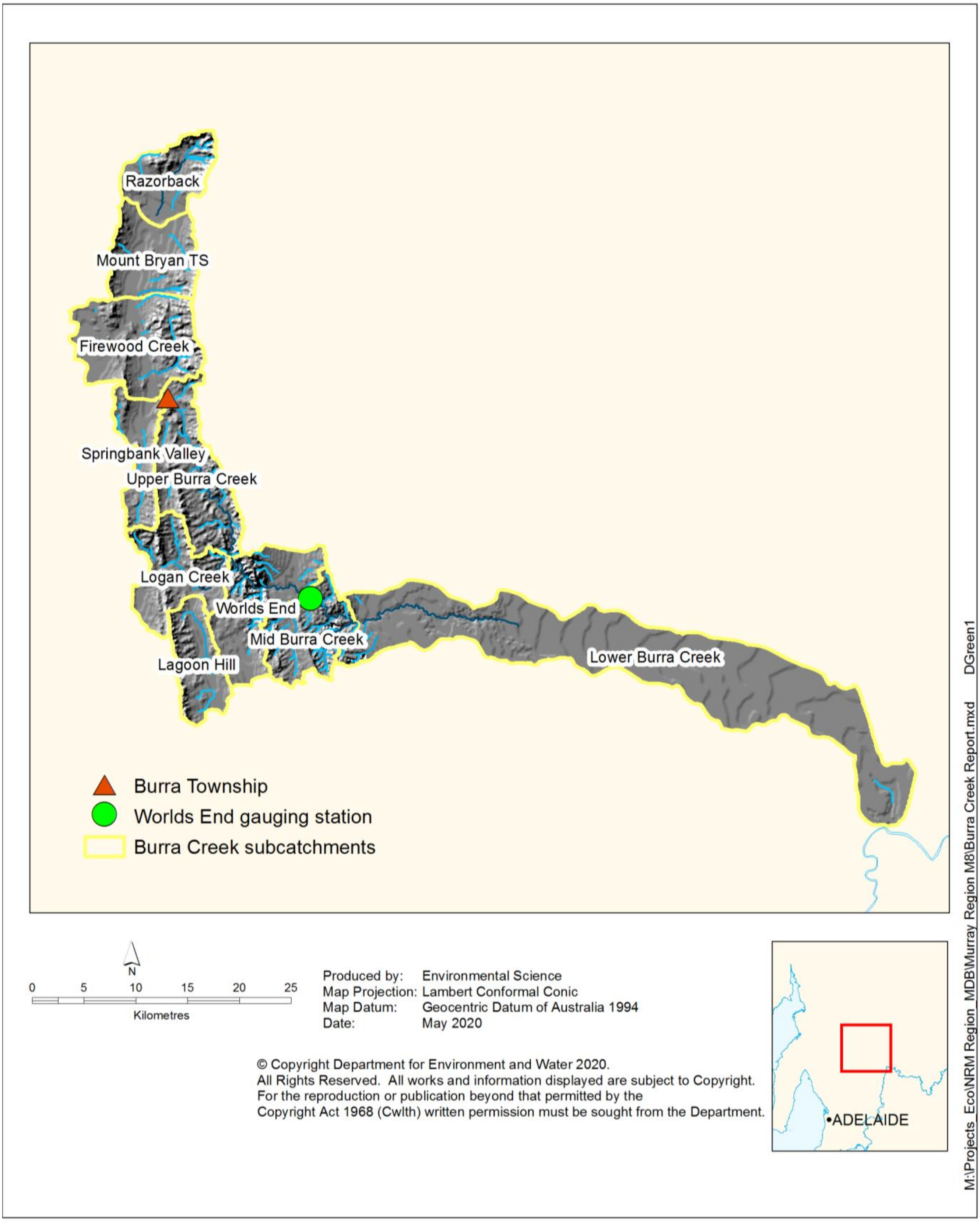

Figure 1: Burra Creek Catchment, focus of the assessment of environmental objectives for the NMLRW.

3 Ecological objectives and targets

The risk to the ecological objective of the NMLRW ecological asset were identified as low through the risk assessment process applied to all of South Australia's WRPAs (DEWNR, 2017c). As such, the current controls were deemed sufficient to manage the risk. Ecological targets were adopted from the LTWP (DEWNR 2017a) and EWRs adopted from previous assessments (Deane et al. 2008) (Table 1).

Table 1: Ecological target and environmental water requirements for the Northern Mt Lofty Ranges Watercourses adapted from previous work adapted from Deane et al. (2008).

Priority Environmental Asset	Ecological Objective/Target	Environmental Water Requirement
Northern Mount Lofty Ranges Watercourses	Aquatic fauna and flora supported within permanent pools	Maintenance of the existing baseflow to permanent pools.
		Maintenance of occasional overbank and higher flows to scour and maintain pool depths, and assist in maintaining salinity levels.

3.1 Evaluation of ecological objectives

The South Australian approach to the assessment and evaluation of environmental objectives is based around three key evaluation questions (DEW in prep. b). Table 2 provides a summary of the evaluation plan for the SA Murray Region.

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

Key evaluation question	Focus of evaluation	Evaluation method
To what extent are we achieving environmental objectives?	The level of water resource development in the area will be the key information source. This will be supplemented with water data from the Worlds End gauge station. Supporting ecological information will be used if available.	The evaluation will focus on if the water resource development level in the area increased to or above the limits set in the SAMDNB NRM Plan at 30% of May to November runoff. In order to ensure that the limits are correct, and that landholders are complying with the requirements of the SAMDB NRM Plan, the surface water flow data from the Worlds End gauge will be assessed to see if there is any significant change/downward trend. These assessments will need to incorporate rainfall data (rainfall coefficients) to ensure that the measured change is due to increased/unregulated development or climatic conditions. Supporting ecological information will be used in an appropriate manner, depending on the type of information available.

If we are not achieving environmental objectives, why not?	The accuracy of the development level will be the key focus of this component. This investigation will be triggered if the other supporting information shows a change in the achievement of environmental objectives.	If a change is detected that suggests that the environmental objectives are not being met then there are two key things that need to be assessed. The first is to assess if the estimated development is correct. The development level assessment relies on the accuracy of the estimated development level, which could be inaccurate for a number of reasons including different use levels of water resources from that estimated or illegal water extraction. The second is if the 30% development limit allowed too much water to be removed from the system resulting in degradation of the aquatic habitat. This assessment will require hydro-ecological investigations to link the hydrology and ecology together. If this assessment is identified as a requirement then this will be flagged as a future priority as the current level of ecological data is not current or sufficient to undertake the assessment.
To what extent is provision of environmental water contributing to achievement of expected objectives?	As there is no environmental water provided this is a passive process. This question is not considered relevant for this process.	

4 Method

The assessment method was developed based on the Evaluation and Reporting Plan for the SA Murray Region WRPA (DEW in prep. a). Both of the two environmental water requirements (EWRs) identified relate to the flow/presence of water in the permanent pools of the Burra Gorge reach. It is assumed that the main impact to the achievement of these EWRs is the level of development in the upstream catchment. The assessment looked at these development levels and the impact on the hydrology of the Burra River Catchment.

This is supplemented with an assessment of flow data at the Worlds End Gauge downstream of the Burra Gorge. The assessment of the flow data looked at general trends in the flow as well as an assessment of the specific EWRs identified in Table 1. Rainfall data for the Burra Catchment is also assessed to provide context for the flow results. Finally, any available ecological data for the reach was reviewed.

4.1 Assessment of development levels

Development levels were assessed based on the level of dam development in the Burra Creek Catchment. The level of development was assessed for each of the subcatchments of the Burra Creek Catchment separately. This was done as these are the areas used for the ongoing management of the area. Dams were digitised from aerial imagery and their surface area was used to estimate volumes. The volume of water captured is compared to the runoff generated from rainfall to assess if development is within the limits set in the SAMDB NRM Plan (30% of May to November runoff, NR SAMDB 2015).

Development levels were also used to assess the level of hydrological impact to the ecologically relevent parts of the flow regime using the 'impact metric' developed by Green (in prep.).

4.2 Assessment of surface water flows

Flow data was collected from the Worlds end gauging station located downstream of Burra Gorge. The gauging station monitors daily flow data coming out of the gorge before the creek starts to lose water into the unconsolidated sediments of the Murray floodplain. The original gauge station (A4260536) collected data from 15/01/1974 to 22/07/2009 (available here) while the new gauge (A4261148) started collecting data on 1/12/2007 and is still operating (available here) (WaterConnect 2020). While both of the gauges are in the same location, the construction of the controlling section of the gauge is very different. The original gauge was very inaccurate at low flows while the new gauge is designed to capture the low flows well. This difference means that the data sets are not able to be linked into a single dataset.

The surface water flows were also assessed relative to the rainfall for the region. Rainfall data was collected from the rainfall gauge at Burra Community School (Station 21077). The station commenced data collection in 1961 and is currently operating. The whole dataset was used to assess long term rainfall trends for the catchment while a smaller window (December 2007 – June 2019) spanning the data available from the new Worlds End gauge was used to assess trends in runoff generated from the catchment.

4.3 Trend assessment

Where possible, a trend assessment was undertaken to assess the general trend across the reporting period, as well as across the entire time period of available data. Trend assessment was undertaken using R Studio (version 1.1.383, running R version 3.4.2, R Core Team, 2013) using Bayesian Generalized Linear Models (using the stan-glm function in the rstanarm package, Stan Development Team 2016). Estimates of slope were used to characterise the likelihood of trends within the data in line with the Intergovernmental Panel on Climate Change likelihood categories (based on Mastrandrea et al., 2010), Table 3).

Table 3: Trend assessment classes based on the percentage of positive/negative slopes returned from the Bayesian modelling approach.

% positive slope results	% negative slope results	Trend assessment
99-100	0-1	Virtually certain increase
95-99	5-1	Extremely likely increase
90-95	10-5	Very likely increase
66-90	10-33	Likely
33-66	33-66	About as likely as not
10-33	66-90	Likely decrease
10-5	90-95	Very likely decrease
5-1	95-99	Extremely likely decrease
0-1	99-100	Virtually certain decrease

4.4 Ecological data assessment

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 undertaken by the EPA in 2010 (available here, EPA 2020). This assessment was done using the EPA's aquatic ecosystem assessment methods (Goonan et al. 2018).

5 Limitations

An overarching limitation of the achievement of long term environmental outcomes is the focus on flow. It is well established that flow in seasonally intermittent watercourses is the master variable in ecosystem condition, but it is not the only driver of condition. Landuse, introduced predators, stock access and water quality among others are also important in ecosystem condition. Therefore, it is acknowledged that other drivers outside flow may limit the ecosystem response to improved flow conditions and prevent the achievement of ecological outcomes in the longer term.

While there is limited historical ecological monitoring of Burra Creek, there is no regular ecological monitoring of Burra Creek. Therefore, the assessment of environmental objectives is primarily based on surface water flow data. 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 for a review of relevant literature). In the specific case of Burra Creek, the achievement of the EWRs is suggested to be sufficient to achieve the ecological objective. While the conceptual links between the data presented and the ecological objectives is well established there is a risk that the data assessed will be of insufficient temporal scale to detect change in ecological condition.

6 Results

6.1 Development levels

The most recent digitisation of the dams of the Burra Creek Catchment was undertaken in 2007. Since then there has been limited development of new dams in the catchment (Kuchel, S. personal communication, 2017). Due to the lack of new development it was deemed acceptable to use the figures developed from Deane et al. (2008), summarised in Table 3. As there has been no follow up work to update the development levels, no trend assessment has been undertaken.

Table 4: Burra Creek Catchment data detailing the level of water resource development including number, volume, density of dams, allowable take and the impact metric results.

Sub-catchment name	Number of Dams	Total dam storage (ML)	Dam density (ML/KM^2)	Total permitted 30% Rule (ML)	% Demand relative to allowed take	Impact Metric
Razorback	71	102	1.92	122	83%	0.1229
Mt Bryan	90	174	2.74	148	**117%**	0.1012
Firewood Creek	84	120	1.21	239	50%	0.1184
Springbank Valley	55	95	2.37	110	87%	0.0933
Upper Burra Creek	77	172	1.91	213	81%	0.1447
Logan Creek	52	100	1.53	161	62%	0.1483
Lagoon Hill	105	113	2.4	117	97%	0.1311
Worlds End	75	107	1.3	174	62%	0.1625
Mid Burra Creek	29	57	0.93	NA*	NA*	0.1909
Lower Burra Creek	122	370	1.1	NA*	NA*	0.1606

* Issues with modelling prevented these number from being calculated. For details see Deane et al. (2008).

Mt. Bryan was the only sub-catchment to exceed the allowable level of demand. A number of the other sub-catchments are within 20% of the limit. The majority of the dams in each of the sub-catchments are small volume stock and domestic dams, which accounts for the high number of dams relative to the storage capacity.

The ecological impact of dam development is assessed using the Impact Metric assessment. This assessment provides a 0–1 metric that represents the level of impact to the ecologically relevant parts of the flow regime (Green, in prep.). When compared to other South Australian catchments, Burra Creek Catchment is generally more impacted (Figure 2). While the total number of dams or their total volume are not as high as observed in southern catchments of the Mount Lofty Ranges, the lower rainfall/dryer catchment (typically to the north of the region) means that the relative impact of the dams is greater.

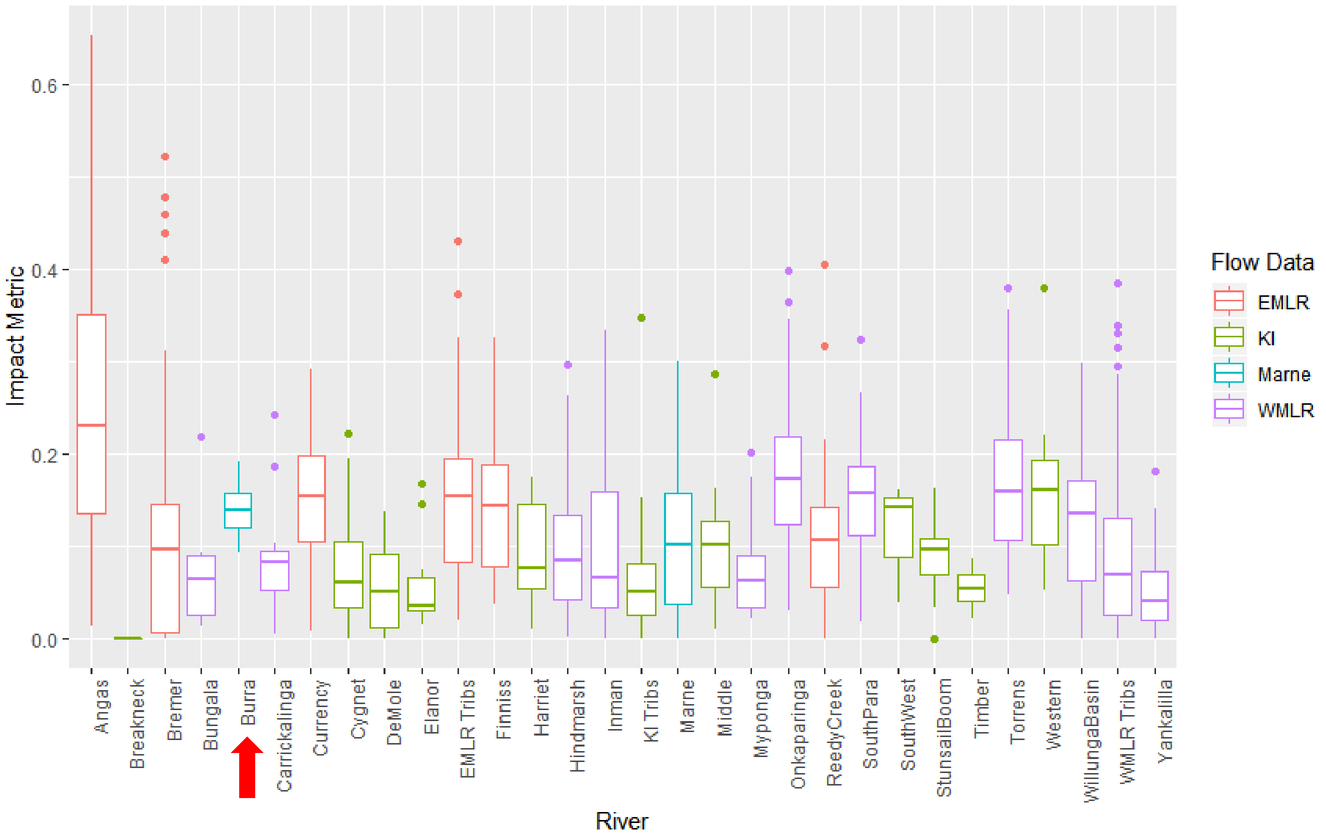

Figure 2: Impact metric results for catchments in the Mt Lofty Ranges and Kangaroo Island illustrating the relative position of Burra Creek.

6.2 Flow assessment – "Maintenance of the existing baseflow to permanent pools"

6.2.1 Baseflow

The baseflow EWR is "Maintenance of the existing baseflow to permanent pools". Baseflow was assessed by examining the number of cease to flow days recorded at the Worlds End gauge station. Baseflow at this location is generated by the discharge of groundwater across the break of slope of Burra Gorge. This is the main source of water for the permanent refuge pools. 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. Baseflow was defined as flow greater than 0.05ML/day. According to the assessment by Deane et al. (2008) base flow through Worlds End should be permanent.

Across the reporting period (2014–2019) there were two events in 2018 where baseflow ceased for a total of 101 days (Figure 3). It is difficult to establish if this is outside the normal range for the site as the longer term dataset shows higher flow values due to the inaccuracy of the site measuring low flows. A third cease to flow event was identified in the new gauge data that occurred in 2008 for a total of 42 days.

6.2.2 Flow Trend

Given surface water flow was constant (e.g. no zero flow days, except for 101 days in 2018). It was not possible to undertake a trend assessment. Rather, the overall surface water flow at the site was assessed to examine the trend in the total amount of water moving through the site. The surface flow data from the two gauges were assessed independently due to the inability to link the data.

The trend in the longer term flow data from the Worlds End gauge (A4260536) was classed as 'virtually certain decrease'. All of the 4000 iterations of the model produced a negative slope with a mean slope of -0.00208 (90% confidence interval -0.003 to -0.002). The flow data from the new gauge (A4261148) showed a 'virtually certain increase' with 99.7% of the results showing a positive slope. The mean slope across all iterations was 0.01433 (90% confidence interval 0.006 to 0.023). Both of these results are represented visually in Figure 3.

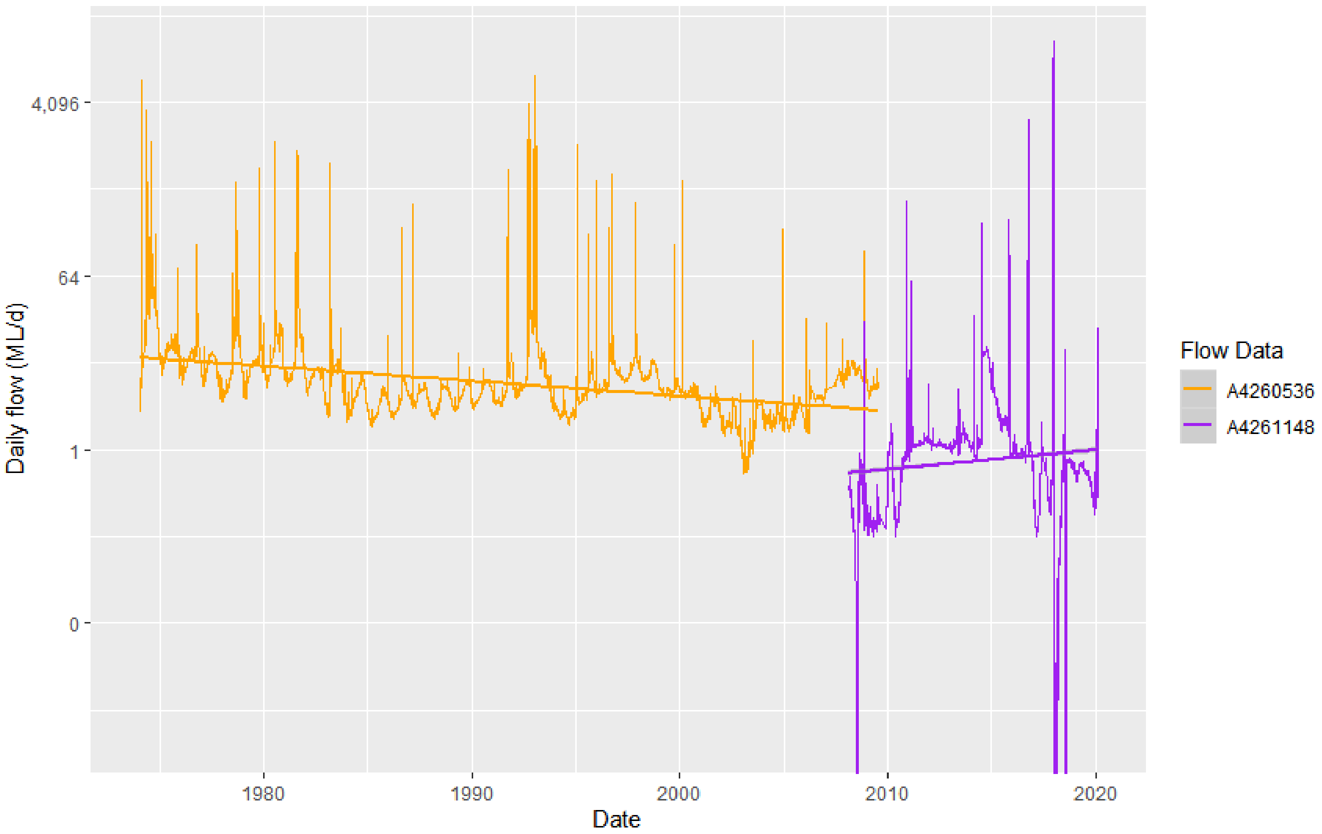

Figure 3: Daily flow from the Worlds End gauge stations transformed using log2 for ease of viewing. The trend lines are simple linear regressions across the individual data series.

To assess if changes in the flow were linked to rainfall or other drivers (water resource development) a simple runoff assessment was undertaken on the data from the new Worlds End gauge (A4261148) and rainfall from Burra Community School, located centrally in the Burra Creek Catchment. The runoff assessment was conducted by dividing the total flow volume by the total rainfall for each month. The results from this assessment help provide an estimate of how much of the rainfall across the catchment is converted into flow at the Worlds End gauge. The runoff assessment does not take into account other variables that may influence flows at the gauge including groundwater inputs (both from within the catchment but delayed due to the time required to pass through the aquifers or groundwater from outside the catchment).

As noted above, the trend in the flow data from 2007 to 2020 was classed as 'virtually certain increase'. This is opposite to the results for the trend assessment for the rainfall data from the same period (figure 4). The rainfall trend from 2007 to 2020 was classed as 'extremely likely decrease' with 98.3% of the model runs producing negative slopes. The mean slope was -1.05 x 10-4 (90% confidence interval -1.87 x 10-4 to -2.36 x 10-5). A longer timeframe was also assessed (1961-2020, the entire rainfall dataset for the site) and showed a very likely decrease in rainfall over the last 59 years. The analysis returned 94.7% negative slopes with a mean slope of 7.44 x 10-6. On average there is approximately 60 mm less rainfall per year now compared to 1961 when records began.

The monthly runoff trend (2007 – 2020) was classed as 'likely increase' with 87.8% of results showing a positive trend. The mean slope is 0.0129 (90% confidence interval -0.005 to 0.031). All trends for the 2007 – 2020 period are shown in Figure 4. The difference in the trends for the rainfall and flow/runoff indicates that either less water is being retained in the landscape, likely due to higher intensity rainfall events leading to less infiltration, or changes in the groundwater discharge to Burra Creek. These two options are almost certainly not exclusive but how they are linked is unsure.

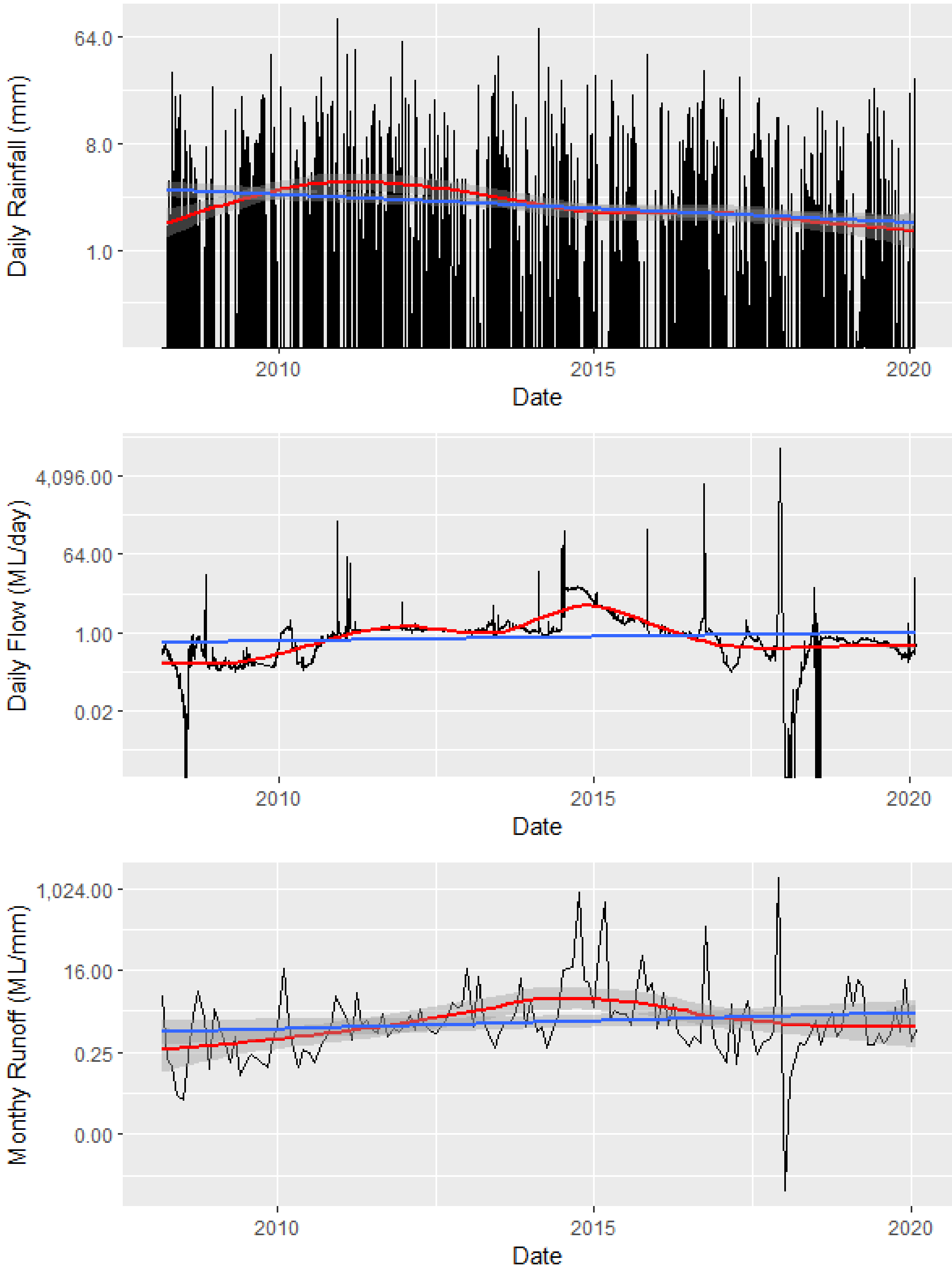

Figure 4: Plots of the daily rainfall (Burra Community School), daily flow at Worlds End and calculated runoff. The red line is a simple smoothing applied to the data while the blue line is a linear regression representing the trend.

6.3 Flow Assessment – 'Maintenance of occasional overbank and higher flows to scour and maintain pool depths, and assist in maintaining salinity levels'

6.3.1 Higher flows

Higher flows and overbank flows were assessed using both sets of flow data. As both gauges are capable of measuring higher flows, the number of high flow days per year across the two datasets were merged as the sensitivity of the gauging site is considered to be similar for flows of this magnitude. This produced a single time series from 1974 to 2019. A threshold of 20ML/day was used to classify a flow as 'high flow'. This is a significant flow volume which would be sufficient to totally flush and scour the permanent pools in Burra Gorge. Based on the assessment in Deane et al. (2008) flows of this magnitude should be seen every 1–2 years.

Across the reporting window (2014–2019) there were 12 days with flow greater than 20ML/day. Of these days, 10 days occurred in 2014 and 2 days in 2015. There has been no high flow days since winter 2015. Historically the number of high flow days has varied. 1974 was an extremely wet year in the catchment with over 220 days of high flow. In general, the number of high flow days per year is less than 10 with only 6 years since 1974 having over 25 days of high flow.

6.3.2 Higher flows trend

The number of high flow days per year is presented in Figure 5. The trend was classified as 'virtually certain decrease' with all 4000 iterations of the model producing a negative slope. The mean slope was -0.100 (90% confidence interval -0.137 to -0.063). It should be noted that 1974 was a significant flooding year and similar flows have not been seen since. As this was the first year of the data set it likely has a strong influence on the results.

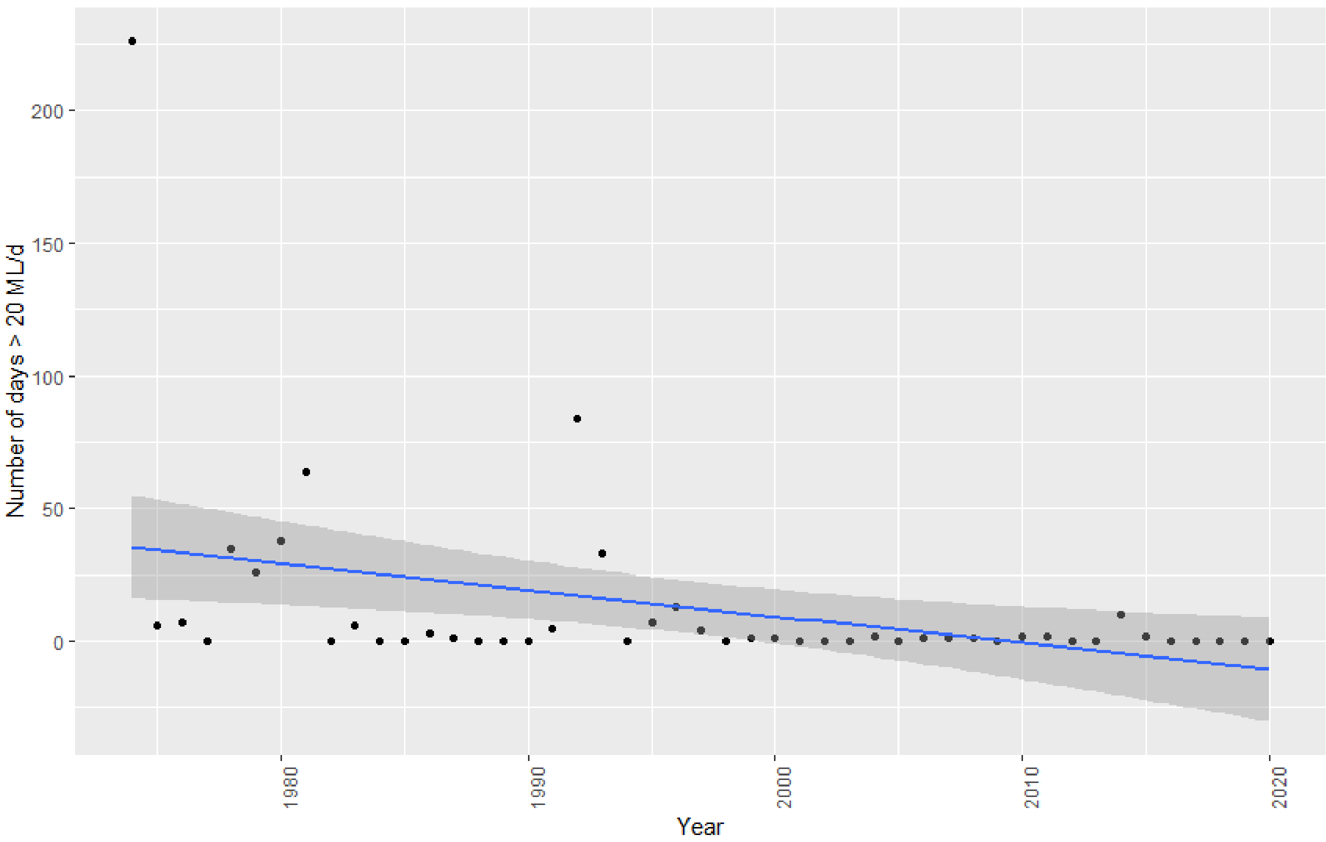

Figure 5: Annual summary of the number of days with flow greater than 20ML. The blue line represents a simple linear regression to illustrate the slope.

6.4 Environmental information

The most recent ecological assessment of the permanent pools of Burra Creek was undertaken by EPA in 2010 (available here, EPA, 2020). The site was rated as 'Fair' using the EPA aquatic ecosystem condition reporting condition assessment process. There was evidence of human disturbance, including nutrient enrichment and fine sediment deposition. The latter indicating that more higher flow days are needed to clear the silt being washed in from upstream.

A total of 24 species of macroinvertebrate were identified. The community was dominated by species tolerant to poor water quality such as amphipods (*Austrochiltonia australis*) and corixid waterbugs (Micronecta) in the pools and blackflies (*Simulium ornatipes*), chironomids (including Cricotopus and Procladius) and caddisflies (*Cheumatopsyche* Spp.) in the riffles. Of particular note, a rare damselfly (*Notosticta solida*) and beetle (*Laccophilus sharpi*) were collected.

There have been no native fish recorded in the Burra Creek. Only eastern gambusia (*Gambusia holbrooki*) were collected. There are previous records of Rainbow trout (*Oncorynchus mykiss*). Brown trout (*Salmo trutta*) is also known from the Burra Creek Catchment in the larger pools from past stocking events (Deane et al., 2008). These fish are likely no longer present in the system as stocking ceased over 15 years ago.

The riparian vegetation was considered to be mostly native with a range of emergent species (mostly *Typha domingensis* and *Phragmites australis* with several others). The riparian zone extended over 10 metres in width and was mostly native species of shrubs and trees with exotic grasses and weeds as the understory.

7 Evaluation

7.1 To what extent are we achieving environmental objectives?

7.1.1 EWR - Maintenance of the existing baseflow to permanent pools

The evidence examined in this report suggest that the baseflow were maintained to the permanent pools.

Using the flow at the Worlds End gauge station as a surrogate measure, the number of cease to flow days has been minimal, with only two cease to flow events totaling 101 days occurring over the reporting period (2014–2019). Both of these events occurred in 2018, one of driest years experienced in the region for the last 100 years. The length of these events would have likely had an impact on the instream fauna with rheophilic species negatively impacted. However, the permanent pools would have continued through the cease to flow period meaning that all obligate aquatic flora and fauna would have been able to persist.

There are multiple drivers that impact on the baseflow through the permanent pools including rainfall, water resource development, landuse, vegetation and groundwater discharge. As part of this assessment, two of the key drivers (rainfall and water resource development) were also assessed to identify whether trends in these factors may provide insight in to the current and future status of permanent pools in Burra Creek.

The development of water resources (dam development) was last assessed in 2008 and is considered to be stable since that time.

Rainfall showed an extremely likely decrease over the last 12 years and a very likely decrease over the last 59 years (see trend classifications in section 4.3). Based on the trend, average annual rainfall is now approximately 60 mm less than it was 59 years ago when records started. Despite the decrease in rainfall, flow through the Worlds End gauge has shown a virtually certain increase over the last 12 years (see figure 3). This is also reflected in the increasing runoff measurement for the catchment. The reason for this is unknown, however, is likely linked to the changes in rainfall intensity (i.e. more intense rainfall events but less rainfall overall). There could also be a link to changing groundwater discharge. It is likely that over a longer timescale, the cumulative impact of declining rainfall will present as reduced flow, however, this was not the case over the last 12 years.

7.1.2 EWR - Maintenance of occasional overbank and higher flows to scour and maintain pool depths, and assist in maintaining salinity levels

The evidence examined in this report suggests that higher flows and overbank flows were not maintained.

The assessment showed that over the past 59 years there had been a virtually certain decrease of days with flow greater than 20ML/day. Over the reporting period there were a total of 12 high flow days, however, none have occurred in the last three years. While having a run of years without high flows is not unexpected in the catchment, the decreasing trend in the number of days and the longer runs of years without high flow events will likely lead to ecological degradation.

The paucity of high flow days would likely have increased sediment buildup along the length of the watercourse, including the permanent pools of the gorge, with an associated loss of habitat diversity and increase in *Typha domingensis* and *Phragmities australis* that prefer stable water levels.

7.1.3 Ecological Objective - Aquatic fauna and flora supported within permanent pools

Based on the evidence presented here, it is considered that the ecological objective has been met for the reporting period (2014–2019).

While the higher flows EWR was not met and the baseflow EWR was not met for the entire time over the reporting period, the permanent pools have been maintained to provide refugia for aquatic flora and fauna. It is likely that the condition of the ecosystem has degraded due to the lack of higher flows. The paucity of high flows facilitates sedimentation of permanent pools and more stable flows and water levels reduces habitat diversity by providing favourable conditions for *Typha domingensis* and *Phragmities australis*, which may out compete other native flora species.

7.2 If we are not achieving environmental objectives, why not?

The overbank and higher flows EWR was not met. High flows are less impacted by the development of water resources than low or medium flows. By their nature, they will fill and spill any dams in the catchment quickly (especially at flows of 20 ML/day) reducing their impact on the flow through the system. For this reason, it is noted that development levels are likely not to have an impact on the achievement of this EWR. The reason that this EWR has not been met is the lack of sufficient rainfall events to create the required runoff.

7.3 To what extent is provision of environmental water contributing to achievement of expected objectives?

In the case of the Burra Creek, environmental water was considered to be delivered by the management of development levels within the catchment. By keeping development within the 30% of May to November runoff limit that is set in the SAMDB NRM plan, this effectively ensures that the remaining water is available for other users including the environment. The majority of sub-catchments in the Burra Creek Catchment are within 20% of this limit, with one exceeding it. Without a more detailed assessment, including surface water and groundwater modelling, it is not possible to determine if the limits are too high or low. It is assumed that while the two EWRs are being met, the flows are suitable for the protection of biodiversity in permanent pools, meeting the environmental objectives.

8 Actions to achieve environmental outcomes

8.1 Future assessment

Future assessment of the LTWP objectives for the NMLRW should incorporate on-ground assessment of the condition of the permanent pools of the Burra Gorge. The assessment of EWRs provides an indication of ecosystem condition, however, thresholds regarding the time, duration and return interval over which an EWR may fail to be achieved before the ecological objective cannot be met is unknown. Specifically, the duration and return interval of high flow events that are needed to maintain aquatic flora and fauna is a key knowledge gap.

The future assessments should also incorporate an assessment of the groundwater levels in the region. It is possible that there is a lag between falling rainfall in the catchment and the reduction in groundwater discharge further down the catchment. If this is case then the baseflow observed at the Worlds End gauge could reduce/cease without warning unless properly monitored and assessed.

9 Conclusion

The environmental objectives for the Murray Region WRPA are considered to be met for the 2014–2019 reporting period.

The baseflow EWR was met as flow through the Burra Gorge was near perennial for the majority of the reporting period, with two cease to flow periods recorded in 2018. This was one of the driest years in the past 100 years and therefore impacts to baseflow was expected. Baseflows were recorded again through 2019 after the cease to flow events in 2018.

The higher flows EWR was not met. Water resource development over the catchment had limited impact on higher flows, and the inability to meet the higher flows EWR was largely attributed to declining rainfall across the region. The reduction in the frequency of these higher flows would likely have had an ecological impact, which was noted by Deane et al. (2008) and the EPA (2020), however, the severity of this impact is currently unknown.

Flow in Burra Creek over the past 12 years was determined to have improved. While this is encouraging, the long-term trends in rainfall and long term trends in flow are decreasing. If these long-term trends persist, it is likely that the baseflow and higher flow EWRs may not be met in the next reporting period (2019–2024) and that the aquatic ecosystems of Burra Creek will be at risk of degradation.

Key messages:

- Aquatic flora and fauna in Burra Creek were considered to have been supported within permanent pools based upon an assessment of rainfall and flow data.
- Baseflows were largely maintained from 2014–2019, however, there was a paucity of higher flows (>20 ML/day). Whilst baseflows are critical to the conservation of biodiversity in permanent pools, higher flows are also needed to improve water quality, reduce sedimentation and increase biodiversity.
- Flows measured at the Worlds End gauge have improved over the past 12 years but were found to have suffered long-term declines. Rainfall across the catchment has declined over the past 59 years, with annual totals now ~60 mm less on average. If these long-term trends continue in the next reporting period (2019–

2024), it is likely that the baseflow and higher flow EWRs will not be met and the aquatic ecosystems of Burra Creek may deteriorate.

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