Aquatic ecosystem condition reports

2016 panel assessment of creeks and rivers from the Adelaide and Mount Lofty Ranges NRM region

Issued July 2017

EPA 1105/17: This information sheet describes the outcome of the panel assessment of creeks and rivers from the Adelaide and Mount Lofty Ranges Natural Resources Management (NRM) region, sampled during autumn and spring 2016.

Introduction

The Environment Protection Authority (EPA) coordinates a monitoring, evaluation and reporting (MER) program on the aquatic ecosystem condition of South Australian creeks and rivers. This MER program is designed to meet several objectives:

- Providing a statewide monitoring framework for creeks and rivers that revolves through the NRM regions with sufficient frequency to allow for state of the environment reporting purposes.
- Describing aquatic ecosystem condition for broad general public understanding.
- Identifying the key pressures and management responses to those pressures.
- Providing a useful reporting format that can support environmental decision making within government, community and industry.

This information sheet provides a summary of the scientific work used in assessing monitoring data from creeks and rivers. Aquatic ecosystem science is not always rigid and precise; it is often open to different interpretations in several respects. Therefore, the EPA has decided that the best way to assess the condition of streams is through an expert panel deliberation that uses a consistent descriptive modelling approach. The panel members comprised an environmental consultant and two biologists from the EPA (the authors of this assessment). All have at least 15 years' experience in monitoring and assessing a range of streams across South Australia.

The panel members were:

- Peter Goonan, EPA
- Tracy Corbin, EPA
- Chris Madden, Freshwater Macroinvertebrates

This information sheet is a technical document that contains relatively sophisticated concepts and content. It summarises the scientific assessment of data collected from creeks and rivers found in the Western Mount Lofty Ranges during 2016.

Site selection

A total of 38 sites were sampled during autumn and spring 2016 from the Adelaide and Mount Lofty Ranges, ranging from sites on the Light River in the north to Back Valley Creek on the Fleurieu Peninsula in the south.

Adelaide and Mount Lofty Ranges NRM region

A series of fixed sites were selected for sampling from the region in consultation with staff from the Adelaide and Mount Lofty Ranges NRM (AMLRNRM), Department for Environment, Water and Natural Resource (DEWNR), and the South Australian Research & Development Institute (SARDI). They included five previously identified sites from each of the 'best' and 'worst' condition streams in the region to provide the context for defining the condition gradient that was used to assess all the data collected in 2016, and to help show if the condition of sites changed significantly over time.

Another 12 sites that have significance for water resource planning in the region were included, to supplement data collected in 2013 from these same sites. A site downstream from Talisker Mine was selected by DEWNR staff to determine if runoff from this disused silver-lead mine was affecting Campbell Creek, and another site was included in the middle of the Deep Creek catchment to see if discharges and runoff from upstream agricultural activities were affecting a large section of this Adelaide Hills stream.

Three sites from the Light River catchment were included to determine if runoff from the 2015 Pinery fire caused additional stress to the river, with sites located towards the downstream, middle and upstream extent of the burnt zone. The remaining sites were selected to provide greater coverage from the upper and mid-reaches of various streams on the Fleurieu Peninsula and Mount Lofty Ranges, thereby ensuring the spread of sites extended across the entire NRM region.

Two additional sites were included in the original study design but were unable to be sampled during either survey period due to heavy rains making access tracks inaccessible in autumn and time and access problems prevented work at these sites in spring. This meant that no data was able to be obtained from either Boat Harbour Creek (2016.WMLR25) or The Deep Creek (2016.WMLR26).

Fixed sites versus random site selection

It is important to note that selecting fixed sites provides targeted information about the sampled sites and gives only a broad indication of the general condition of waters in a region. The lack of randomly selected sites limits the ability for this sort of study design to provide a statistically valid assessment of all waters in a region with some measure of known error (Stevens and Olsen 2004).

The EPA has developed a database covering all stream reaches found in South Australia that can be used to identify randomly selected sites (Catchment Simulations Solution 2011), which would allow the findings to be statistically scaled up to report on the number or proportion of stream reaches in different condition classes or subject to a water quality or habitat disturbance. If this type of information is required in the future then sites can be selected using this approach but as part of negotiations with partner organisations, the above fixed and selected site sampling approach was endorsed and used in sampling streams from the region in 2016.

The assessment

Members of the expert panel individually rated each site using a descriptive model for interpreting change in aquatic ecosystems in relation to increasing levels of disturbance (Davies and Jackson 2006). The assumption in this assessment is that biological (ecological) condition deteriorates as the degree of human disturbance in the catchment increases, and conversely, the best condition occurs where there is little to no human disturbance of the environment (Figure 1).

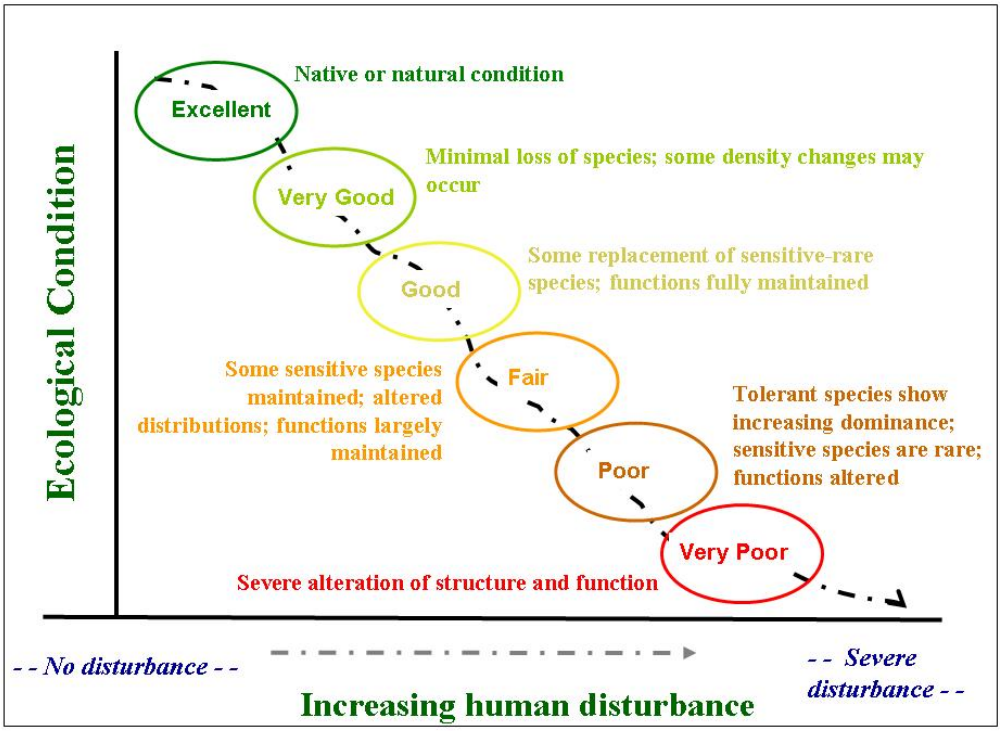

Figure 1 **Human disturbance gradient showing the six different ecological condition grades or ratings ranging from excellent (best) to very poor (worst) with a brief definition of each condition**

The process used to grade or rate sites involved the following steps. Firstly, a conceptual model describing the biological and environmental responses to a general disturbance gradient was developed, reviewed and updated by the panel (Table 1). Secondly, species lists were compiled which described the expected biotic assemblage for up to six potential condition ratings, based on the data that was collected in 2016 (Table 2). Thirdly, each site was given a rating based on the macroinvertebrate communities, vegetation assemblages, water chemistry and sediment features that were recorded during the autumn and spring sampling periods. Note that for sites that were consistently dry, only the vegetation data, sediment and habitat features were used to provide a rating; during wetter periods, at least some of these types of sites would probably rate differently but the assessment was based on the conditions that occurred during 2016. Lastly, the individual ratings derived by the panel members were combined to produce an overall, or final, rating for each site (Table 3).

The final reported ratings were derived by determining the mode (ie the most common rating from the panel ratings for each site); if the panel members disagreed and recommended three possible ratings, then the final rating was to be determined by omitting the best and worst rating and selecting the middle rating. In the interests of being transparent about the final ratings derived using this process, all results have been included in Table 3 to show where the panel agreed or showed some difference of opinion in terms of rating individual sites.

The ratings in the model range from Excellent to Very Poor. However, given the extent of vegetation clearance, land-use modifications, widespread grazing by stock and feral animals, and presence of introduced aquatic species in the region, the panel considered that Excellent probably no longer occurs and was certainly not evident from the sites sampled in 2016.

2016 results

Table 4 provides a summary of the overall condition rating for each site sampled in 2016. No sites were in an Excellent condition but 20 sites (52%) were given either a Very Good or Good rating. The remaining 18 sites (48%) were given either a Fair, Poor or Very Poor rating due to their generally degraded condition.

Condition rating	Adelaide and Mount Lofty Ranges Sites	
	# sites	% sites
Excellent	0	0
Very Good	2	5
Good	18	47
Fair	8	21
Poor	9	24
Very Poor	1	3
TOTAL	38	100

The sites that were assigned a Very Good rating included First Creek off Tunkalilla Road and nearby Tunkalilla Creek near Arthur Hill, with both located on the Fleurieu Peninsula west from Victor Harbor. These streams were characterised by the large amount of native vegetation remaining within their catchments, presence of flowing freshwater habitats, lack of significant signs of human disturbance affecting each stream, and by the large number of rare, sensitive and/or flow-dependent macroinvertebrates that were seen at each site in 2016.

Sites assigned to the Good and Fair categories each showed evidence of either slight to moderate nutrient enrichment during at least one of the sampling periods sampled. They included a wide range of streams from the wetter parts of the region characterised by the presence of some native vegetation within their catchments. They retained a functioning riparian zone, and each provided habitat for at least a few rare, sensitive and/or flow-dependent macroinvertebrates. The Good sites included: Jacobs Creek in the Barossa Valley to the north, a site from the Little Para River upstream from the reservoir, four sites from the Torrens River catchment (First, Deep and Sixth creeks), three sites from Brownhill Creek, a site from Scott Creek in the Onkaparinga River catchment, and nine sites from Fleurieu Peninsula streams in the south (Myponga River, The Deep, Boat Harbour, Callawonga, First, Tunkalilla and Balaparudda creeks). Multiple sites were sampled from some streams, which accounts for differences between the numbers and streams cited.

The Fair sites included six sites from the Adelaide Hills and two from the Fleurieu Peninsula. The Hills sites included North Para River and Tanunda Creek in the north, Cox Creek in the Onkaparinga River catchment, Brownhill and Aldgate creeks, and Sturt River near Adelaide. Campbell Creek and a site from First Creek off Tunkalilla Road located between Victor Harbor and Cape Jervois were also assigned Fair ratings because they both showed evidence of significant nutrient enrichment and degraded riparian zones, and only provided habitat for a limited number of significant aquatic species.

The Poor streams were found among the cleared agricultural land from parts of the Mount Lofty Ranges, ranging from the Mid North in the north to a small coastal tributary of the Inman River on the Fleurieu Peninsula in the south. The Mount Lofty Ranges sites were from Light River, South Para River, River Torrens and Millers Creek in the Torrens River catchment, Inverbrackie Creek in the Onkaparinga River catchment, and Pedler Creek south of Adelaide near Seaford. Back Valley Creek was the only stream assigned this rating sampled from the southern part of the region. These streams all lacked significant areas of native vegetation in their catchments, had ineffective riparian zones that were dominated by

introduced grasses and included a few scattered gums, and showed evidence of significant nutrient enrichment effects (eg very high nutrient concentrations, large algal growths, anaerobic sediments, dominance by organic-feeding macroinvertebrates) and some were also affected by high salinity.

The only stream that was given a Very Poor rating was Walkers Creek in the North Para River catchment. This site was also found among cleared agricultural land to the north of Adelaide, and was characterised by a lack of remnant native vegetation near the stream, no functioning riparian zone separating the creek from adjacent land uses, showed excessive signs of nutrient enrichment, was highly saline, and provided habitat for only a sparse assemblage of the most pollution-tolerant macroinvertebrates.

Variability in panel member ratings

The results in Table 3 show that the expert panel members assigned the same condition rating to 21 of the 38 sites sampled (55%) and the remaining sites only differed by one condition rating of each other. This indicates that there was considerable consistency for rating the sites using this approach and that the conceptual models provided an accurate representation of the range of stream types that occurred in the region in 2016.

It is important to note that it would be unrealistic to expect to obtain complete agreement in rating sites using an expert panel approach, or indeed any other means of integrating and reporting on measures of stream condition (eg classifying sites using indices or models based on the reference-based concept, gradient analysis, comparisons against guidelines) due to the problems associated with separating groups along a continuum of possible groups, using environmental data that is inherently highly variable.

Water chemistry of South Australian streams

Table 5 provides a statistical summary of the major chemistry and algal biomass (estimated using chlorophyll measurements) parameters taken at each of the wet sites in autumn and spring. The results have been summarised for each season and combined to provide an indication of the measured variation in individual parameters during 2016.

Most streams were fresh to moderately fresh (salinity 400–1,200 mg/L based on converting electrical conductivity units x 0.6), alkaline (pH >7), well oxygenated (>7mg/L), enriched with nitrogen (>0.5 mg/L and many >1 mg/L) and with a low to moderate amount of chlorophyll (<5 ug/L).

There are only a few undisturbed streams that are covered in remnant native vegetation that can provide a benchmark or reference for the water quality of streams in the region. They include streams located within nature conservation reserves (eg First Creek in Cleland Conservation Park and parts of Sixth Creek in Montacute Conservation Park) in upland, rocky, steeply sloping landscapes that have historically been unsuitable for development. However, there are too few of these streams distributed across the region and none located in mid to lowland reaches that can provide an undisturbed reference for the many streams that occur among catchments that were substantially cleared and modified for agriculture and residential housing over 100 years ago.

To overcome this type of problem, the US EPA (2000) advocated using the 25th percentile of all data from a region to help set nutrient thresholds, which were expected to approximate the tipping point where streams were likely to be at increased risk of being degraded by excess nutrients. Using this approach, the data provided in Table 5 indicates that the nutrient thresholds for the Western Mount Lofty Ranges based on 2016 data were as follows:

Western Mount Lofty Ranges	*Total Nitrogen (TN) 0.45 mg/L*
	Total Phosphorus (TP) 0.02 mg/L

These concentrations are comparable to those often cited in the scientific literature using the same statistical criterion (see Chambers *et al* 2012 and Smucker *et al* 2013) and similar to the trigger values of TN = 0.5 mg/L and TP = 0.02 mg/L that were proposed for the protection of sensitive mayflies and stoneflies from South Australian waters (Corbin and Goonan 2010).

Previous thresholds using this same statistical approach for sites sampled from the same region in recent years have showed some minor variation with TN but a consistent TP value. For example in 2015, the 25th percentile from 17 sites sampled provided a TN = 0.37 mg/L, whereas in 2013 the nutrient values from 46 sites sampled gave a TN = 0.6 mg/L. The generally higher nitrogen values recorded in 2013 may have been climate related, due to the hot temperatures and average rainfall patterns recorded across the region in that year (Bureau of Meteorology website climate summaries[1]. In comparison, 2015 was a warm year with below average rainfall which may have reduced the amount of nutrient entering streams from adjacent agricultural and urban sources. A warm autumn and cold spring characterised 2016, with many parts of the Mount Lofty Ranges recording the wettest year on record which probably caused more of a dilution effect as compared to the other years sampled (Bureau of Meteorology website)[2].

Conceptual models

A central assumption of the conceptual models was that the high nutrient concentrations (eg nitrogen and phosphorus) recorded from South Australian streams originated from human activities in each catchment, rather than from some unknown natural source (eg NLWRA 2001). This is consistent with the general poor nutrient status of ancient Australian soils and the need for native plants to conserve and recycle nutrients, rather than allow the regular export of nitrogen and phosphorus from the land into streams, where the nutrients may eventually be deposited many kilometres away.

Consequently, it was assumed that historical and present stock and feral animal grazing land uses, and cropping activities since European settlement have contributed towards the nutrient enrichment of many streams in each region in modern times. This may be evident through measuring higher than expected concentrations of nutrients in water samples (eg TN> 0.5 mg/L or TP> 0.02 mg/L as described above) and/or noting signs of enrichment due to the presence of particularly large growths of phytoplankton, filamentous algae or aquatic plants.

Under such conditions, a generalist assemblage of aquatic macroinvertebrates typically dominates because they are capable of exploiting the high plant productivity and tolerating occasional poor water quality events that often occur in such streams. In contrast, few if any of the regionally rare, sensitive and/or habitat specialists would be expected to occur in such streams, and never in large numbers. These types of enrichment responses were subsequently incorporated into the conceptual models to represent the biological and chemical patterns that have been described in the scientific literature for well over 100 years.

Similarly, another assumption of the models was that the very high salinity of some streams in each region has been caused, or at least exacerbated, by the extent of native vegetation clearance and replacement by cropping and grazing practices in some catchments in the past, which has in some cases created conditions that has promoted the secondary salinisation of streams due to inflow of saline groundwater.

High salinity has been recognised as a major factor for the loss of salt-sensitive species and creation of conditions that favour only the more salt-tolerant species to be able to colonise and subsequently complete their lifecycles. Recent research indicates that most freshwater species are generally replaced by salt tolerant species when salinities exceed about 5,000–10,000 mg/L, and that different threshold effects are evident with different taxonomic groups (eg Nielsen *et al* 2008, Kefford *et al* 2011).

While it is possible that some streams from parts of the Mount Lofty Ranges may have approached or exceeded this salinity range prior to European settlement, it was assumed as part of this assessment that the extensive land-use changes brought about by farming has mobilised more salt into each affected stream than would have occurred if the landscape had remained unchanged, and that streams with a salinity at or above 5,000 mg/L represent a highly disturbed state in the conceptual models for the region.

1 www.bom.gov.au/climate/current/statement_archives.shtml

2 www.bom.gov.au/climate/current/

Dry sites

Finally, it should be noted that the ratings for dry sites in particular, may vary when water is present. This should, however, be considered within the broader context of the variability that will occur in any stream in response to differences in the frequency and timing of floods and droughts, in the distribution and abundance of stock and feral animals accessing stream reaches, and the many other biological, chemical and physical habitat changes that undoubtedly occur over time. Despite this, the ratings assigned in this report provide what are expected to be an accurate condition assessment of those sites sampled in 2016 using the conceptual model that was specifically developed for the Western Mount Lofty Ranges.

References

Catchment Simulations Solutions 2011,*Spatially balanced sampling site selection for streams in South Australia: Pilot project for Adelaide and Mount Lofty Ranges region*, unpublished report to the Environment Protection Authority, Revision 2, May 2011.

Chambers PA, McGoldrick DJ, Brua RB, Vis C, Culp JM and GA Benoy 2012, 'Development of environmental thresholds for nitrogen and phosphorus in streams', *Journal of Environmental Quality* 41:7–10.

Corbin TA and PM Goonan 2010, 'Habitat and water quality preferences of mayflies and stoneflies from South Australian streams', *Transactions of the Royal Society of South Australia* 134:5–18.

Davies SP and SK Jackson 2006, 'The biological condition gradient: a descriptive model for interpreting change in aquatic ecosystems', *Ecological Applications* 16:1251–1266.

Kefford BJ, Marchant R, Schafer RB, Metzeling L, Dunlop JE, Choy SC and P Goonan 2011, 'The definition of species richness used by species sensitivity distributions approximates observed effects of salinity on stream macroinvertebrates', *Environmental Pollution* 159:302–310.

National Land and Water Resources Audit 2001, *Nutrient balance in regional farming systems and soil nutrient status*, Final report NLWRA, September 2001.

Nielsen DL, Brock MA, Vogel M and R Petrie 2008, 'From fresh to saline: a comparison of zooplankton and plant communities developing under a gradient of salinity with communities developing under constant salinity levels', *Marine and Freshwater Research* 59:549–559.

Smucker NJ, Becker M, Detenbeck NE and AC Morrison 2013, 'Using algal metrics and biomass to evaluate multiple ways of defining concentration-based nutrient criteria in streams and their ecological relevance', *Ecological Indicators* 32:51–61.

Stevens DL Jr and AR Olsen 2004, 'Spatially balanced sampling of natural resources', *Journal of the American Statistical Association* 99:262–278.

US EPA 2000, *Ambient water quality criteria recommendations, information supporting the development of state and tribal nutrient criteria, rivers and streams in nutrient ecoregion XIV*, EPA_822-B-00-002, Office of Science and Technology, Office of Water, US Environmental Protection Agency, Washington DC.

Further information

Legislation

Online legislation is freely available. Copies of legislation are available for purchase from:

Service SA Government Legislation Outlet
Adelaide Service SA Centre
108 North Terrace
Adelaide SA 5000

Telephone: 13 23 24
Facsimile: (08) 8204 1909
Website: shop.service.sa.gov.au
Email: ServiceSAcustomerservice@sa.gov.au

General information

Environment Protection Authority
GPO Box 2607
Adelaide SA 5001

Telephone: (08) 8204 2004
Facsimile: (08) 8124 4670
Freecall: 1800 623 445 (country)
Website: www.epa.sa.gov.au
Email: epainfo@epa.sa.gov.au

Table 1 Conceptual model of ecological responses to a disturbance gradient in the Adelaide and Mount Lofty Ranges NRM region

Rating	Excellent	Very Good	Good	Fair	Poor	Very Poor
Stressor description	As naturally occurs; probably no longer present in the western Mount Lofty Ranges due to the level of vegetation clearance and landscape modification. Streams with natural vegetation communities, such as First and Sixth creeks and low-order streams in the upper South Para River in the Mount Lofty Ranges, and coastal creeks on the southern Fleurieu Peninsula (eg Aaron Creek, lower reaches of The Deep Creek and First Creek) may represent this state on occasions but the presence of introduced species and nutrient enrichment associated with human uses in the catchment precludes rating sites in the region as Excellent.	Least impacted streams with largely natural vegetation and low levels of human disturbance are not common in the region and may only include First and Sixth creeks and low order streams in the upper South Para River in the Mount Lofty Ranges, and coastal creeks on the southern Fleurieu Peninsula (eg Aaron Creek, lower reaches of The Deep Creek and First Creek). These streams have few introduced species present and show little sign of nutrient enrichment.	Best condition sites showing initial signs of enrichment; likely to occur in streams with large areas of natural vegetation remaining in their catchments and generally characterised by permanent/near permanent, flowing, freshwater habitats but may also include more ephemeral habitats. Numerous streams in the watersheds of all the water reservoirs in the region would be expected to represent this condition in most years.	Moderate nutrient enrichment: likely to commonly occur in the region due to the extent of vegetation clearance and associated agricultural development. This is likely to result in significant nutrient enrichment and sediment effects, and result in poorer ratings being assigned.	Gross nutrient enrichment or degradation; likely to commonly occur in the region due to the extent of vegetation clearance and associated agricultural development and urbanisation. Ephemeral and saline streams in the region are likely to show extensive enrichment effects due to the lack of substantial dilution flows in most years.	Severely altered; may occur in the region in urban stream reaches, downstream from wastewater discharges and highly degraded ephemeral and more permanent streams in extensively cleared agricultural settings. Sites assigned to this rating will be affected by a toxicant or other disturbance that significantly limits the diversity and abundance of aquatic life present in a stream.

Rating	Excellent	Very Good	Good	Fair	Poor	Very Poor
Biological assemblages	Native assemblages of plants and animals; usually with many rare or sensitive species present; typically high *Ephemeroptera, Plecoptera* and *Trichoptera* (EPT) richness; no symptoms of stress or introduced aquatic species present. Temporary and ephemeral habitats have a low EPT richness but provide habitat for many colonising insects (eg beetles, waterbugs and dipterans); abundances of all species generally low.	Best of what is left, least disturbed assemblages; high richness; intolerants and specialist taxa dominate abundances; may include some introduced species present in low abundances.	Typical assemblages for least impacted streams; good richness; generalist assemblage that includes at least some rare and sensitive species; emerging symptoms of stress in relation to nutrients and fine sediments; at least some remnant native vegetation present.	Impaired assemblages; generalists and tolerant taxa dominate numbers which usually includes some very abundant taxa; sensitive and rare taxa, if present, in very low numbers; usual absence of some taxa expected for the available habitats present; at least some trees present in the local catchment and on the banks.	Degraded assemblages; tolerant and generalist species dominate but numbers usually reduced, although 1–2 generalist taxa may be present in high abundances; only 1–2 rare or sensitive species present in low abundances or absent; often only few scattered trees in the catchment and on the banks.	Severely degraded assemblages with few taxa and generally low abundances; may have large numbers of one tolerant taxon, such as worms, mosquito larvae, amphipods (*Austrochiltonia*) or midges (*Chironomus, Tanytarsus or Procladius)*; can include organic feeders in highly polluted waters (eg syrphid larvae); vegetation often completely comprised introduced or planted species.
Water chemistry conditions	As naturally occurs; no human sources of contaminants present (eg nutrient enrichment, deposits of waste with high levels of hormones not impacting on water quality) and no pest species.	Least disturbed; high proportion natural features means waters are well oxygenated and low in nutrients and turbidity; may be coloured due to tannins sourced from native plants.	Largely unremarkable water quality with at least some nutrients present at higher concentrations than expected, coupled with at least one plant indicator showing emerging signs of enrichment effects (eg chlorophyll *a* >10 ug/L,	Fair water quality with generally saturated dissolved oxygen (when sampled during the day); at least one nutrient present at a high concentration and high plant productivity (eg chlorophyll *a* >10ug/L, filamentous algae >10% cover	Poor water quality with generally saturated dissolved oxygen (when sampled during the day); nutrients present at high concentrations and high plant productivity evident at the site (eg usually chlorophyll *a* >10ug/L, filamentous algae >10%	Very poor water quality with at least one parameter at a toxicant concentration that is likely to limit the aquatic diversity of a stream; often very low dissolved oxygen and may be saline and enriched in nutrients but algal and plant growth limited.

Rating	Excellent	Very Good	Good	Fair	Poor	Very Poor
			filamentous algae >10% cover and/or macrophytes >35% cover); but site not overwhelmed.	and/or macrophytes >35% cover) evident on occasions.	cover and macrophytes >35% cover) most of the time.	
Physical habitat and flow patterns	Natural habitat and flow patterns; no or few farm dams present; range of sediment types present and not always anaerobic.	Near natural habitat and flow regimes; mostly well vegetated catchments with few dams present; range of sediment types present and not always anaerobic.	Good habitat structure and flow patterns; extent of dam development has not caused an obvious loss of riffle (flowing) habitats; range of sediment types present and not always anaerobic.	Fair habitat structure and flow patterns; many dams may be present in the catchment and likely to affect flow patterns; anaerobic fine sediments usually present, except when large algal growths occur and oxygenate the sediments.	Poor habitat structure and flow patterns; may have many dams present in the catchment and obviously affect flow patterns; anaerobic fine sediments usually present, except when large algal growths occur and oxygenate the sediments.	Severe modifications to physical habitat and usually with unnatural flow patterns due to abstraction or discharges; little to no remnant native vegetation remaining; cleared agricultural or urban sites; anaerobic fine sediments, rip-rap or alien sediments often present.
Human activities and sources in the catchment	No obvious human disturbances but may include roads and sparse rural housing; no point sources and diffuse pollution not detectable, largely due to the extent of vegetation surrounding each stream.	No significant human disturbances but may include some rural housing and roads; no point source discharges and diffuse pollution not obviously affecting the aquatic ecosystem due to the extent of native vegetation surrounding each stream.	Effects of human disturbance becoming obvious; point sources may be present but do not dominate flows; good buffer zones and/or riparian vegetation present that help to mitigate diffuse pollution effects from surrounding land uses.	Point and diffuse source enrichment effects evident; riparian zone not effective at mitigating nutrients and fine sediment typically entering these streams.	Obvious point and/or diffuse source enrichment effects present; unbuffered channel with ineffective riparian vegetation other than introduced grasses; major changes to catchment land use with little remnant vegetation remaining and agriculture and/or urban uses dominate.	Severe point and/or diffuse source effects that may include toxicant responses; effects dominate water quality and biological response with little signs of the original waterway evident; unbuffered channel that has undergone extreme modifications in an urban or agricultural setting.

Table 2 List of biota expected to occur for each rating in the Adelaide and Mount Lofty Ranges NRM region

Streams in an Excellent condition probably no longer occur in the region; they would be expected to support some sensitive and rare species, similar to sites in very good condition, but have no introduced species present.

	Very Good	Good	Fair	Poor	Very Poor
Attribute 1 **Rare and/or regionally endemic**	**Ephemeroptera** *Tasmanophlebia;* **Trichoptera** *Ulmerochorema;* **Diptera** Thaumaliidae (*Austrothaumalea*); **Fish** *Galaxias olidus*	**Ephemeroptera** *Tasmanophlebia;* **Trichoptera** *Ulmerochorema;* **Diptera** Thaumaliidae (*Austrothaumalea*); **Fish** *Galaxias olidus*	**Trichoptera** *Ulmerochorema*; **Fish** *Galaxias olidus*	None present	None present
Attribute 2 **Sensitive, rare or vulnerable specialist taxa with narrow environmental requirements**	**Ephemeroptera** *Offadens*, *Centroptilum;* **Plecoptera** *Illiesoperla, Newmanoperla, Riekoperla*; **Trichoptera** *Lingora, Triplectides similis, Taschorema, Oxyethira columba, Leptorussa, Orphninotrichia, Cheumatopysche;* **Odonata** *Hemigomphus, Austrogomphus;* **Diptera** *Paracnephia* and Chironomidae (*Riethia);* **Coleoptera** *Simsonia*	**Ephemeroptera** *Offadens, Centroptilum*; **Plecoptera** *Illiesoperla, Newmanoperla, Riekoperla;* **Trichoptera** *Lingora, Triplectides similis, Taschorema, Leptorussa, Orphninotrichia, Cheumatopysche;* **Odonata** *Hemigomphus, Austrogomphus;* **Diptera** *Paracnephia* and Chironomidae (*Riethia);* **Coleoptera** *Simsonia*	**Ephemeroptera** *Offadens*; **Plecoptera** *Illiesoperla, Riekoperla;* **Trichoptera** *Lingora, Triplectides similis, Taschorema, Leptorussa, Cheumatopysche*	None present	None present
Attribute 3 **Sensitive, ubiquitous taxa**	**Ephemeroptera** *Thraulophlebia, Atalophlebia*; **Plecoptera** *Dinotoperla, Austrocerca;* **Diptera** *Austrosimulium, Simulium melatum*	**Ephemeroptera** *Thraulophlebia, Atalophlebia*; **Plecoptera** *Dinotoperla, Austrocerca;* **Diptera** *Austrosimulium, Simulium melatum*	**Ephemeroptera** *Thraulophlebia, Atalophlebia;* **Plecoptera** *Dinotoperla, Austrocerca;* **Diptera** *Austrosimulium, Simulium melatum*	**Ephemeroptera** *Atalophlebia australis;* **Plecoptera** *Austrocerca* (low numbers if present)	None present in region

	Very Good	Good	Fair	Poor	Very Poor
Attribute 4 **Opportunistic or generalist taxa**	**Hydracarina** (*Oxus, Procorticacarus, Piona,* Oribatidae); **Mollusca** *Angrobia, Ferrissia, Glyptophysa;* **Ephemeroptera** *Cloeon*, *Tasmanocoenis*; **Trichoptera** *Notalina*, *Oecetis, Triplectides, Hellyethira, Ecnomus, Lectrides;* **Odonata** Aeschnidae, Telephlebiidae*;* **Diptera** Dixidae, Empididae, Chironomidae *(Eukiefferiella, Thienemaniella, Rheotanytarsus);* **Coleoptera** low numbers of aquatic beetles may be present	**Hydracarina** (*Oxus, Procorticacarus, Piona,* Oribatidae); **Mollusca** *Angrobia, Ferrissia, Glyptophysa;* **Ephemeroptera** *Cloeon*, *Tasmanocoenis*; **Trichoptera** *Notalina*, *Oecetis, Triplectides, Hellyethira, Ecnomus, Lectrides;* **Odonata** *Xanthagrion*, *Austrolestes*, *Hemicordulia,* Aeschnidae, Telephlebiidae*;* **Diptera** Dixidae, Empididae, Chironomidae *(Eukiefferiella, Thienemaniella, Cladotanytarsus, Rheotanytarsus);* **Coleoptera** *Sternopriscus, Necterosoma, Chostonestes, Limnoxenus, Macrogyrus, Platynectes*	**Hydracarina** (*Oxus, Procorticacarus, Piona,* Oribatidae); **Mollusca** *Angrobia, Ferrissia, Glyptophysa (*often in high numbers)*;* **Ephemeroptera** *Cloeon*, *Tasmanocoenis*; **Trichoptera** *Notalina*, *Oecetis, Triplectides, Hellyethira, Ecnomus, Lectrides;* **Odonata** *Xanthagrion*, *Austrolestes*, *Hemicordulia;* **Diptera** Dixidae, Chironomidae *(Eukiefferiella, Thienemaniella, Cladotanytarsus, Rheotanytarsus);* **Coleoptera** *Sternopriscus, Necterosoma, Chostonestes, Limnoxenus, Macrogyrus, Platynectes*	**Hydracarina** (*Piona,* Oribatidae); **Mollusca** *Angrobia, Glyptophysa* (often in high numbers)*;* **Ephemeroptera** (in low numbers) *Cloeon*, *Tasmanocoenis*; **Trichoptera** *Triplectides, Hellyethira;* **Odonata** *Xanthagrion*, *Austrolestes*, *Hemicordulia;* **Diptera** Chironomidae *(Cladotanytarsus, Tanytarsus);* **Coleoptera** *Sternopriscus, Necterosoma, Platynectes*	**Coleoptera** *Necterosoma*

	Very Good	Good	Fair	Poor	Very Poor
Attribute 5 **Tolerant taxa**	**Turbellaria**; **Nematoda; Oligochaeta; Amphipoda** *Austrochiltonia*; **Decapoda** *Paratya, Cherax;* **Diptera** *Simulium ornatipes,* Culicidae (low numbers), Ceratopogonidae (*Alluauodomyia, Dasyhelea, Nilobezzia, Ceratopogon, Bezzia, Culicoides*), Chironomidae (*Procladius, Paramerina, Parametriocnemus, Paralimnophyes, Cricotopus, Chironomus, Dicrotendipes);* **Hemiptera** (low numbers of *Microvelia, Micronecta, Agraptocorixa, Anisops, Enithares);* **Odonata** *Ischnura*	**Turbellaria**; **Nematoda; Oligochaeta; Amphipoda** *Austrochiltonia*; **Decapoda** *Paratya, Cherax;* **Diptera** *Simulium ornatipes,* Culicidae, Stratiomyidae, Ceratopogonidae (*Alluauodomyia, Dasyhelea, Nilobezzia, Ceratopogon, Bezzia, Culicoides*), Chironomidae (*Procladius, Paramerina, Parametriocnemus, Paralimnophyes, Cricotopus, Chironomus, Dicrotendipes);* **Hemiptera** (moderate numbers of *Microvelia, Micronecta, Agraptocorixa, Anisops, Enithares);* **Odonata** *Ischnura*	**Turbellaria**; **Nematoda; Oligochaeta; Mollusca** Hydrobiidae*;* **Amphipoda** *Austrochiltonia*; **Decapoda** *Paratya, Cherax*; **Collembola; Diptera** *Simulium ornatipes,* Culicidae (often high numbers), Stratiomyidae, Ceratopogonidae (*Bezzia, Culicoides*), Chironomidae (*Procladius, Paramerina, Parametriocnemus, Paralimnophyes, Cricotopus, Chironomus, Dicrotendipes);* **Hemiptera** (often high numbers of *Microvelia, Micronecta, Agraptocorixa, Anisops, Enithares);* **Odonata** *Ischnura*	**Turbellaria**; **Nematoda; Oligochaeta; Mollusca** Hydrobiids; **Amphipoda** *Austrochiltonia*; **Decapoda** *Paratya, Cherax*; **Collembola; Diptera** *Simulium ornatipes,* Culicidae (often high numbers), Stratiomyidae, Ceratopogonidae (*Bezzia, Culicoides*), Chironomidae (*Procladius, Paramerina, Parametriocnemus, Paralimnophyes, Cricotopus, Chironomus, Dicrotendipes);* **Hemiptera** (often high numbers of *Microvelia, Micronecta, Agraptocorixa, Anisops, Enithares);* **Odonata** *Ischnura*	**Oligochaeta** (often in high numbers)**; Amphipoda** *Austrochiltonia*; **Collembola**; **Diptera** Culicidae*,* Stratiomyidae, Ceratopogonidae (*Bezzia, Culicoides*)*,* Chironomidae (*Procladius*, *Chironomus*; the latter sometimes in large numbers); **Hemiptera** *Micronecta, Anisops, Enithares*
Attribute 6 **Non-endemic or introduced taxa**	**Mollusca** *Physa* and *Potamopyrgus* in low numbers; **Decapoda** *Cherax tenuimanus*	**Mollusca** *Physa* and *Potamopyrgus* in low to moderate numbers; **Decapoda** *Cherax tenuimanus*	**Mollusca** *Physa* and *Potamopyrgus* in moderate to high numbers*;* **Decapoda** *Cherax tenuimanus;* **Fish** *Gambusia*	**Mollusca** *Physa* and *Potamopyrgus* in moderate to high numbers*;* **Fish** *Gambusia*	**Mollusca** *Physa;* **Fish** *Gambusia* (rarely present due to poor water quality)

Note: Only 2 species found previously in this region (in 2008, 2011 and/or 2013) were not collected in 2016; the caddisfly *Apsilochorema* and the dipteran *Thaumaliidae (Austrothaumalea)*.

Table 3 Condition ratings given by each panel member and final overall rating for the 38 sites assessed from the Adelaide and Mount Lofty Ranges NRM region during 2016

Note: Site codes indicate the year sampled. NRM region followed by the site number. Refer to the EPA website www.epa.sa.gov.au for the site map coordinates and the site-based aquatic ecosystem condition reports.

[1] denotes the five best condition sites based on prior knowledge of creeks and rivers in each region; these were not necessarily expected to represent the best condition sites that were being assessed during 2013

[2] denotes the five worst condition sites based on prior knowledge of creeks and rivers in each region; these were not necessarily expected to represent the worst condition sites that were being assessed during 2013

[3] denotes the sites that were selected by each NRM/DEWNR (Natural resource management and Department of Environment, Water and Natural Resouces) to assist with water allocation planning in each region

[4] denotes the habitats at each site, eg dry sites, or if edge (E) or both edge and riffle (ER) aquatic habitats were present; results for each autumn and spring sampling period were separated by comma, so E,ER means edge was sampled in autumn and both edge and riffle were sampled in spring). NS indicates sites not sampled

Site code	Site name	Habitats[4]	Very Good	Good	Fair	Poor	Very Poor	Final rating
2016.WMLR05	First Creek, Tunkalilla[1]	ER, ER	2	1				Very Good
2016.WMLR30	Tunkallilla Creek, Arthur Hill	NS, ER	2	1				Very Good
2016.WMLR01	First Creek, upstream from waterfall[1]	ER, ER		3				Good
2016.WMLR02	Scott Creek, Scotts Bottom[1]	ER, ER		2	1			Good
2016.WMLR03	The Deep Creek, middle of the park at culvert[1]	ER, ER		2	1			Good
2016.WMLR04	Brownhill Creek, northern branch[1]	ER, ER		2	1			Good
2016.WMLR13	First Creek, upstream from Waterfall Gully[3]	ER, ER		3				Good
2016.WMLR15	Callawonga Creek, near Callawonga[3]	ER, ER	1	2				Good
2016.WMLR16	Sixth Creek, upstream junction with Torrens River[3]	ER,ER	1	2				Good
2016.WMLR22	Boat Harbour Creek, Boat Harbour[3]	ER, ER		3				Good
2016.WMLR24	Little Para River, One Tree Hill Crossing	E, ER		2	1			Good

Site code	Site name	Habitats[4]	Very Good	Good	Fair	Poor	Very Poor	Final rating
2016.WMLR28	Tunkalilla creek, Eric Bonython Conservation Park	ER, ER		3				Good
2016.WMLR29	Callawonga Creek, north of Taylors Road	E, E		3				Good
2016.WMLR31	Tunkalilla Creek, near conservation land adjacent to Illawonga Road	ER, ER		3				Good
2016.WMLR32	Balaparudda creek, conservation land north of Mount Scrub Road	E, ER		3				Good
2016.WMLR33	Brownhill creek, Brownhill Creek Road near CFS track	ER, ER		2	1			Good
2016.WMLR34	Brownhill creek, Brownhill Creek Road	ER, ER		2	1			Good
2016.WMLR35	Jacobs Creek, Kaiser Gauge Station	E, ER		2	1			Good
2016.WMLR36	Myponga Creek, Myponga pump shed	ER, ER		3				Good
2016.WMLR40	Deep Creek, near Norton Summit	ER, ER		2	1			Good
2016.WMLR07	Sturt River, Sturt Road[2]	E, E			3			Fair
2016.WMLR08	Cox Creek, Uraidla[2]	E, E			2	1		Fair
2016.WMLR11	North Para River, near Chateau Yaldara Winery[3]	ER, ER			3			Fair
2016.WMLR12	Tanunda Creek, Bethany Reserve[3]	Dry, ER			3			Fair
2016.WMLR14	Brownhill Creek, downstream from caravan park[3]	ER, ER		1	2			Fair
2016.WMLR18	Aldgate Creek, Mylor[3]	ER, ER		1	2			Fair
2016.WMLR23	Campbell Creek, downstream from Talisker Mine	ER, ER			3			Fair
2016.WMLR27	First Creek, off Tunkalilla Road	ER, E			3			Fair
2016.WMLR06	South Para River, south-eastern edge of Gawler[2]	Dry, E			1	2		Poor

Site code	Site name	Habitats[4]	Very Good	Good	Fair	Poor	Very Poor	Final rating
2016.WMLR09	Inverbrackie Creek, Woodside[2]	E, E				3		Poor
2016.WMLR17	Back Valley Creek, upstream junction with Kirk Road[3]	E, E				3		Poor
2016.WMLR19	Millers Creek, south from Forreston[3]	E, E				3		Poor
2016.WMLR20	River Torrens, north from Mount Pleasant[3]	E, E				3		Poor
2016.WMLR21	Pedler Creek, upstream from Landcross Farm[3]	Dry, Dry				2	1	Poor
2016.WMLR37	Light River, Pinkerton Plains	E, ER				3		Poor
2016.WMLR38	Light River, Kapunda Bridge	ER, ER			1	2		Poor
2016.WMLR39	Light River, Linwood	E, E				3		Poor
2016.WMLR10	Walkers Creek, southeast from Freeling[2]	E, E					3	Very Poor

Table 5 Water chemistry and algal summary statistics from sites sampled from the Western Mount Lofty Ranges in 2016 (units given are mg/L unless otherwise indicated)

Parameter	Autumn (n=34 wet sites)				Spring (n=37 wet sites)				Combined Autumn + Spring (n=71 wet sites both seasons combined)			
	mean	25th percentile	50th percentile	75th percentile	mean	25th percentile	50th percentile	75th percentile	mean	25th percentile	50th percentile	75th percentile
Chlorophyll *a* (ug/L)	4.77	0.60	1.57	2.43	2.24	0.46	0.88	1.9	3.45	0.49	1.23	2.41
Chlorophyll *b* (ug/L)	0.67	0.05	0.05	0.05	0.27	0.05	0.05	0.05	0.46	0.05	0.05	0.05
Oxidised N (NOx)	0.17	0.00	0.05	0.15	0.08	0.0015	0.013	0.047	0.12	0.00	0.03	0.11
Total nitrogen	1.06	0.59	0.88	1.29	0.88	0.394	0.782	1.095	0.96	0.45	0.78	1.15
Total phosphorus	0.11	0.02	0.05	0.09	0.13	0.02	0.032	0.044	0.12	0.02	0.04	0.08
Water temperature (°C)	12.02	10.83	11.70	12.73	18.48	16.1	17.8	21	15.39	11.90	14.90	17.85
Conductivity (uS/cm)	1888.88	303.50	543.00	1259.25	2155.40	542	964	1945	2027.77	375.00	726.00	1782.50
Dissolved oxygen	8.27	7.51	8.50	9.05	7.96	7.18	7.96	8.48	8.12	7.30	8.19	8.90
pH (pH units)	7.76	n/a	n/a	n/a	7.46	n/a	n/a	n/a	7.60	n/a	n/a	n/a