Technical information supporting the South Australian Basin Plan Environmental Outcome Evaluation

Eastern Mt Lofty Ranges

Department for Environment and Water
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Summary

The Eastern Mt Lofty Ranges (EMLR) water resource planning area (WRPA) has several priority environmental assets identified in the long term watering plan, generally based on surface water catchments. The watercourses of these assets are generally intermittent rivers interspersed with permanent pools. These rivers support a community of aquatic macroinvertebrates, fish and riparian vegetation. The management of the water resources of these regions is through Water Allocation Plans (WAPs) which seek to protect water for the environment by limiting the level of development of water resources, reducing development in over developed areas and returning low flows to the catchments.

A program logic developed for this assessment identified three levels of outcomes defined as short term, intermediate term and long term. The short term outcomes relate to meeting hydrological outcomes that seek to create a better flow regime for the aquatic ecosystems of the EMLR by 2025. This flows onto the intermediate term outcomes, which relate to fish recruitment and macroinvertebrate condition. The long term achievement of the intermediate outcomes will lead to the long term outcome of healthy and resilient ecosystems with rivers and creeks regularly connected to their floodplain and, ultimately, the ocean.

An assessment against the outcomes identified in the LTWP was undertaken using the hydrological data and ecological information available for the region. The three flow metrics that were used for the assessment have been identified as the three key components of the flow regime that impact on ecological condition (fish, macroinvertebrate and aquatic/riparian vegetation) that are impacted by the development of water resources. These flow metrics were compared to a baseline condition that represented the flow regime with the effects of dams and watercourse extractions removed. This baseline condition is not a target nor the condition of the area at the commencement of the Basin Plan in 2012 but a standardized baseline against which comparisons can be made. The target for each flow metric was maintenance of flow condition within a site specific acceptable range associated with the baseline.

In general, the number of zero flow days has increased relative to the baseline, while the number of fresh flows over the low flow season (December – April) and Transition 1 (T1) season (May- June) have dropped relative to the baseline. Across the reporting period, both the number of zero flow days and the number of T1 fresh flows are declining.

The changes in the hydrological condition appear to be having an impact on the ecology of the area with the fish condition data assessed showing overall poor condition and a general trend of getting worse through time. The assessment of the fish data identified a degraded fish community across the majority of the region, dominated by tolerant native species and exotic species. The more flow sensitive species are now limited in distribution and are declining across the EMLR. The EPA assessments of the overall aquatic ecosystem condition, focusing on the macroinvertebrate community, showed generally degraded condition with a decline in diversity through time as noted in the reports.

None of the short-term outcomes are considered to be met for this reporting period (2014–2019). The timeline for the achievement of the short-term hydrological outcomes in the LTWP is 2025. The assessment undertaken in this report shows that these outcomes are currently not being met, which is expected as the implementation of policies to provide environmental water is still underway. The $31 million Flows for the Future Program to restore low flows has, to-date, been implemented at over 350 sites in the EMLR and is funded through to the end of 2023. The impacts of this investment will take time to be fully realized and the short term outcomes are expected to improve in future reporting periods.

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 Eastern Mount Lofty Ranges (EMLR) water resource plan areas (WRPA) (DEW 2017). The LTWP identifies the priority environmental assets (PEAs) and priority ecosystem functions (PEFs) for the area and the associated environmental water requirements. The EMLR 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 reporting requirements

The reporting requirements outlined in Schedule 12 of the Basin Plan provides 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 5 yearly 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 outcome 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 EMLR WRPA, 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 Eastern Mt Lofty Ranges environmental area

2.1 Context

The EMLR WRPA, described as area SW7 in the Basin Plan, covers an area of approximately 3588 km^2 from the Marne River Catchment in the north to Currency Creek in the south. This area is managed as two prescribed water resource areas (PWRA) under the *Landscape South Australia Act 2019*, the EMLR and the Marne Saunders PWRA. The watercourses of the area are predominantly intermittent streams that generally begin flowing in autumn and cease to flow in early-mid summer. There are several sections of perennial flow supported by groundwater discharge. The streams rise in the hills at the western edge of the area and flow east towards the River Murray and Lake Alexandrina. Of the thirteen larger watercourses, six flow into Lake Alexandrina, while the remaining seven flow into the River Murray upstream of Murray Bridge. The largest and most notable watercourses in the EMLR WRPA include the Finniss, Angas and Bremer rivers in the south and Reedy Creek and the Marne River in the north.

The EMLR WRPA represents important and outlying stream habitat in the lower reaches of the Murray-Darling Basin. There are many water dependent ecosystems (WDEs) in the EMLR WRPA, including some of national and international significance (VanLaarhoven & van der Wielen, 2012). Nearly all of the watercourses of the EMLR WRPA support permanent pools, which are deep pools that are maintained year-round by the influx of groundwater. These pools provide a vital refuge for obligate aquatic flora and fauna during the typical annual cease to flow period and provide a source for re-colonisation when flows and subsequent stream connectivity returns. There are also numerous wetlands throughout the area.

The ecosystems of the area have been, and continue to be, impacted by the development of water resources, in particular, dam development. The level of demand for water resources in the EMLR WRPA led to the prescription of the water resources.

The WRPA comprises two prescribed water resource areas, the EMLR and the Marne Saunders. The water allocation plan for the Marne-Saunders was adopted in January 2010 (Natural Resources SAMDB, 2010) and the WAP for the EMLR was adopted in December 2013 (Natural Resources SAMDB, 2013). Planned environmental water, as outlined in the water resource plan, is established through the range of principles that limit the take or consumptive use of water in order to support the needs of water-dependent ecosystems. This includes the setting of consumptive use limits for management zones, requirement to return low flows and the protection of baseflows, making them priority environmental assets under the definition in the Basin Plan (refer Green, 2016).

2.2 Aquatic ecosystems of the EMLR PWRA

The range of conditions present naturally across the rivers, creeks and streams of the EMLR WRPA support a diverse community of aquatic flora and fauna. Across the area there are 26 species of native fish, representing more than half of all native species present in the MDB, and eight exotic species (Whiterod, 2018). The area also supports a diverse macroinvertebrate community with over 400 species recorded in the past 25 years (DEW unpublished data, SA EPA 2020). For a full description of the aquatic ecosystems of the EMLR WRPA refer to the WAPs for the EMLR (Natural Resources SAMDB, 2013) and Marne Saunders (Natural Resources SAMDB, 2010).

The South Australian Environmental Protection Authority (EPA) undertakes condition assessments across the State every five years. These assessments are based mostly on the aquatic macroinvertebrate community collected at the site but also incorporate water quality, habitat structure, riparian vegetation, land use, stock access and erosion/sedimentation. The last major series of reports for the EMLR region was undertaken in 2015 (SA EPA, 2020). The regional summary noted that most sites were in fair (5) or poor (6) condition with three sites in good

condition (SA EPA, 2015). A further two sites were sampled in 2018 near Mt. Barker as part of a focused investigation. No sites were found to be in excellent, very good or very poor condition. Several rare and sensitive species of aquatic macroinvertebrate were found, mainly in the Finniss River where the flow is closer to perennial. There was clear signs of nutrient enrichment across most of the sites studied and the riparian zones were generally lacking in trees and shrubs, dominated by exotic grasses and weeds. These findings generally match with previous assessments of the WPRA area. However, previous assessments of the macroinvertebrate community have identified a greater diversity of rare and sensitive species which have not been recorded since. The EPA's records identify 25 rare and sensitive taxa that have not been recorded in the last decade (SA EPA, 2015).

Of the 26 native fish species recorded in the EMLR WRPA there is broad diversity in life history, habitat requirements and sensitivities. In the upper reaches of the regions watercourses there are more sensitive species, including mountain galaxias, obscure galaxias, southern pygmy perch and river blackfish (Whiterod, 2018). The remainder of the species are generally found in the terminal wetlands of the river systems driven by flows in the River Murray or are diadromous species that have only recently been able to regain access to the rivers though upgrades to the barrages between Lake Alexandrina and the Coorong. The most common and widely distributed fish species in the EMLR WRPA is the introduced eastern gambusia.

3 Ecological objectives and targets

The ecological objectives and targets for the EMLR WRPA have been identified in the EMLR long term watering plan and further developed in the Matter 8 evaluation and reporting plan (DEW, unpublished data). These objectives and targets are based on the ecological objectives and targets from the EMLR WAP. The ecological objective identified in the LTWP is 'to maintain water-dependent ecosystems at an acceptable level of risk for meeting the overall objective of maintaining/restoring self-sustaining populations of aquatic/riparian flora/fauna that are resilient to drought.' This objective is underpinned by two ecological targets. The two targets are:

1. better-than-marginal recruitment in >7 out of 10 years for southern pygmy perch and mountain and obscure galaxias
2. moderate to good macroinvertebrate community condition.

For the purpose of the Matter 8 evaluation, these targets will hereafter be referred to as environmental outcomes. These outcomes will be underpinned by targets that were developed as part of the planning process. Figure 1 illustrates the program theory linking activities to the ecological outcomes and basin plan outcomes (from DEW, unpublished).

The short-term outcome (2020-2025) is the achievement of a suitable flow regime. A suitable flow regime is defined in the EMLR WAP as 'a site meeting at least 85% of the EWR metrics'. The EWR metrics are listed in the WAP (Natural Resources SAMDB, 2013).

These metrics were refined in the Matter 8 planning process down to three key indicators, and associated targets (DEW, unpublished data) (Table 1). Based on the time frames for the achievement of outcomes, it is only expected that the short term outcomes will be achieved at present. For this reason, this assessment will focus on these outcomes. Ecological condition will be referred to based on existing assessments but the intermediate term outcomes (the two listed above) will not be directly assessed.

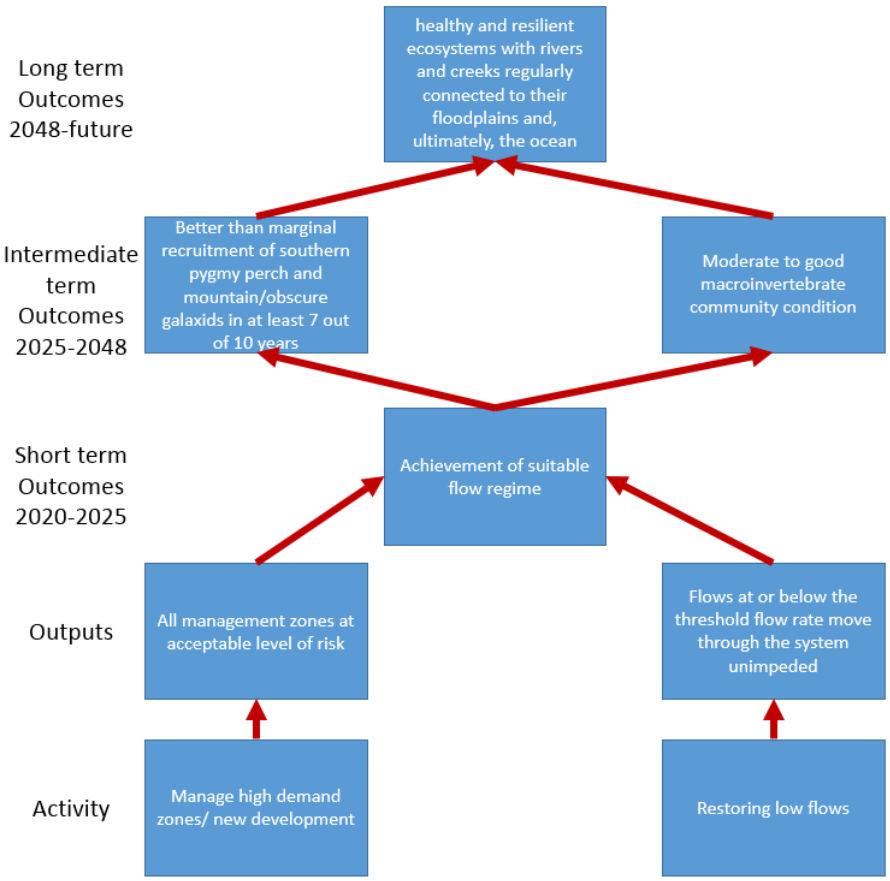

Figure 1: Simple program theory for the achievement of environmental outcomes for the EMLR WRPA (DEW, unpublished).

Table 1: Summary of the flow targets developed for the assessment of environmental outcomes for the EMLR WRP area (DEW, unpublished).

Indicator	Ecological relevance	Proposed target	Desired outcome
Number of zero flow days	Documented links to fish and macro community condition, water quality benefits	The percentage difference in the number of zero flow days between the modelled No Dams scenario and the actual observed flow is equal or lower than the expected value by 2025	Decrease in the number of zero flow days from the current level to a level closer to the expected value under the WAP modelling
Number of low flow season fresh flow days	Small pulses through the low flow season freshen the water in the refuge habitats, increasing the resilience of the habitat as a whole	The percentage difference in the number of Low flow season freshes between the modelled No Dams scenario and the actual observed flow is equal or lower than the expected value by 2025	Increase in the number of low flow season fresh flow days from the current level to a level closer to the expected value under the WAP modelling
Number of T1 fresh flow days	T1 freshes act as a cue for several ecological processes, scour habitat, wet benches and provide habitat.	The percentage difference in the number of T1 season freshes between the modelled No Dams scenario and the actual observed flow is equal or lower than the expected value by 2025	Increase in the number of T1 season fresh days from the current level to a level closer to the expected value under the WAP modelling

* Fresh flow day is defined as a day where the flow is greater than two times the median non-zero flow for the season in question.

3.1 Evaluation of ecological outcomes

The South Australian approach to the assessment and evaluation of environmental outcomes was based on three key evaluation questions (DEW, unpublished). Table 2 provides a summary of the evaluation plan for the EMLR WRPA.

Table 2: Key evaluation questions used for this assessment of the environmental outcomes for the EMLR WRPA

Key evaluation question	Focus of evaluation	Evaluation method
To what extent are we achieving environmental outcomes?	Progress towards the environmental outcomes will be assessed through achievement of targets with the understanding that the achievement of targets will be dependent on time since the implementation of policies. Short-term assessment of the ecological targets will be qualitative.	Targets will be assessed across each of the assets using available data. Flow targets will be assessed against flow data provided by the monitoring network across the EMLR. Ecological targets will be qualitatively assessed through the data collected through ecological monitoring programs across the EMLR.
If we are not achieving environmental outcomes, why not?	The evaluation will focus on the assumptions that underpin the achievement of the environmental outcomes. The assessment of the key assumptions will provide insights into why targets are failing. This will also need to be considered along with the expected timelines for achievement of targets.	For the environmental outcome that has not been met, has: 1) the underlying requirements been met 2) sufficient time passed to allow for meeting of the target 3) the assumptions made for the meeting of the target been met. This three-step progression will allow for an assessment of why an environmental outcome has not been achieved.
To what extent is provision of environmental water contributing to achievement of expected outcomes?	The assessment of the impact of environmental water will be undertaken through a trend assessment of ecological indicators. The current trend (prior to 2018) reflects the management of the water resource prior to the implementation of the major environmental water policies in the water allocation plan.	Trend assessment of the ecological indicators can be taken using established methods used for trend assessment for the South Australian Trend and Condition Report Cards. This is a Bayesian statistical method that examines likelihood of positive or negative trends.

4 Method

The assessment method was developed based on the Evaluation and Reporting Plan for the EMLR WRPA (DEW, unpublished). Modifications to the proposed plan have been made based on available data and updated methodology.

As noted above, the assessment of environmental outcomes for the period 2014-2019 has focused on the achievement of the short term outcomes. These outcomes are hydrological and are not expected to be fully achieved until 2025, however, some of the policies protecting environmental water are in place and others are being implemented. This assessment will provide an important baseline for future assessments and, with time, will provide an indication on the effectiveness of the policies in managing risk to the aquatic ecosystems in the EMLR WRPA. Ecological data will be assessed in a supporting role only with no direct assessments of the intermediate outcomes (fish recruitment or macroinvertebrate condition).

4.1 Assessment of hydrological targets

4.1.1 Condition assessment

Flow data from all flow gauges operating across the EMLR WRPA was collected from the Hydstra database (also available from WaterConnect (South Australian Govenment, 2020)). Flow records were assessed for completeness and any sites that had more than 10% missing data for the reporting period (2014–2019) were excluded. WaterCress surface water models (Penney et al. 2019) were run for the cut down list of flow gauge locations to extract a daily flow record with the effects of dams and water extractions removed, henceforth referred to as the 'baseline'. This time series was from 1974–2006 to align with the same data that was used for the development of the EMLR WAP.

Flow data was processed using the R language and environment, operated in R Studio (R Studio version 1.2.5042, running R version 4.0.0 R Core Team, 2013). The three flow metrics were calculated for each flow year (December to November) for the reporting period and averaged. This process was repeated for the baseline dataset, which consisted of modelling of the no dams scenarios. The average metrics for the modelled baseline were compared to those for the actual flow recorded over the reporting period. Condition was described based on the difference between the two.

The condition of the number of zero flow days was split into two different classes based on the perenniality of the site in the baseline scenario (Table 3). If the site was perennial or near perennial under the baseline scenario a stricter condition assessment was applied as smaller changes to the flow through these sites will result in larger ecological changes. A perennial or near perennial site was defined as having 30 or less cease to flow days on average under the baseline flow data based on discussions with local fish and macroinvertebrate exerts. The condition of the two fresh metrics was assessed based on the difference from the baseline as per Table 4.

Table 3: Condition classes used for the zero flow day metric separated by the perenniality of the site under no dams/extraction modelled data.

Flow class	Improved over baseline	Very good	Good	Fair	Poor	Very poor
Perennial or near perennial (<30 days cease to flow)	Number of cease to flow days less than baseline	0–5 day increase in days	5–10 day increase in days	10–20 day increase in days	20–30 day increase in days	No longer perennial, actual flow greater than 30 cease to flow days
Intermittent (>30 days cease to flow)	Number of cease to flow days less than baseline	Less than 10% increase in cease to flow days	10-20% increase in cease to flow days	20-30% increase in cease to flow days	Greater than 30% increase in cease to flow days	Greater than 100% increase in cease to flow days

Table 4: Flow target condition scoring criteria for the low flow and T1 fresh flow days target

Condition score	Percentage difference
Very good	Less than 15%
Good	15-30%
Fair	30-45%
Poor	Greater than 45%

4.1.2 Trend assessment

To establish a long-term trend in the three metrics, flow data collected at the identified flow gauges was assessed back to 2009. Not all flow gauges had data going back this far (in which case the assessment was undertaken for the period of data available). The trend assessment was also undertaken on the flow data for the reporting period (2014–2019) for comparison.

Trend assessment was undertaken using R Studio (version 1.2.5042, running R version 4.0.0 R Core Team, 2013) using Bayesian Generalized Linear Mixed Models (using the stan-glmer function in the rstanarm package, Stan Development Team, 2016). The number of days each of the metrics was met per flow year was modelled with site included as a random factor. Estimates of slope from the 4000 model iterations 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 5).

Table 5: 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

4.2 Ecological data assessment

There is no quantitative assessment of the ecological targets in this report. Qualitative inferences were made from existing datasets and assessments undertaken across the EMLR WRPA in the reporting period (2014–2019). There are several sources of ecological data that were assessed including:

- South Australian Environmental Protection Authority aquatic ecosystem condition reports from 2015 (SA EPA, 2015)
- Annual fish monitoring across the EMLR from 2000 to 2019 (Whiterod, Gannon, & Zukowski, 2019).

5 Limitations

An overarching limitation of the achievement of long term environmental outcomes is the focus on flow and the achievement of a suitable flow regime. It is well established that flow in seasonally intermittent rivers is the master variable in ecosystem condition, but it is not the only driver of condition. Land use, 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.

Of the 34 gauges operating flow gauges operating across the EMLR WRPA, only 17 were suitable for use across the 2014-2019 timeframe. Some gauges did not have a complete flow record, i.e. started post 2014, or had excessive missing data (many gauges were damaged in the 2016 floods). Many of these gauges will provide usable data for the next round of reporting. The lower number of gauges with usable data will limit the ability of the evaluation to assess all priority environmental assets of the EMLR WRPA.

The Watercress models that were used to produce the baseline flow dataset are considered to be well calibrated and robustly reflect the flow regime of river systems with the effects of dams and extractions removed (Penney et al. 2019). However, there are locations where large discrepancies between modeled flow and the observed flow. These sites remained in the assessment for transparency and noted for discussion. There is also a limitation of comparing modelled and actual flow data. While the models are considered to be very good, they are still models that will never be able to replicate the exact flow in the real world. This is particularly important when it is considered that flow generation in the Mt. Lofty Ranges can be from several sources, some of which are not fully captured by the catchment models. This is why general metrics were used rather than specific dates, volumes or timing.

There is also a degree of uncertainty in the flow data recorded at the flow monitoring stations. Flow monitoring stations are regularly visited and calibrated to ensure that the data is as accurate as possible but uncertainties exist for several reasons including:

1) The uncertainty in measuring low flows (especially on broad crested weir or natural rock bars compared to a v-notch).
2) The degree of validation achieved on the rating curve against actual flows measured in the field.

For the purpose of reporting at this point in time, a full evaluation of the ecological data is not warranted as the first step in the progression to environmental outcomes is the establishment of a suitable flow regime by 2025. There are multiple programs collecting ecological data and the next round of Matter 8 reporting will benefit from not only a longer time series of data, but also greater implementation of the WAP policies including the Flows for the Future Program, due for completion in 2023.

6 Results

6.1 Hydrological assessment

6.1.1 Assessment of flow metrics

Across the EMLR WRPA there were 17 gauges that met the requirements for the flow data (Table 6). The gauges were spread across the area with six of the defined assets represented. It is important to note that the split of perennial and intermittent is not representative of the broader area. Across the whole EMLR WRPA the proportion of intermittent streams is higher than represented here. WaterCress models were available for all of the selected sites with model data from 1974–2006 (DEW unpublished data). The baseline data was used to calculate the flow thresholds for the three metrics (Appendix 1).

Using the thresholds in Appendix 1, the number of days that the thresholds were met in the respective season was calculated for both the baseline data and the actual flow data for each of the sites. These were then assessed against the condition assessment tables presented in section 4.1 (Table 6).

There were a few cases where the difference between the baseline data and the actual data was considered to be too large to be the result of dam development/water extraction and was considered to be an issue with the baseline data modelling process (see limitations). The condition assessment for these sites was not used for evaluation.

Table 6: Results of the condition assessment for each of the three flow metrics for each of the assessment sites. Cells are colour coded for ease of assessment. Cells that are not coloured are likely influenced by modelling issues with the resultant condition rating not reflective of the actual condition.

Site	Asset	Catchment area	Intermittency Class	Change in # of Zero Flow days (days)	Zero flow day condition	Percent difference in low flow season fresh flows	Low flow season fresh condition	Percent difference in T1 season fresh flows	T1 season fresh condition
A4260530	Southern Cluster	Middle	Perennial	4.71	Very good	92%*	Poor	-74%*	Improved over no dams
A4261103	Finniss River	Upper	Intermittent	-4.30	Improved over no dams	12%	Very good	-268%*	Improved over no dams
A4261075	Finniss River	Middle	Perennial	111.55*	No longer perennial	94%*	Poor	62%*	Poor
A4261208	Finniss River	Lower	Perennial	1.03	Very good	16%	Good	-15%	Improved over no dams
A4261144	Angas River	Upper	Perennial	0.00	Very good	-908%*	Improved over no dams	-308%*	Improved over no dams
A4260503	Angas River	Upper	Perennial	56.86	No longer perennial	63%	Poor	83%	Poor
A4261074	Angas River	Lower	Perennial	-2.92	Improved over no dams	18%	Good	-135%*	Improved over no dams
A4261222	Bremer River	Middle	Intermittent	42.60	Fair	67%	Poor	13%	Very good
A4260558	Bremer River	Middle	Intermittent	63.63	Very poor	54%	Poor	28%	Good
A4260688	Bremer River	Middle	Intermittent	39.34	Fair	65%	Poor	44%	Fair

Site	Asset	Catchment area	Intermittency Class	Change in # of Zero Flow days (days)	Zero flow day condition	Percent difference in low flow season fresh flows	Low flow season fresh condition	Percent difference in T1 season fresh flows	T1 season fresh condition
A4260679	Bremer River	Middle	Perennial	7.30	Good	64%	Poor	-57%	Improved over no dams
A4261071	Bremer River	Lower	Perennial	249.03*	No longer perennial	57%	Poor	73%	Poor
A4261100	Saunders Creek	Middle	Intermittent	24.66	Very good	57%	Poor	100%	Poor
A4261014	Marne River	Middle	Intermittent	100.69	Poor	79%	Poor	59%	Poor
A4260605	Marne River	Middle	Intermittent	115.18	Poor	58%	Poor	93%	Poor
A4261007	Marne River	Lower	Intermittent	33.07	Good	84%**	Poor	100%**	Poor
A4261011	Marne River	Lower	Intermittent	16.43	Very good	100%**	Poor	100%**	Poor

* data differences considered to be due to baseline data modelling issues, not resource development. The degree to which resource development is impacting on these results is unclear.
** Sites are extremely ephemeral and only flow during major flow events, smaller fresh flows are generally lost to groundwater.

6.1.2 Assessment of flow trends

Trend was assessed for the three metrics across the reporting period (2014–2019). The results of the trend assessment are shown in Table 7.

Table 7: Trend assessment for the three metrics averaged across flow sites of the EMLR PWRA across the reporting period (2014–2019) including the percentage of negative/positive slopes returned from the 4000 model iterations, mean slope and confidence intervals.

Metric	Percent negative slope	Percent positive slope	Mean slope	90% confidence interval	Trend assessment
Zero flow days	16%	84%	0.051	-0.034 to 0.135	Likely increase
LFS Fresh	13%	87%	0.162	-0.072 to 0.405	Likely increase
T1 Fresh	100%	0%	-0.220	-0.312 to -0.134	Virtually certain decrease

The results show that there is a likely increase in the number of zero flow days, a likely increase in LFS fresh days and a virtually certain decrease in the number of T1 fresh days across the EMLR PWRA. Whilst there is variation across the individual sites, most are consistent with the overall trend (Figure 2). This figure also illustrates the differences between the actual flow data recorded at the sites against the baseline (average represented by the red lines).

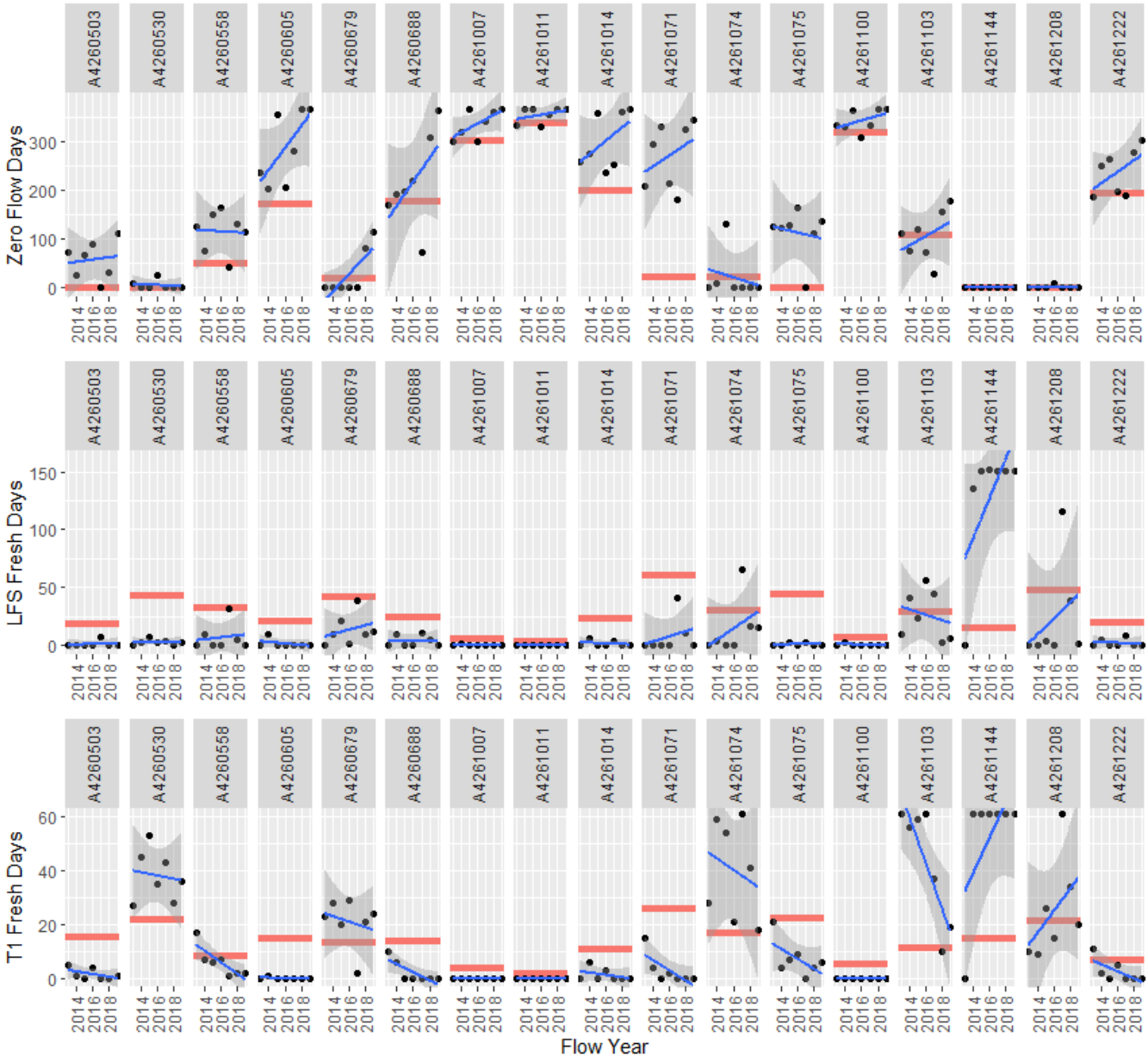

Figure 2: Three flow metrics for each year (black dots) for assessment across the reporting period (2014–2019). Blue lines are simple linear regressions representing the trends for individual sites. The red lines represent the mean result from the baseline data.

6.2 Ecological assessment

6.2.1 Macroinvertebrates

The SA EPA aquatic ecosystem condition assessments were last undertaken in the EMLR in 2015 with two additional sampling events undertaken in 2018 as part of a directed investigation around Mt. Barker (Table 8, EPA 2020). The assessments found that of the 16 sites assessed during the reporting period (2014–2019) most sites were in fair or poor condition (seven and six respectively). The remaining three sites were classed as good. For the definitions of the EPA condition classes refer to Goonan, Corbin, & Cummings (2018).

Table 8: SA EPA condition assessments undertaken between 2014 and 2019 in the EMLR WRPA.

Catchment	Site Name	Year	Longitude	Latitude	Condition
Angas River	Gould Creek, near Macclesfield	2015	138.859	-35.207	Poor
Angas River	Paris Creek, south of Macclesfield	2015	138.831	-35.217	Poor
Bremer River	Bremer River, near Callington	2015	139.023	-35.167	Fair
Bremer River	Mount Barker Creek - ds Bald Hills Road	2018	138.888	-35.072	Fair
Bremer River	Mount Barker Creek, Salem	2015	139.023	-35.139	Fair
Bremer River	Mt Barker Creek - us Mt Barker Springs	2018	138.908	-35.079	Fair
Bremer River	Nairne Creek, near Petwood	2015	138.959	-35.078	Poor
Bremer River	Rodwell Creek, west from Woodchester	2015	138.964	-35.202	Fair
Bremer River	Western Flat Creek, Mount Barker	2015	138.850	-35.078	Poor
Deep Creek	Deep Creek, Deep Creek Road	2015	138.733	-35.392	Fair
Dry Creek	Dry Creek, west from Monarto Zoo	2015	139.132	-35.107	Poor
Finniss River	Blackfellows Creek, near Keemya Conservation Park	2015	138.695	-35.282	Good
Finniss River	Finniss River, near Yundi	2015	138.669	-35.321	Good
Finniss River	Meadows Creek, near Meadows	2015	138.697	-35.198	Fair
Finniss River	Ti Tree Creek, near McHarg Creek	2015	138.740	-35.260	Good
Marne River	Marne River, near Cambrai	2015	139.280	-34.666	Poor

The assessments show that the streams in the southern region of the EMLR WRPA are generally in better condition, with all three sites rated as 'good' being located in the Finniss River Catchment. The more intermittent or saline sites were rated lower. For a more detailed assessment see the regional summary produced by the SA EPA available here (SA EPA, 2020). There are additional site assessments available linked from the main report.

6.2.2 Fish

The fish condition assessment work undertaken across the EMLR WRPA has been undertaken annually since 2000 and uses the condition assessment method developed in Whiterod and Hammer (2014). Condition assessments have been undertaken annually since 2007, with the 2019 assessment (Whiterod et al., 2019) based on sampling from 65 sites across the EMLR. Not all sites are within the EMLR WRPA (e.g. Inman River Catchment). The assessment found 21 species (15 native species and 6 exotic species). There are 26 native species and 8 exotic species recorded in the EMLR WRPA (Whiterod, 2018).

The condition of the fish community of the EMLR was assessed in 2019 as moderate using the condition assessment method developed by Whiterod and Hammer (2014) (Table 9). This represents a slight decline since the last assessment in 2018 (Whiterod et al., 2019) and a marked decline since 2013. Several of the key species showed population declines including southern pygmy perch, mountain galaxias and obscure galaxias. However, river blackfish showed an increase in numbers across the region and diadromous fish species were found in increasing numbers further up the southern catchments of the EMLR. For more details refer to Whiterod et al. (2019).

Table 9: Fish community condition assessment undertaken by Whiterod et al. (2019) based on the methods developed by Whiterod and Hammer (2014). Condition is rated on a scale of 1 to 9 with 1-3 considered poor condition (red), 3-6 considered fair condition (orange) and 6-9 considered good condition (green). Reaches are: headwaters (HW), upper pool riffle (UC), mid pool-riffle (MC), gorge (GO), lowland (LO) and terminal wetlands (TW) with reaches not sampled denoted with n/s.

		Condition score												
		Reach						Overall						
No	Catchment	HW	UC	MC	GO	LO	TW	2019	2018	2017	2016	2015	2013	2009
1	Angas	n/s	8.0	2.0	n/s	3.8	1.0	2.0	2.0	3.0	3.0	4.0	5.5	4.0
2	Bremer	n/s	1.0	3.0	3.0	2.5	2.0	2.0	3.0	3.0	2.0	2.5	3.0	0.5
3	Currency	n/s	6.0	4.0	n/s	2.5	2.0	3.3	4.5	3.5	4.5	2.8	3.5	3.5
4	Finniss	n/s	9.0	2.5	n/s	3.0	2.5	3.0	4.0	4.0	4.0	5.0	2.5	4.0
5	Inman	n/s	n/s	5.0	n/s	n/s	n/s	5.0	4.0	4.0	4.0	2.5	3.5	6.0
6	Marne	n/s	3.0	0.0	0.0	2.8	n/s	1.3	2.5	3.3	0.0	2.3	2.0	0.0
7	Reedy	n/s	n/s	5.0	5.0	n/s	n/s	5.0	4.0	4.0	3.0	3.5	3.8	2.0
8	Salt, Premimma & Rocky Gully	n/s	n/s	n/s	n/s	n/s	5.5	5.5	2.0	2.0	3.0	3.0	1.0	2.5
9	Saunders	n/s	n/s	n/s	n/s	0.0	n/s	0.0	0.0	7.0	n/s	5.0	2.0	0.0
10	Tookayerta	n/s	3.0	4.0	n/s	3.0	3.0	3.0	3.3	2.8	3.3	2.5	3.5	3.0

								2019	2018	2017	2016	2015	2013	2009
	2019	n/s	4.5	3.5	3.0	2.8	2.3	3.0	3.1	3.4	3.0	2.9	3.3	2.8
	2018	n/s	5.0	2.5	4.8	3.0	2.0							

Additional ecological data is collected in the EMLR WRPA through a specific monitoring program associated with the Flows for the Future program. This monitoring program is specifically designed to assess the hydrological and ecological impact of reinstating low flows through the Angas Catchment by assessing changes in aquatic vegetation, macroinvertebrates, water quality and geomorphology. This program began in 2017 and will run through to 2023. A full assessment of the data has yet to be undertaken, and is due in 2023. This will be incorporated into the next round of Matter 8 reporting.

7 Evaluation

7.1 To what extent are we achieving environmental outcomes?

7.1.1 Achievement of flow metric targets

The evidence examined in this report shows that the targets set for the metrics are in general not being met. Of the three flow metrics assessed, the zero flow days target is the most consistently achieved with nine of the sites assessed meeting the target (good or better condition). The low flow season fresh target is met four times while the T1 fresh target is met eight times. It should be noted that some of the passing sites are likely only to be passing due to the modelled data not being an accurate reflection of the actual flows for the site. In general, the models are considered suitable for use for this purpose, however some sites are not well calibrated.

7.1.2 Achievement of ecological outcomes

There has been no quantitative assessment of the ecological outcomes so the evaluation of ecological outcomes is based on the assessments undertaken by others. Based on the information available, in combination with the flow indicator assessment in section 7.1.1, it would be considered highly unlikely that the ecological outcomes are being met for the EMLR WRPA at this time. While the achievement of the environmental outcomes is considered an intermediate term outcome, the declining trends observed are cause for concern.

The macroinvertebrate communities have been assessed at a broad scale since 2015 so any assessment based on this information needs to consider this. The ecological outcome refers to 'moderate to good' condition. This is not defined at any stage, therefore, this report uses the 'fair' rating from the EPA as a surrogate for moderate. The data across the reporting period (2014–2019) showed six of the sixteen sites (38%) in poor condition, below the desired level. This is not considered to meet the level for the environmental outcome.

The general fish community condition has been declining over the reporting period (Whiterod et al., 2019). This was highlighted by the three species that are specifically identified in the ecological outcomes for the EMLR WRPA. The populations of mountain galaxias and obscure galaxias has shown an overall decline across the EMLR WRPA. While some sites have shown an increase in numbers, in general the numbers of fish are declining with the total loss of fish from two sites. The population condition and recruitment success of these species is highly related to the flow (Whiterod, Hammer, & Vilizzi, 2015). The reductions in flows, especially the metrics identified in this report, are considered to be key in this decline. The loss of these species from sites is generally due to insufficient flows over the low flow season to maintain the presence/quality of water. They are good recolonizing areas when flows are sufficient to allow for dispersal.

Southern pygmy perch are considerably rarer across the EMLR WRPA than the Galaxias species. In 2019 they were found in three catchments (Currency Creek, Finniss River and Angas River) with 67 individuals caught across the EMLR WRPA. The population structure appears to be consistent meaning that there is some breeding occurring, however, the declining numbers mean the species is still at considerable risk in the region.

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

The assessment showed that in general, flow metric targets are not being achieved and therefore the short-term ecological outcomes (e.g. achievement of a suitable flow regime) are consistently not being met across the EMLR WRPA. A three stepped process as defined in Table 2 has been used to assess why the flow metric targets have not been met. In summary, has:

1) the underlying requirements been met,
2) sufficient time passed to allow for meeting of the target, and

3) the assumptions made for the meeting of the target been met.

The underlying requirements for the achievement of the ecological outcomes in the EMLR WRPA are mainly linked to the implementation of policies in the WAPs, specifically the limiting of development to sustainable levels, reduction of demand in zones over the sustainable level and the reinstatement of low flows through the catchment.

There is currently no new development allowed in the EMLR WRPA so there are no new areas over the sustainable level defined in the WAP.

The areas where the current demand is over the sustainable level have been assessed using a risk assessment process to identify which ones cause the highest risk to the environment and which ones are high demand but the level or risk to the environment is acceptable based on location specific characteristics (DEWNR, 2015). This process identified 24 zones that posed an intolerable risk to the environment. To date no reductions in demand/allocated volume have been effected in these zones. It should be noted that areas of high demand are localised creating hot spots and do not represent a risk to the sustainable diversion limits for the EMLR WRP.

The implementation of low flows is being undertaken by the Flows for the Future (F4F) Program. To date the program has installed low flow solutions at approximately 350 sites across the Angas, Bremer and Marne catchments. The Gateway Review for the F4F program identified that on average an additional 105ML of water is available at the end of the catchment under the current implementation (at the time of modelling) (DEW, 2019). This program is funded through to the end of 2023 and aims to fully realise the low flow policies for the EMLR WRPA. However, as the program is not yet completed, the expected flow benefits have not been fully realised.

Therefore, it is considered that the underlying requirements have not yet been met to allow for the achievement of the short-term outcomes. Continued implementation of low flows in the EMLR through the Flows for the Future Program will be important for the achievement of the short-term outcomes by 2025. As the underlying requirements have not been met, an assessment of the last two questions has not been undertaken.

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

Environmental flows in the EMLR WRPA are provided through two mechanisms: development levels that protect water for downstream users including the environment, and the provision of low flows. The capping of development has likely prevented further degradation of the environment, however, given the timeframes for the provision of low flows through the system, the ecosystems are considered, at this point in time, to be at an unacceptable level of risk of not meeting their ecological outcomes (VanLaarhoven & van der Wielen, 2012). The hydroecological investigations that have been undertaken to underpin the WAP identified that, without the provision of low flows, development beyond 5% of resource capacity would place ecosystems at an unacceptable level of risk. As the development levels in nearly all zones are beyond 5% and low flows are not yet being fully provided, the risk of degradation remains. This is observed in the flow metrics assessed.

8 Actions to achieve environmental outcomes

The LTWP for the EMLR WRPA was developed based on the WAPs. The WAPs have been developed to achieve a range of outcomes including environmental outcomes. The continued implementation of the policies in the WAPs is the key action needed to achieve environmental outcomes. The WAPs that cover the EMLR WRPA (the EMLR WAP and the Marne Saunders WAP) are required to be reviewed every 10 years. The Marne Saunders WAP was reviewed in early 2020 and left unchanged as it was considered to provide appropriate controls for the management of the water resources in the area. The EMLR WAP is due for review by 2023. The review may identify the need to update components of the WAP; this could include the ecological targets, objectives and outcomes sought through the implementation of the WAP. The ecological targets and outcomes identified in the LTWP for the EMLR WRPA (and in turn the Matter 8 assessment) are all based on the EMLR WAP. While the review and potential update of the WAP will not require an update to the LTWP, it will likely require changes to the WRP which would in turn trigger a review of the LTWP. This process should minimize the risk of actions under a revised WAP being inconsistent with the targets and outcomes noted in the LTWP.

8.1 Future assessment of environmental outcomes

Future assessment of the targets and outcomes for the EMLR WRPA will benefit the availability of additional information. There were many flow monitoring sites that were excluded as they started between 2016 and 2018. The majority of these sites are part of the F4F program and data will continue to be collected to at least 2023, meaning they should meet the requirements for inclusion in the next round of monitoring.

Having additional information to assess this at a broader spatial scale will be beneficial. It is also noted that between now and the next round of monitoring, improved surface water models will likely be available, which may improve some of the issues observed with some sites and the disconnect between the baseline and actual flow data.

The next round of reporting will also include an assessment of the intermediate term outcomes. This with require an assessment of the ecological data that is specific to the intermediate term outcomes. The assessment of the macroinvertebrate condition will require additional work to develop a suitable condition assessment method. Neither the WAP nor the Matter 8 evaluation and reporting plan have a clear method for the assessment of condition. There are several options that are, or will be, available including new condition assessment methods from the SA EPA. The issue of method will likely be addressed in the process to review the WAP that is due to occur by 2023.

The assessment of the fish outcomes will benefit from a long term fish monitoring dataset used in this report (Whiterod et al, 2019). The WAP review process is likely to include a review of the fish targets used and may include additional targets or metrics that can also be assessed to further explore the condition of the fish populations of the EMLR PWRA.

9 Conclusion

The assessment of the flow data from across the EMLR WRPA has shown that the short-term environmental outcomes have largely not been achieved to date. The expected timeline for the achievement of the short-term environmental outcomes is 2025, therefore it is not unexpected that positive ecological outcomes are yet to be observed in many sites.

The key actions required for the achievement of the environmental outcomes are the implementation of WAP policies that relate to the protection and provision of water for the environment, particularly the provision of low flows. This policy is being implemented through the Flow for the Future Program, currently funded by the Commonwealth, to the end of 2023. This program aims to fully implement the low flows policies of the WAPs of the EMLR.

The ecological assessments of the EMLR fish and aquatic ecosystems reviewed as part of this assessment show that the aquatic ecosystems are still degraded and show declining condition.

Key messages:

- Flow data from across the EMLR WRPA suggests that the flow regime is not sufficient to keep the aquatic ecosystems in the desired condition. This was supported by evidence from environmental condition assessments that showed condition for both fish and macroinvertebrate communities are declining.
- The development of water resources in the EMLR WRPA had changed the way the water flows through the watercourses of the area, generally resulting in less flowing days, and fewer pulse flows over the low flow season or T1 season. The reduction in these flows is linked to the decline in condition of aquatic ecosystems.
- Policies in the water allocation plans that are designed to protect and improve the amount of water available for the environment are not yet fully implemented. The achievement of environmental outcomes is dependent on the implementation of these policies. Implementation of the low flows policies is being undertaken through the Flows for the Future Program and is funded to the end of 2023. This program aims to fully implement low flows across the whole of the EMLR.

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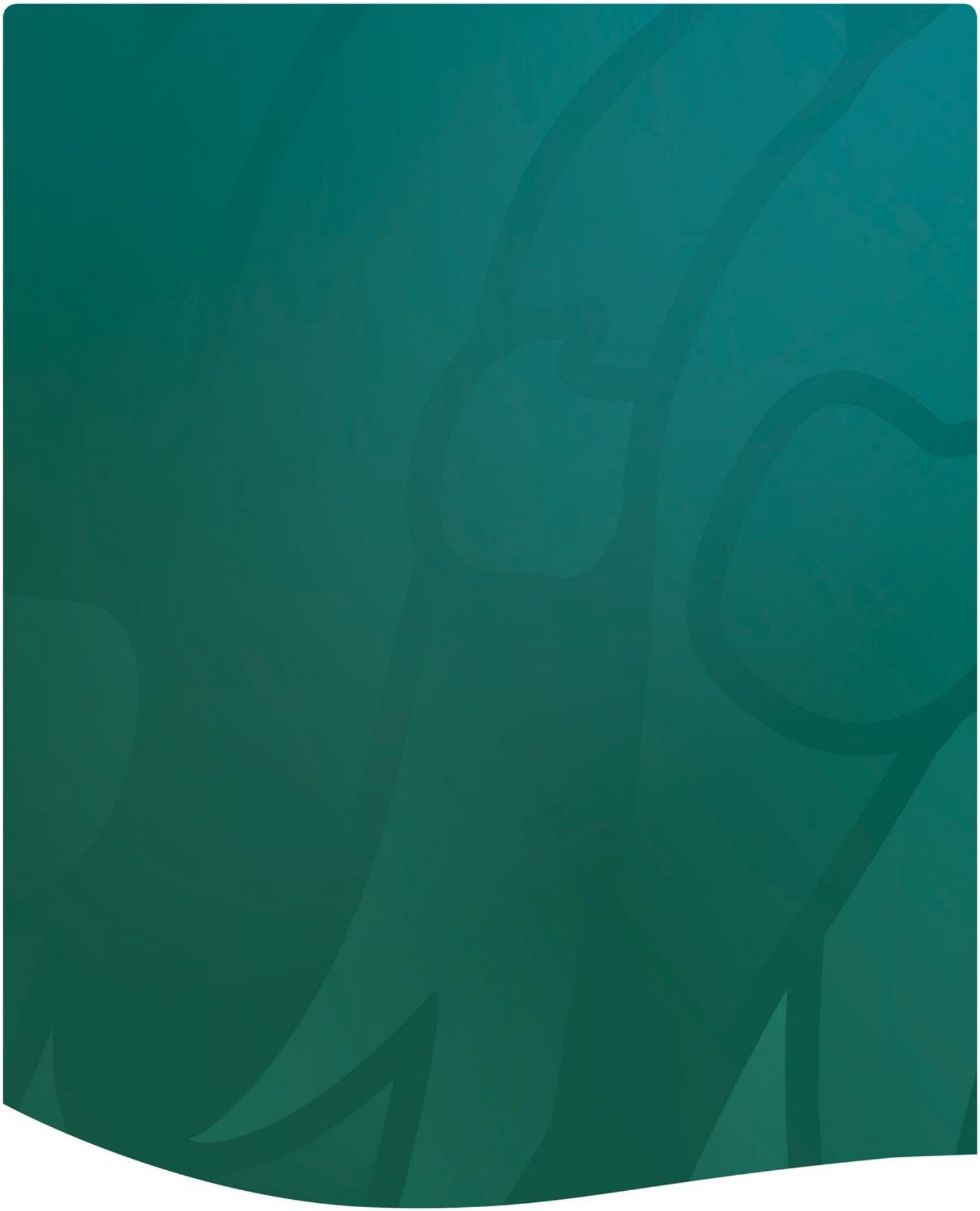
11 Appendices

11.1 Appendix 1

Appendix 1: Details of the flow gauges suitable for inclusion in the assessment of environmental outcomes including location details, intermittency class and flow thresholds developed from the baseline data.

Site	Asset	Catchment area	Easting	Northing	Intermittency Class	Low flow Threshold (ML/day)	Low flow season fresh threshold (ML/day)	T1 season fresh threshold (ML/day)
A4260530	Southern Cluster	Middle	290521	6075278	Perennial	0.05	5.82	3.394
A4261103	Finniss River	Upper	300432	6085034	Intermittent	0.05	0.494	0.407
A4261075	Finniss River	Middle	297642	6089905	Perennial	0.05	17.65	22.62
A4261208	Finniss River	Lower	301350	6081355	Perennial	0.05	19.76	25.04
A4261144	Angas River	Upper	301026	6107774	Perennial	0.05	0.8	1.55
A4260503	Angas River	Upper	304939	6099634	Perennial	0.05	4.6	10.58
A4261074	Angas River	Lower	315429	6091255	Perennial	0.05	4.64	16.9
A4261222	Bremer River	Middle	318297	6130701	Intermittent	0.05	0.675	1.023
A4260558	Bremer River	Middle	313040	6120556	Intermittent	0.05	1.358	2.946
A4260688	Bremer River	Middle	320374	6110330	Intermittent	0.05	0.862	0.97
A4260679	Bremer River	Middle	319922	6109878	Perennial	0.05	7.42	10.16
A4261071	Bremer River	Lower	322536	6086981	Perennial	0.05	2.057	3.164
A4261100	Saunders Creek	Middle	336476	6153872	Intermittent	0.05	5.09	7.02
A4261014	Marne River	Middle	332812	6165408	Intermittent	0.05	1.27	9.24
A4260605	Marne River	Middle	337994	6161660	Intermittent	0.05	1.84	17.2
A4261007	Marne River	Lower	344830	6162245	Intermittent	0.05	148.64*	90.9*
A4261011	Marne River	Lower	359745	6158773	Intermittent	0.05	517.82*	268.02*

* Lower Marne flow sites is highly intermittent with very short, large volume pulse flows generated by large rainfall events.



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