Technical note supporting the Aquatic Ecosystem Condition (EPA condition assessments) Trend and Condition Report Card

DEW Technical note 2018/04

Government of South Australia
Department for Environment and Water

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Summary

The trend and condition of the State's aquatic ecosystems was assessed using data collected by the Environmental Protection Authority (EPA). The EPA undertake assessments of the condition of the State's rivers, streams and lakes as part of its role. These assessments report the condition of aquatic ecosystems using a combination of indicators including vegetation, aquatic macroinvertebrates and water quality. These data were analysed using Bayesian modelling to provide an estimate of current condition as well as trend since 2008. These assessments do not include the River Murray. For details on the River Murray, refer to the River Murray Report Cards.

The data showed that the overall condition of the State's aquatic ecosystems is fair. This is due to a number of factors linked to changes that have occurred to the catchment areas of rivers, streams and lakes. For example, land clearance, land use change and the capture and diversion of water has drastically altered the aquatic environment leading to reductions is water quality and species diversity.

The statewide trend in aquatic ecosystem condition is improving. Contributing to this is the fact that the current monitoring approach used began during the Millennium Drought (2001-2009), when water resources were at record lows across the State. Since the end of the drought, the amount and timing of flows has improved sufficiently to show some regional improvements in condition. These regional improvements were not enough to change the statewide condition assessment. Further improvement will be required to improve the condition of aquatic resources, including the management of key pressures impacting water and habitat quality and quantity.

1 Introduction

The Natural Resources Management Act (2004) has a requirement ''to keep the state and condition of the natural resources of the State under review.' In order to consolidate the data collected around the state into a simple, easy to interpret information source, the Department for Environment and Water (DEW) produces report cards for the state's natural resources. Previous rounds of report cards have reported against the targets in the South Australian Natural Resource Management Plan (Government of South Australia, 2012). However, for the next round of reporting, the report cards will not only seek to report on the state of the natural resources of South Australia, but will also form the main source of data for the State of the Environment Report.

The State of the Environment Report (SOER) is a legislated requirement under the Environmental Protection Act (1993). The SOER has several key assessments that need to be undertaken including:

- an assessment of the condition of the major environmental resources of South Australia 112(3(a));
- a specific assessment of the state of the River Murray, especially taking into account the Objectives for a Healthy River Murray under the River Murray Act 2003 112(3(ab)); and
- identify significant trends in environmental quality based on an analysis of indicators of environmental quality 112(3(b)).

As part of the assessment of the major environmental resources of South Australia, this report and associated report card will assess the trend and condition of aquatic ecosystems across the State. South Australia is the driest state, on the driest inhabited continent and as such water is a critical resource. Water resource development has been a major part of the economic development of South Australia which has led to the State having world recognised industries e.g. South Australian wine regions. However, the development of water resources and the subsequent use of water has had a negative effect on the water dependent ecosystems across the State.

The use of water for productive purposes means that there is less water in the system for the environment. Rivers and streams are systems that have developed in response to several key drivers, of which the amount of water and the timing of flow (the flow regime) is considered to be the master variable (Datry et al. 2014). Associated with the changes in the flow regime, are changes in other key drivers of aquatic ecosystem condition such as water quality and riparian vegetation.

Agricultural practices are associated with decreases in the quality of water in rivers and streams. The processes behind these changes range from simple input of additional nutrients through the application of fertilizers through to complex interactions between ground water and surface water impacting salinity (Buck et al. 2010).

The changes in the flow regime and water quality have impacts on both the flora and fauna of these aquatic systems, generally resulting in negative impacts such as reduced species richness (the loss of more sensitive species), terrestrial vegetation encroachment (terrestrial vegetation moving into the river) and changes in the shape of the river and character of the river. These changes are not just associated with the reductions of ecological condition of the river, they also represent changes in the river that will have impacts for productive users of the water resource.

Due to the importance of water as a resource and the environmental value of the ecosystems that are associated with these aquatic systems, the Government of South Australia considers their management a high priority. The Natural Resources Management Act (2004) provides a framework for the management of water resources by providing mechanisms for local Natural Resources Management Boards to control the amount of water that is used. These controls vary based on the level of risk to water resources from no controls through to active management under Water Allocation Plans.

Monitoring of aquatic ecosystems not only provides important data, but it also provides a means for the local NRM Boards to assess if the use of water is causing excessive degradation to water dependent ecosystems. In addition to the NRM Act, the Environment Protection Act (1993) also contains clauses that stipulate that the environment shall be monitored (Goonan et al. 2012).

There are multiple programs that monitor the condition of the State's rivers, streams and lakes. The majority of these are localised monitoring programs that are designed to monitor effects of specific management actions or infrastructure projects. The Environmental Protection Agency (EPA) undertake the only statewide monitoring program, the Aquatic Ecosystem

Condition Reporting program (EPA Website). This program has been running in its current form since 2008 and provides a condition assessment of the State's rivers, streams and lakes. This report will use this information as the basis of the assessment of the trend and condition of the State's rivers, streams and lakes.

The EPA provides more detailed assessments of the results of the monitoring program at the regional and site scale. These assessments include a more in depth look at the data informing the results for each site as well as point of note (important species, site based impacted etc.). These assessments also include site based examinations of pressures and stressors as well as management recommendations. For a more detailed look at individual sites, or regional assessments, refer to the EPA website (here).

2 Methods

2.1 Condition assessment

The condition assessment is undertaken using a combination of water quality measurements, riparian habitat assessments and macroinvertebrate community assessment. These assessments are undertaken at a series of both random and fixed sampling sites across each of the South Australian NRM Regions on a rolling schedule, generally undertaken every five years. For a discussion of the site selections and the impacts on the results in greater detail see the individual panel reports available here.

Key parts of the method include:

- Detailed assessment of water quality undertaken on a composite sample taken from the site and assessed in an specialized water analysis laboratory,
- Macroinvertebrate samples are collected from the site and processed on site. Representative specimens from each type of macroinvertebrate collected are preserved and sent to an experienced laboratory technician for microscope identification, and
- Additional observations including streambed type, presence and types of aquatic plants, coverage of aquatic plants and algae, and assessments on the degree and type of terrestrial vegetation, riparian vegetation, and sediment quality (i.e. colour, odour and presence of sulfidic sediment). The land use surrounding the site is also recorded.

The results are collated and an expert panel rate the sites against an ecological conditional gradient (Figure 1). For a detailed explanation of the methods used to assess the condition of individual sites see EPA (2016).

The condition assessment scores that are provided by the EPA assessment (EPA AECR scores) do not directly align with the condition assessments used for the State Report Cards (NRM Condition scores). The EPA condition assessment uses a six class condition rating system while the Report Cards use a four class system. The alignment of these condition assessments is provided in Table 1.

The River Murray is not included as part of the EPA's assessments of aquatic ecosystem condition. The River Murray is a component of the Murray Darling basin that covers multiple states and is managed both at the state and federal level. It has its own monitoring programs that assess the ecological condition of the River and its floodplains and wetlands. For an assessment of the River Murray condition refer to the River Murray Report Cards.

The results as assessed at both the State level and at the NRM level. The NRM Regions names are provided in appendix 1. The most recent condition results for each region were used as the basis for assigning condition for each of the regions. The NRM Condition score was assigned base on the EPA condition score with the highest number of sites in that region based on the most recent round of sampling. Where there were equal highest numbers across two categories, the skew of the data was used to assign the NRM Condition score. For regions with no data, they were classed as Unknown.

The State NRM Condition score was assigned based using the average condition score from across the regions. The EPA Condition scores were assigned a numerical value (1-6) and then averaged.

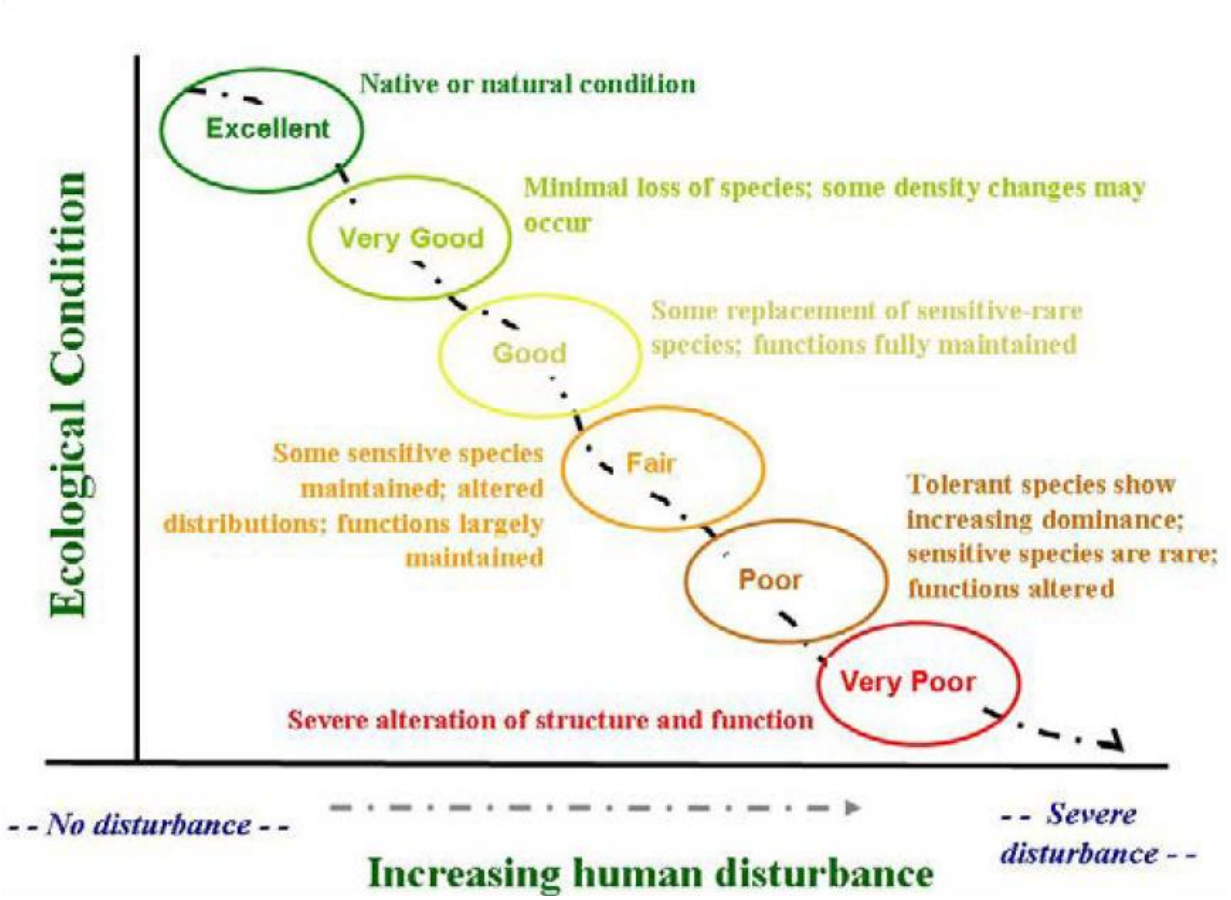

Figure 1: Ecological condition gradient used for the assessment of aquatic ecosystems for the EPA Aquatic Ecosystem Condition Reporting, the EPA AECR scores (Source: EPA 2016)

Table 1: Condition assessment used for the assessment of trend for the aquatic ecosystem assessment of rivers, streams and lakes for South Australia

EPA Condition Assessment (EPA AECR condition score)	Report Card Condition Assessment (NRM Condition score)	EPA Definition	Report Card Definition
Excellent	Very good	Natural or unaffected by human activity, with extensive areas of remnant native vegetation in the catchment area. It is possible some creeks and lakes in remote areas of the state may be given an Excellent rating, however the vast majority are likely to be affected by humans in some way.	The natural resource is in a state that meets all environmental, economic and social expectations, based on this indicator. Thus, desirable function can be expected for all processes/services expected of this resource, now and into the future, even during times of stress (e.g. prolonged drought)
Very good	Very good	Minimal changes in biological condition and the way the ecosystem functions as a result of human settlement. These sites continue to provide a healthy environment for a natural diversity of animal and plant life.	

Good	Good	Often the best we can expect given significant changes to the natural landscape after more than 170 years of European settlement. Although changes to the environment and its animal and plant life are likely to be relatively minor, there will be clear, emerging signs of human impact, which could lead to further decline.	The natural resource is in a state that meets most environmental, economic and social expectations, based on this indicator. Thus, desirable function can be expected for only some processes/services expected of this resource, now and into the future, even during times of stress (e.g. prolonged drought)
Fair	Fair	Moderate changes to animal and plant life at the site, and some change to the way the ecosystem functions. The effects of nutrient enrichment are often evident. The condition of these creeks and lakes is unlikely to meet community expectations for a healthy aquatic ecosystem at least some of the time.	The natural resource is in a state that does not meet some environmental, economic and social expectations, based on this indicator. Thus, desirable function cannot be expected from many processes/services expected of this resource, now and into the future, particularly during times of stress (e.g. prolonged drought)
Poor	Poor	These creeks or lakes are degraded, with evidence of major changes in the animal community and plant life, and moderate changes to the way the ecosystem functions. These sites typically have little native vegetation remaining and very high nutrient levels. Their condition is unlikely to meet community expectations for a healthy aquatic ecosystem most of the time.	The natural resource is in a state that does not meet most environmental, economic and social expectations, based on this indicator. Thus, desirable function cannot be expected from most processes/services expected of this resource, now and into the future, particularly during times of stress (e.g. prolonged drought)
Very poor	Poor	Major changes to both the animal and plant life are apparent with a significant breakdown in the way the ecosystem functions because of human impact. These creeks and lakes are unlikely to meet community expectations for a healthy aquatic ecosystem.	

2.2 Trend assessment

The EPA condition assessment time series data was analysed using a Bayesian linear modelling approach. This modelling approach was used as it provides more information surrounding the results and allows for a more detailed assessment of trend based on variability inherent in the data. Bayesian modelling also provides credible intervals allowing for an objective and transparent assessment of trend and condition. It provides an estimate of the likelihood of the trend or condition assessed. Modelling was undertaken using a binomial model looking at the EPA condition score (scored from 0-5 with 0 being very poor and 5 being excellent). Analysis was undertaken in 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).

Assessment was undertaken on individual sites with Catchment included as a random variable to account for spatial variability. This was included to account for the method by which the sites were selected for sampling. Initially, sites were randomly selected, however, due to specific needs, some sites have subsequently either visited repeatedly or additional sites have been added in.

The following values were estimated from the posterior distribution resulting from the Bayesian analysis:

- slope (trend)
- change between 2008 and 2016 (magnitude of any change)

Generic definitions for trend are provided in Table 2, including the specific values used here as thresholds to define the classes. Regions with no or only a single sampling event were classed as unknown.

Table 2: Trend definitions used for the assessment of trend for the aquatic ecosystem assessment of rivers, streams and lakes for South Australia

Trend	Description	Threshold
Getting better	Over a scale relevant to tracking change in the indicator it is improving in status with good confidence	Greater than 90% likelihood that target achievement trends are positive
Stable	Over a scale relevant to tracking change in the indicator it is neither improving or declining in status	Less than 90% likelihood that target achievement trends are positive or negative
Getting worse	Over a scale relevant to tracking change in the indicator it is declining in status with good confidence	Greater than 90% likelihood that target achievement trends are negative
Unknown	Data are not available, or are not available at relevant temporal scales, to determine any trend in the status of this resource	-
Not applicable	This indicator of the natural resource does not lend itself to being classified into one of the above trend classes	-

2.3 Reliability

The reliability of the data was scored using the scoring system developed for the 2017 Report Cards. This scoring system uses four scores to assess different aspects of the data used to underpin the report card. Scores for all four are then averaged to determine the final score. The four scores categories are:

- Information currency
- Information applicability
- Spatial representation
- Information accuracy

Scoring was undertaken according to Table 2

Table 3: Scoring system for the reliability of the information used to underpin the analysis for the River Murray Fish Passage Report Card

Score given	Information currency	Information applicability	Spatial representation	Information accuracy
1	Information >10 years old	Data are based on expert opinion of the measure	From an area that represents less than 5% the spatial distribution of the asset within the region/state or spatial representation unknown	Better than could be expected by chance
2	Information up to 10 years old	All data based on indirect indicators of the measure	From an area that represents less than 25% the spatial distribution of the asset within the region/state	> 60% better than could be expected by chance
3	Information up to 7 years old	Most data based on indirect indicators of the measure	From an area that represents less than half the spatial distribution of the asset within the region/state	> 70 % better than could be expected by chance

4	Information up to 5 years old	Most data based on direct indicators of the measure	From across the whole region/state (or whole distribution of asset within the region/state) using a sampling design that is not stratified	> 80 % better than could be expected by chance
5	Information up to 3 years old	All data based on direct indicators of the measure	From across the whole region/state (or whole distribution of asset within the region/state) using a stratified sampling design	> 90 % better than could be expected by chance

3 Results

3.1 Condition

The results show that there is a considerable variability in the condition of the State's aquatic ecosystems (Figure 2). The most recent sampling that has been processed is the 2016 data that focused on the Adelaide and Mt Lofty Ranges NRM Region which showed a good score overall. The only other region to be scored as good was the SAAL region in 2012 (the most recent sampling for this region). Both KI and NY were scored as fair in 2013 and 2012 respectively while the remaining regions (EP, SAMDB and SE) were all scored as poor.

Eyre Peninsula (EP) was the only individual region where there were equal high numbers across two categories (fair and poor). In this case the condition of poor was assigned given there were two sites classed as very poor, while no sites were classed better than fair.

The Alinytjara Wilurara (AW) region was classed as unknown as there has been no sampling in that region. There are no EPA aquatic assessments undertaken in the region.

The State level assessment showed that there were equal numbers of regions classed as fair and good with three regions classed as poor. The average of these scores was fair.

Table 4: NRM condition results for the State's rivers, streams and lakes assessed by the EPA using the EPA Aquatic Ecosystem Condition Assessment method. NRM condition scores are assigned using the method in Table 1

Region	Latest Sampling	Number of sites in each condition class						Regional EPA Condition Score	NRM Condition Score
		Excellent	Very good	Good	Fair	Poor	Very poor		
AMLR	2016	0	2	18	8	9	1	Good	Good
EP	2015	0	0	0	4	4	2	Poor	Poor
KI	2013	0	2	3	14	10	0	Fair	Fair
NY	2012	0	1	3	10	4	1	Fair	Fair
SAAL	2012	0	5	29	18	2	0	Good	Good
SAMDB	2015	0	0	3	5	6	0	Poor	Poor
SE	2014	0	0	2	16	21	1	Poor	Poor
State	2016	0	10	58	75	56	5	Fair	Fair

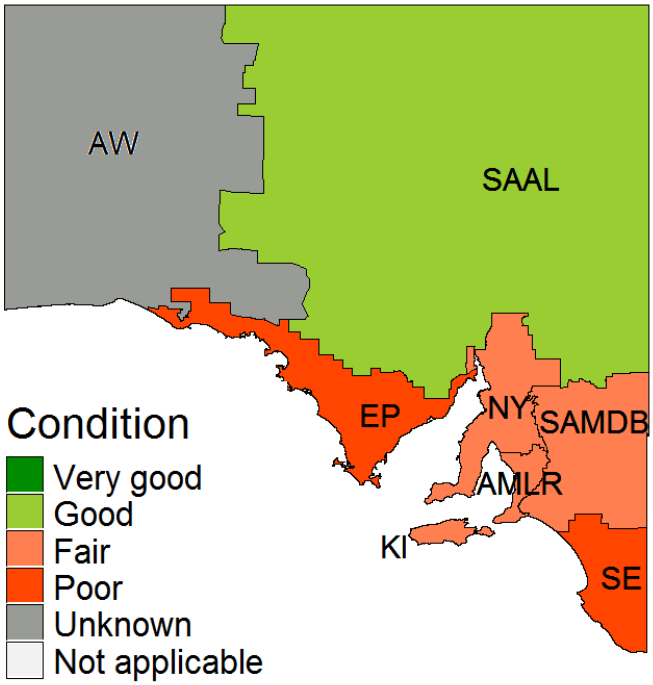

Figure 2: Map of the NRM regions showing their NRM Condition Score based on the most recent round of EPA Condition assessments (2012-2016).

3.2 Trend

The trend assessment across the whole of the state showed that the condition of the State's rivers, streams and lakes is getting better. This means that over 90% of the state modelling runs showed a positive trend from 2008 through to 2016 (Table 5).

The regional results show a similar result, however, only the AMLR region met the 90% criteria to be classed as getting better (Table 5). The rest of the regions were classed as stable although all but the SAMDB region has a positive mean slope (Figure 3) Positive slopes suggest getting better, however, to be classed as getting better, over 90% of the results need to be positive (Figure 4). Several of these regions were very close to the 90% criteria with KI, NY and SE all within 10% (87%, 89% and 81% respectively). Both AW and SAAL were classed as unknown. There has been no sampling undertaken in AW, and only a single sampling event in the SAAL region.

While both the State level and the AMLR results show that the trend is improving, this improvement is not enough make the condition change classes from poor to fair. The NRM Condition scoring system is quite course and is not designed to reflect small changes in condition, rather to reflect large and broad changes.

Table 5: Trend assessment for the State's rivers, streams and lakes summarised from the 4000 Bayesian Modelling runs

Region	Mean Slope	Negative Slope percentage	Positive Slope percentage	Lower Credible Interval	Upper Credible Interval	90% Credible Interval	Trend
AMLR	0.0821	0%	100%	0.0388	0.1256	0.039 to 0.126	Getting better
EP	0.0281	35%	65%	-0.1007	0.1557	-0.101 to 0.156	Stable
KI	0.0961	13%	87%	-0.0425	0.2400	-0.043 to 0.24	Stable

NY	0.1146	9%	89%	-0.0373	0.2673	-0.037 to 0.267	Stable
SAMDB	-0.0065	55%	45%	-0.0871	0.0746	-0.087 to 0.075	Stable
SE	0.0345	19%	81%	-0.0317	0.0993	-0.032 to 0.099	Stable
State	0.0694	0%	100%	0.0386	0.0996	0.039 to 0.1	Getting better

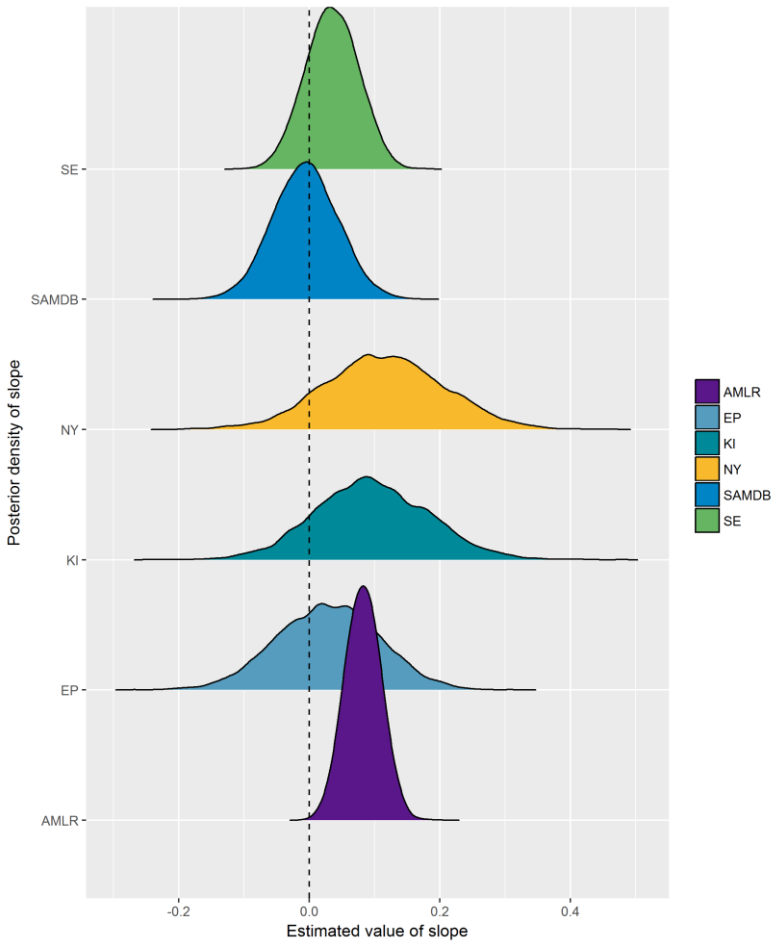

Figure 3: Estimates of the slope (trend) across the NRM regions of South Australia from the 4000 Bayesian modelling runs. Positive slopes suggest getting better, however, to be classed as getting better, over 90% of the results need to be positive (e.g. AMLR region)

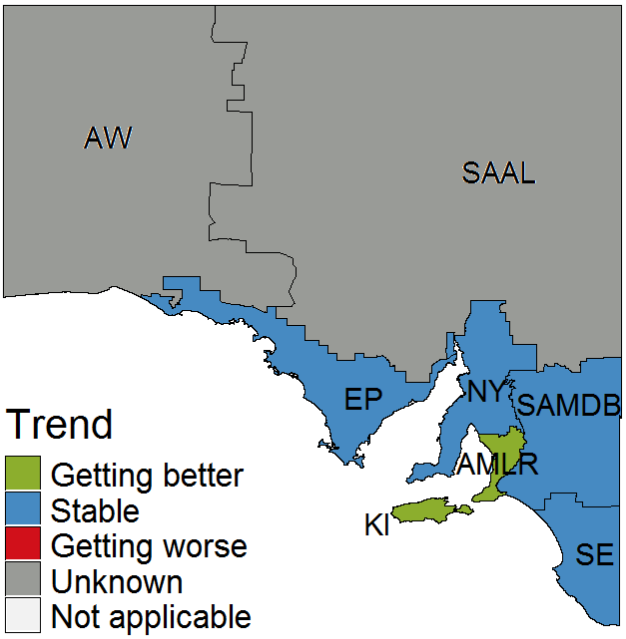

Figure 4: Map of the trend assessment results for the aquatic ecosystem assessment

3.3 Reliability

Overall the reliability score of for the report was four. The scores for each of the four guides along with justification is provided in Table 6.

Table 6: Results of the reliability assessment of the ecosystem condition trend and condition report card

Guide	Score	Justification
Currency	3	Time since collection varies from region to region with the most recent data being 2016 and the oldest data being 2012.
Applicability	4	EPA condition scores are derived based on expert opinion. However, they are very closely tied to a large site-specific dataset that provides evidence for the assessment.
Spatial representation	2	Spatial coverage is limited to a small number of sites across the state. While these sites are selected with the intention of providing an estimate of condition across the NRM regions, the number of sites sampled compared to the number of aquatic habitats is less than 25% of the state.
Accuracy	5	Data is collected by trained staff in the manner described in EPA (2016).

4 Discussion

4.1 Condition

The conditions of the aquatic ecosystems of South Australia have been shown to be in a fair state overall for this assessment. This means, in general, there has been moderate changes to animal and plant life at the site, and some change to the way the ecosystem functions. The effects of nutrient enrichment are often evident. The condition of these creeks and lakes is unlikely to meet community expectations for a healthy aquatic ecosystem at least some of the time.

This result was expected given the many and varied pressures that exist on the aquatic ecosystems of the State. With the exception of Rocky River on Kangaroo Island, all of the State's rivers, stream and lakes have been subjected to some form of modification. Key changes that have occurred include vegetation clearance, land use changes, water abstraction by dams and pumps, increased nutrient inputs, increased sedimentation and erosion and introduced plants and animals. All of these pressures compound resulting in an overall reduction in condition of aquatic ecosystems. The areas that show better condition are those that either are less impacted (e.g. SAAL Region) or those areas that have higher rainfall (e.g. AMLR Region).

Managing the State's water resources responsibly to ensure that there is an acceptable balance of water between users, including the environment, is a key role of the South Australian Government. As part of this role, plans for managing water are developed in which the needs of economic, social and environmental users of water are considered. This is complimented by on-ground programs run by the NRM regions that focus on reducing the impacts of the other pressures noted above by fencing off and revegetating rivers and streams.

4.2 Trend

The trend across the whole of the state was considered to be getting better from 2008 to 2016. This result was not considered surprising as 2008 was towards to end of the Millennium Drought (2001-2009). This drought had a significant impact on the water resources of the State with reduced water levels placing additional stress on all water resource users. Since the end of the drought, the amount and timing of water moving through the states rivers, streams and lakes has improved allowing the aquatic ecosystems a change to recover.

The fact that the improving hydrological conditions since the end of the drought has not lead to a change in the condition score for the State's aquatic ecosystems suggests that the other pressures identified above are still playing a critical role in limiting the condition of aquatic ecosystems.

The regional results show that while all but one area had a mean (and median) positive slope, only the AMLR was classed as getting better. This result was primarily driven by the 2016 sampling results which showed generally improved results. The AMLR region has the greatest number of sampling events which provides greater confidence in the results. The other regions all showed a stable trend with the mean slopes ranging from slightly negative to positive. As with the State level results, these changes were not significant enough to cause a change in the overall condition suggesting that the other pressures mentioned about are still playing a very influential role in aquatic ecosystem condition.

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