Aquatic ecosystem condition reports

2013 panel assessment of creeks and rivers from the Kangaroo Island and Adelaide and Mount Lofty Ranges NRM regions

Issued July 2014

EPA 1048/14: This information sheet describes the outcome of the panel assessment of creeks and rivers from the Kangaroo Island and Adelaide and Mount Lofty Ranges Natural Resources Management (NRM) regions, sampled during autumn and spring 2013.

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 rnvironment 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 Macro-invertebrates

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 on Kangaroo Island and the Western Mount Lofty Ranges during 2013.

Site selection

A total of 77 sites were sampled during autumn and spring 2013, comprising 31 sites from Kangaroo Island and 46 sites from the Adelaide and Mount Lofty Ranges NRM regions.

Kangaroo Island NRM region

The sample sites were largely selected from a list of previously sampled (fixed) sites throughout the island to ensure that the spatial extent of the stream network that could be accessed by roads. Sites were located across the elevational gradient (eg lowland, mid-reach and upper reach) of many of the major streams to assist with future water resource planning by the Kangaroo Island NRM (KI NRM). A new site was included from the lower reach of Chapman River, just upstream from Lashmar Lagoon, on request by the KI NRM; previous sampling in this catchment had been limited to the mid- and upper reaches. Additional sites were also included in the Middle River catchment upstream from the reservoir, to assist with a current review of water allocation planning carried out by the Department for Environment, Water and Natural Resources (DEWNR). One randomly located site was also included (tributary of Western River) from a list of potential back-up sites, to replace a site from Rocky River that could not be sampled.

In order to build on more than 20 years of knowledge about the water quality and ecology of streams from the island, sampling was also carried out on five of the previously identified ‘best condition’ and five of the ‘worst condition’ streams to provide context for defining the condition gradient that was subsequently going to be based on 2013 data.

Note that this sampling design provides targeted information about the fixed sites that are sampled and only gives an indication of the general condition of waters in each region. The lack of randomly selected sites limits the ability for this design to provide a statistically valid assessment of all waters in a region with some measure of known error (Stevens and Olsen 2004).

Adelaide and Mount Lofty Ranges NRM region

A combination of fixed and random sites were selected for sampling from the region in consultation with staff from the AMLR NRM and DEWNR. The fixed sites included 12 previously sampled sites that have significance for water resource planning in the region. Another six sites were also included from the Barossa area to provide DEWNR with additional data and information to assist with water allocation planning and assessment work that is currently underway in the upper North Para River catchment.

Similar with Kangaroo Island, previous knowledge was used to select five of each of the ‘best’ and ‘worst’ condition sites from the Western Mount Lofty Ranges to provide context for defining the condition gradient that was used to assess the data collected from the region in 2013. The remaining 18 sites were randomly selected from a stream reach database developed for South Australia by the EPA (Catchment Simulations Solution 2011). This approach ensured that sites were distributed throughout the stream network in the region, including lower-order tributaries that rarely hold water.

Site randomisation and validation

The random sites were selected using an unequal probability of selection criterion to ensure a similar number of sites were generated for each stream order (Catchment Simulations Solution 2011). Streams rise as a large network of small first-order streams that rarely hold water unless they exist as a chain-of-ponds, and where they join form a second-order stream, and where second-order streams join form a third-order stream, and so on further down the stream network.

This sampling design using randomly selected sites provides a statistically valid approach to report on the condition of all waters in the region (see Stevens and Olsen 2004 and references) and enables the results to be reported as kilometres or percentage of streams in a region with different condition ratings, or subject to a specific pressure (eg nutrient enrichment, fine sediment deposition and degraded riparian zones).

For the Western Mount Lofty Ranges region, nearly 67,000 stream order 1 sites were available for final selection whereas there were only a few thousand sites from stream orders 6 and 7 that were potentially available. Since there are so few large streams in the region, only three sites were selected from the combined grouping of stream orders 6 and 7; three sites were sampled from each of the other stream orders.

Only sites located within 250 m from the nearest road were included in the final listing of potential sites to minimise the distance involved in walking across farmland and to limit any potential conflicts with landowners (Catchment Simulations Solution 2011). The sites were then overlain on topographic maps and viewed using Google Maps™ to ensure they were located on a stream network and appeared suitable to sample (eg not in a farm dam or reservoir). Any unsuitable sites or sites where landowner access was subsequently refused were omitted and then the next randomly selected site was evaluated for its suitability to sample. The final selection of sites was carried out by the field sampling team, resulting in a small number of sites being relocated a few hundred metres from the original coordinates to avoid potential conflicts with farming practices (eg presence of stock) or proximity to a dam.

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).

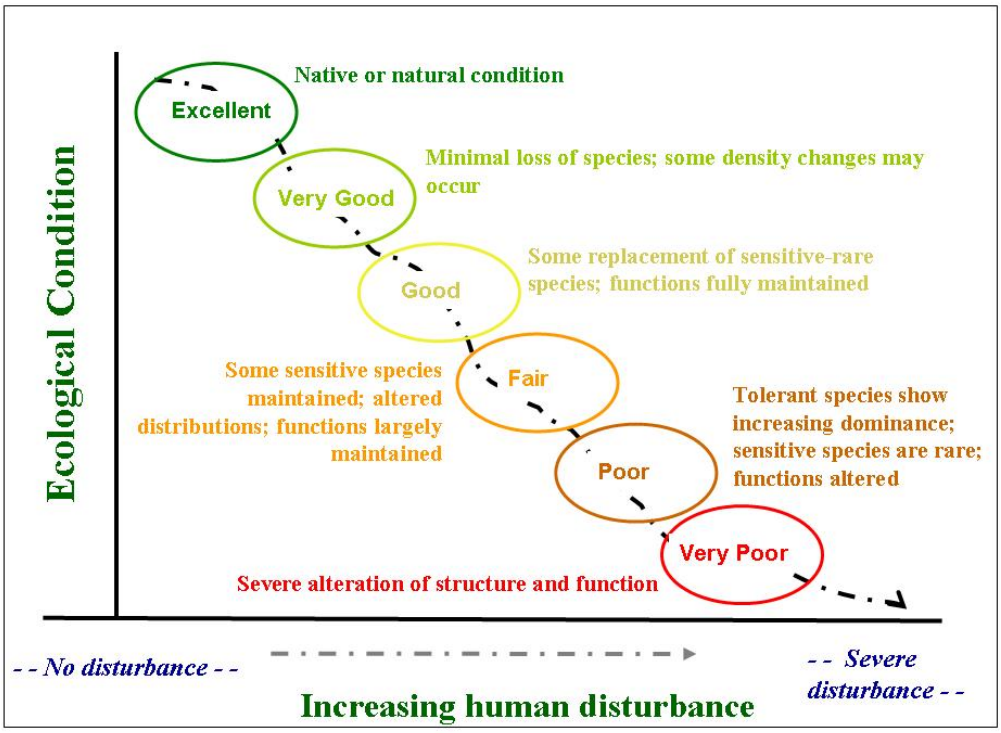

Figure 1 **Human disturbance gradient showing the six different ecological condition grades or ratings ranging from excellent (best) to very poor (worst) with a brief definition of each condition**

The process used to grade or rate sites involved the following steps:

1 Conceptual models describing the ecological responses to general disturbance gradients were developed, reviewed and updated by the panel; separate models were developed for Kangaroo Island and the Western Mount Lofty Ranges to represent the different stream types that possibly occurs in the these regions (Tables 1–2).

2 Species lists were compiled for each model which described the expected biotic assemblage for up to six potential condition ratings, based on the data that was collected in 2013; separate species lists were developed for Kangaroo

Island and the Western Mount Lofty Ranges to describe any obvious biotic differences that occur across these regions (Tables 3–4).

3 Each site was given a rating based on the macro-invertebrate communities, vegetation assemblages, water chemistry and sediment features 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 sites would probably rate differently but the assessment was based on the conditions that occurred during 2013.

4 The individual ratings derived by the panel members were combined to produce an overall, or final, rating for each site (Table 5).

The final reported ratings were derived by determining the mode rating (most common rating from the panel ratings for each site); in cases where the panel members disagreed and recommended three possible ratings, the final rating was determined by omitting the best and worst rating and selecting the middle rating. In the interests of being open and transparent, all results have been included in Table 5 to show where the panel agreed or showed some difference in opinion.

The ratings in the model range from Excellent to Very Poor. However, given the presence of introduced aquatic species and the extent of stock and feral animal grazing in each region, the panel considered that Excellent probably no longer occurs and was certainly not evident from the sites sampled in 2013. Similarly, the Very Poor rating was also unlikely to occur on Kangaroo Island because it typically applies to severely altered streams in urban areas or downstream from mines leaking metals, acid or salt into local waterways; only some of the more urbanised streams or reaches downstream from wastewater treatment plants in the Western Mount Lofty Ranges were expected to approach this condition.

Results

The results for the 2013 sampling are summarised in Table 5.

Table 5 Overall condition rating for each site sampled in 2013

Condition rating	Kangaroo Island # and (%) sites	Mount Lofty Ranges # and (%) sites	Total number
Excellent	0	0	0
Very Good	3 (10%)	2 (4%)	5
Good	3 (10%)	10 (22%)	13
Fair	15 (48%)	14 (30%)	29
Poor	10 (32%)	18 (39%)	28
Very Poor	0	2 (4%)	2
TOTAL	**31**	**46**	**77**

The sites that were assigned with a Very Good rating included two from Rocky River (KI01 and 31) and a site from Breakneck River (KI02) within Flinders Chase National Park st the western end of Kangaroo Island, and two streams called First Creek from the Western Mount Lofty Ranges; one site was located near Adelaide upstream from the waterfall in Cleland Conservation Park (WMLR13) and the other site was from a coastal stream near Tunkalilla, on the southern Fleurieu Peninsula (WMLR05). These streams were characterised by the large amount of native vegetation remaining within their catchments, presence of flowing freshwater habitats in spring, and the large number of rare, sensitive and/or flow-dependent macro-invertebrates that were seen at each site in 2013.

Sites assigned to the Good and Fair categories 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 each

region, characterised by the presence of some native vegetation within their catchments, still retained a functioning riparian zone, and provided habitat for at least a few rare, sensitive and/or flow-dependent macro-invertebrates.

The Good sites were also located at the western end of Kangaroo Island, in and around Flinders Chase, and included Ravine des Casoars, De Mole and North West rivers (KI04, 23 and 27 respectively). The AMLR NRM sites were located within the higher rainfall areas of the Adelaide Hills and Fleurieu Peninsula, and included sites from the Little Para River, and Jacobs, Sixth, First, Brownhill, Scott, Callawonga and Boat Harbor creeks, and a site on an unnamed creek at Mount Bold and another from Deep Creek.

The Fair sites were located largely from across the middle of the island and included multiple sites from the Middle River catchment (KI06, 11–14), Harriet River (KI17 and 26), Western River catchment (KI22 and 24), Cygnet River catchment (KI03 and 16), and single sites from the South West River, Stun'Sail Boom, Smith and Springy creeks. The sites from the Western Mount Lofty Ranges rated in a Fair condition included multiple sites from the Gawler River catchment (WMLR 12, 34, 42, 44–45), Onkaparinga catchment (WMLR 18, 26, 38 and 40), Sturt River catchment (07 and 14) and a few of the smaller streams in the Fleurieu Peninsula.

The Poor streams were found among the cleared agricultural land from around the middle to the eastern side of Kangaroo Island and from parts of the Mount Lofty Ranges, stretching from the Mid North southwards to some of the small coastal streams of the Fleurieu Peninsula. The Kangaroo Island streams included sites from the Timber Creek catchment (KI08, 28 and 29), Chapman River (KI09, 19, 30), lower Cygnet River (KI15 and 20), Willson River (KI07) and Emu Bay Creek (KI25); these were typically saline or ephemeral streams located from the lower rainfall parts of the island.

The Mount Lofty Ranges streams included multiple sites from the Gawler River catchment (WMLR06, 11, 37, 39, 41 and 46), Bungala Creek catchment (WMLR23, 29 and 32), Pedler Creek catchment (WMLR21 and 31), Onkaparinga River catchment (WMLR08 and 09), Torrens River catchment (WMLR19 and 20), and single sites from Back Valley Creek, unnamed creek near Sellicks and tributary of Maslin Creek. These streams all lacked significant areas of native vegetation in their catchments, had ineffective riparian zones dominated by a few gums over introduced grasses, and showed evidence of significant nutrient enrichment effects (eg very high nutrient concentrations, large algal growths, anaerobic sediments, dominance by organic-feeding macro-invertebrates).

Similarly, the Very Poor streams were found among cleared agricultural land to the north and south from Adelaide in the Mount Lofty Ranges, and were characterised by their lack of remnant native vegetation and functioning riparian zones, excessive signs of nutrient enrichment, and sparse assemblages of only the most pollution tolerant macro-invertebrates when wet. They included a dry site on the tributary of Yankalilla Creek (WMLR25) on the Fleurieu Peninsula and a site from the salt-affected Walkers Creek (WMLR10) near Freeling in the Mid North.

Variability in panel member ratings

The results in Table 5 showed that the expert panel members assigned the same condition rating to 45% and 41% of sites sampled from Kangaroo Island and the Western Mount Lofty Ranges respectively; 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 each region in 2013.

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 6 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 for each region have been

summarised for each season and combined to provide an indication of the measured variation in individual parameters during 2013. In general, streams from Kangaroo Island (Table 6a) had more chlorophyll and higher oxidised nitrogen (NO_X), were more saline, cooler, had less dissolved oxygen (DO) and were less alkaline than streams from the Western Mount Lofty Ranges (Table 6b).

Neither region have a large number of undisturbed streams covered in remnant native vegetation that could provide a benchmark for the conditions that occur in most streams, which are typically located within highly modified, agriculturally dominated catchments. The few streams that are located within nature conservation reserves (eg First Creek in Cleland Conservation Park and several streams in Flinders Chase National Park on Kangaroo Island) are generally located within rocky, steeply sloping landscapes that have historically been unsuitable for development; such streams would not provide a suitable benchmark for what would be expected from a small first- or second-order tributary creek from a low rainfall catchment, or from a lowland river surrounded by residential housing. To overcome this type of problem, the US EPA (2000) advocated using the 25% percentile of all data from a region to 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 6 shows that the nutrient thresholds for each region were as follows:

Kangaroo Island *Total Nitrogen (TN) 0.67 mg/L, Total Phosphorus (TP) 0.01 mg/L*
Western Mount Lofty Ranges *TN 0.60 mg/L, TP 0.02 mg/L*

These concentrations are in fact comparable to those often cited in 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 recently proposed for the protection of sensitive mayflies and stoneflies from South Australian waters (Corbin and Goonan 2010).

The two regions showed both similarities and differences among the measurements taken in each season sampled. Kangaroo Island streams had less chlorophyll, oxidised nitrogen (NO_X) and pH, were fresher, warmer and had more dissolved oxygen (DO) in spring compared to autumn, but concentrations of total nitrogen and total phosphorus were similar between seasons. The Western Mount Lofty ranges streams had less chlorophyll, total phosphorus and total nitrogen, and were fresher, warmer, had more DO and were more alkaline in spring compared to autumn.

These patterns may at least be partly related to flow patterns, where 34% of sites from the Mount Lofty Ranges had extensive areas of flowing riffle habitat present compared to 16% of streams from Kangaroo Island during sampling in 2013. This means that higher spring flows in the Western Mount Lofty Ranges streams would have provided more of a dilution effect than occurred on Kangaroo Island, and resulted in the pattern of lowered nutrient concentrations during the warmer sampling period.

Conceptual models

A central assumption of the conceptual models was that the high levels of nutrients (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 macro-invertebrates 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. In some cases this has 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 life cycles.

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 the eastern side of Kangaroo Island, in particular, may have approached or exceeded this salinity range prior to European settlement, it was assumed as part of this assessment that the extensive landuse 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 each region.

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, differences 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 an accurate condition assessment of those sites sampled in 2013 using the conceptual models that were specifically developed for both Kangaroo Island and the Western Mount Lofty Ranges.

References

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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
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Telephone: 13 23 24
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General information

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Table 1 Conceptual model of ecological responses to a disturbance gradient in the Kangaroo Island NRM region

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. Note that temporary and ephemeral habitats may have a low EPT assemblage but provide habitat for a rich group of colonising insects (eg beetles, waterbugs and dipterans), with 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; if present, sensitive and rare taxa 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 oligochaetes, mosquito larvae, amphipods (*Austrochiltonia*) or midges (eg *Chironomus, Procladius* or *Tanytarsus)*; can include organic feeders from highly polluted waters such as syrphid larvae; vegetation often completely comprising introduced species with little to no remnant native vegetation.

Rating	Excellent	Very Good	Good	Fair	Poor	Very Poor
Water chemistry conditions	As naturally occurs; no human sources of contaminants present and pest species not impacting on water quality (eg nutrient enrichment, deposits of waste with high levels of hormones).	Least disturbed; high proportion natural features means waters are well oxygenated and low in nutrients and turbidity; may also be highly coloured due to tannins from native vegetation.	Largely unremarkable water quality with at least some nutrients present at higher than expected concentrations, coupled with at least one plant indicator showing emerging signs of enrichment effects (eg chlorophyll *a* >10 ug/L, filamentous algae >10% cover and/or macrophytes >35% cover) but site not overwhelmed.	Fair water quality with generally saturated dissolved oxygen (when sampled during the day), at least one nutrient present at high concentrations and high algal and higher plant growths (eg chlorophyll *a* >10 ug/L, filamentous algae >10% cover and/or macrophytes >35% cover) evident on occasions.	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* >10 ug/L, filamentous algae >10% cover and macrophytes >35% cover most of the time).	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.
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 flow patterns; 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 dominate on the margins of these stream types.

Rating	Excellent	Very Good	Good	Fair	Poor	Very Poor
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 landuses.	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 or no riparian vegetation remaining other than introduced grasses; major changes to catchment landuse 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 agricultural or urban setting.

Table 2 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, and coastal creeks on the southern Fleurieu Peninsula (eg Aaron Creek, lower reaches of Deep and First creeks) 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, and coastal creeks on the southern Fleurieu Peninsula (eg Aaron Creek, lower reaches of Deep and First creeks). 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; if present, sensitive and rare taxa 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 comprising introduced or planted species.

Rating	Excellent	Very Good	Good	Fair	Poor	Very Poor
Water chemistry conditions	As naturally occurs; no human sources of contaminants present and pest species not impacting on water quality (eg nutrient enrichment, deposits of waste with high levels of hormones).	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, filamentous algae >10% cover and/or macrophytes >35% cover); but site not overwhelmed.	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* >10 ug/L, filamentous algae >10% cover and/or macrophytes >35% cover) evident on occasions.	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* >10 ug/L, filamentous algae >10% cover and macrophytes >35% cover) most of the time.	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.
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.

Rating	Excellent	Very Good	Good	Fair	Poor	Very Poor
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 landuses.	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 landuse 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 3 List of biota expected to occur for each rating in the Kangaroo Island 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. Similarly, streams in Very Poor condition would not be expected to occur due to the absence of large wastewater discharges or urban centres near waterways on the island; streams may approach this condition following a major contaminant spill or accident involving a tanker.

Rating	Very Good	Good	Fair	Poor	Very Poor
Attribute 1 **Rare and/or regionally endemic**	**Trichoptera** *Ulmerochorema;* **Fish** *Galaxias* species	**Trichoptera** *Ulmerochorema;* **Fish** *Galaxias* species	**Trichoptera** *Ulmerochorema*; **Fish** *Galaxias* species	None present	None present
Attribute 2 **Sensitive, rare or vulnerable specialist taxa with narrow environmental requirements**	**Ephemeroptera** *Centroptilum;* **Plecoptera** *Illiesoperla, Newmanoperla, Riekoperla*; **Trichoptera** *Taschorema, Oxyethira columba, Leptorussa, Cheumatopysche*	**Ephemeroptera** *Centroptilum*; **Plecoptera** *Illiesoperla, Newmanoperla, Riekoperla;* **Trichoptera** *Taschorema, Leptorussa, Cheumatopysche*	**Plecoptera** *Illiesoperla, Riekoperla;* **Trichoptera** *Taschorema, Leptorussa, Cheumatopysche*	None present	None present
Attribute 3 **Sensitive, ubiquitous taxa**	**Ephemeroptera** *Thraulophlebia, Atalophlebia*; **Plecoptera** *Dinotoperla;* **Diptera** *Austrosimulium, Simulium melatum*	**Ephemeroptera** *Thraulophlebia, Atalophlebia*; **Plecoptera** *Dinotoperla;* **Diptera** *Austrosimulium, Simulium melatum*	**Ephemeroptera** *Thraulophlebia, Atalophlebia;* **Plecoptera** *Dinotoperla;* **Diptera** *Austrosimulium, Simulium melatum*	None present	None present

Rating	Very Good	Good	Fair	Poor	Very Poor
Attribute 4 **Opportunistic or generalist taxa**	**Hydracarina** *(Oxus, Australiobates, Coaustraliobates, Koenikea, Piona, Procarticacarus);* **Mollusca** *Ferrissia;* **Ephemeroptera** *Cloeon, Tasmanocoenis;* **Trichoptera** *Notalina, Triplectides, Lectrides;* **Odonata** *Telephlebiidae;* ***Diptera*** *Dixidae, Empididae, Tipulidae, Chironomidae (Eukiefferiella, Thienemaniella, Cladotanytarsus, Rheotanytarsus);* **Coleoptera** low numbers of aquatic beetles may be present	**Hydracarina** *(Oxus, Australiobates, Coaustraliobates, Koenikea, Procarticacarus, Piona);* **Mollusca** *Ferrissia;* **Ephemeroptera** *Cloeon, Tasmanocoenis;* **Trichoptera** *Notalina, Triplectides, Lectrides;* **Odonata** *Austrolestes, Hemicordulia, Telephlebiidae;* **Diptera** *Dixidae, Empididae, Tipulidae, Chironomidae (Eukiefferiella, Thienemaniella, Cladotanytarsus, Rheotanytarsus);* **Coleoptera** *Sternopriscus, Liodessus, Necterosoma, Chostonestes, Limnoxenus, Platynectes, Rhantus, Copelatus, Gyrinidae, Scirtidae*	**Hydracarina** *(Oxus, Koenikea, Piona, Procarticacarus);* **Mollusca** *Ferrissia;* **Ephemeroptera** *Cloeon, Tasmanocoenis;* **Trichoptera** *Notalina, Triplectides, Lectrides;* **Odonata** *Austrolestes, Hemicordulia;* **Diptera** *Dixidae, Tipulidae, Chironomidae (Eukiefferiella, Thienemaniella, Cladotanytarsus, Rheotanytarsus);* **Coleoptera** *Sternopriscus, Liodessus, Necterosoma, Chostonestes, Limnoxenus, Platynectes, Rhantus, Copelatus, Gyrinidae, Scirtidae*	**Hydracarina** *(Koenikea, Piona);* **Ephemeroptera** (in low numbers) *Cloeon, Tasmanocoenis;* **Trichoptera** *Triplectides;* **Odonata** *Austrolestes, Hemicordulia;* **Diptera** *Chironomidae (Cladotanytarsus, Tanytarsus);* **Coleoptera** *Sternopriscus, Liodessus, Necterosoma, Limnoxenus, Platynectes, Rhantus, Copelatus, Scirtidae*	**Coleoptera** *Necterosoma*

Rating	Very Good	Good	Fair	Poor	Very Poor
Attribute 5 **Tolerant taxa**	**Oligochaeta; Amphipoda** *Austrochiltonia* (low numbers); **Decapoda** *Cherax destuctor;* **Diptera** *Simulium ornatipes, Culicidae* (low numbers), *Ceratopogonidae (Dasyhelea, Bezzia, Culicoides), Chironomidae (Procladius, Paramerina, Parametriocnemus, Paralimnophyes, Parakiefferiella, Cricotopus, Chironomus, Dicrotendipes);* **Hemiptera** (low numbers of *Microvelia, Micronecta, Agraptocorixa, Anisops, Enithares);* **Odonata** *Ischnura, Diplacodes*	**Oligochaeta; Amphipoda** *Austrochiltonia;* **Decapoda** *Cherax destructor;* **Diptera** *Simulium ornatipes, Culicidae, Stratiomyidae, Ceratopogonidae (Dasyhelea, Bezzia, Culicoides), Chironomidae (Procladius, Paramerina, Parametriocnemus, Paralimnophyes, Parakiefferiella, Cricotopus, Chironomus, Dicrotendipes);* **Hemiptera** (low numbers of *Microvelia, Micronecta, Agraptocorixa, Anisops, Enithares);* **Odonata** *Ischnura, Diplacodes*	**Oligochaeta; Mollusca** *Hydrobiidae;* **Amphipoda** *Austrochiltonia;* **Decapoda** *Cherax destructor;* **Diptera** *Simulium ornatipes, Culicidae* (often high numbers), *Stratiomyidae, Ceratopogonidae (Bezzia, Culicoides), Chironomidae (Procladius, Cricotopus, Paramerina, Parametriocnemus, Paralimnophyes, Parakiefferiella, Chironomus, Dicrotendipes);* **Hemiptera** (often moderate numbers of *Microvelia, Anisops Micronecta, Enithares, Agraptocorixa);* **Odonata** *Ischnura, Diplacodes*	**Oligochaeta; Mollusca** *Hydrobiidae;* **Amphipoda** Austrochiltonia; **Decapoda** *Cherax destructor;* **Collembola; Diptera** *Simulium ornatipes, Culicidae* (often high numbers), *Stratiomyidae, Ceratopogonidae (Bezzia, Culicoides), Chironomidae (Procladius, Paramerina, Parametriocnemus, Paralimnophyes, Parakiefferiella, Cricotopus, Chironomus, Dicrotendipes);* **Hemiptera** (often moderate to high numbers of *Microvelia, Micronecta, Agraptocorixa, Anisops, Enithares);* **Odonata** *Ischnura*	**Oligochaeta** (often in high numbers)**;** **Amphipoda** *Austrochiltonia;* **Diptera** *Culicidae, Stratiomyidae, Ceratopogonidae (Bezzia, Culicoides), Chironomidae (Procladius and Chironomus;* the latter often in large numbers); **Hemiptera** *Micronecta, Anisops, Enithares*

Rating	Very Good	Good	Fair	Poor	Very Poor
Attribute 6 **Non-endemic or introduced taxa**	**Mollusca** *Potamopyrgus* in low numbers; **Decapoda** *Cherax tenuimanus*	**Mollusca** *Potamopyrgus* in low to moderate numbers; **Decapoda** *Cherax tenuimanus*	**Mollusca** *Potamopyrgus* in moderate to high numbers*;* **Decapoda** *Cherax tenuimanus*	**Mollusca** *Potamopyrgus* in moderate to high numbers	None present

Table 4 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. Note that a number of species recorded in 2011 were not collected in 2013, including a mayfly *Nousia fuscula*, hemipteran *Hydrometra*, beetle *Sclerocyphon* and several caddisflies *Apsilochorema, Anisocentropus* and Tasimiidae. Of these, the beetle was found in Sixth Creek in 2013 during a focused search for water-pennies in the region, despite not being collected during the aquatic ecosystem condition sampling program in 2013.

Rating	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

Rating	Very Good	Good	Fair	Poor	Very Poor
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
Attribute 4 **Opportunistic or generalist taxa**	**Hydracarina** *(Oxus, Procarrticacarus, 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, Procarrticacarus, 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, Procarrticacarus, 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*

Rating	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)

Table 5 Condition ratings given by each panel member and final overall rating for each of the 77 sites monitored in the Kangaroo Island and Adelaide and Mount Lofty Ranges NRM region during 2013

Note: Site codes indicate the year sampled. The NRM region is followed by the site number. Refer to the EPA website for the site map coordinates and the site based aquatic ecosystem condition reports.

Randomly selected sites are shown by stream order enclosed in brackets after the site code (eg SO1). Site randomisation was determined by applying a tailored version of CatchmentSIM (Catchment Simulation Solutions Pty Ltd; <www.csse.com.au>).

[1] denotes the 5 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 5 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 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.

Site code	Site name	Habitats[4]	Very Good	Good	Fair	Poor	Very Poor	Final rating
2013.KI01	[1]Rocky River, west from NPWS Headquarters	Dry, E	2	1	–	–	–	Very Good
2013.KI02	[1]Breakneck River, west from NPWS Headquarters	ER, ER	2	2	–	–	–	Very Good
2013.KI31	[3]Rocky River, eastern branch in Flinders Chase	E, E	3		–	–	–	Very Good
2013. WMLR05	[1]First Creek, Tunkalilla	ER, ER	2	1	–	–	–	Very Good
2013. WMLR13	[3]First Creek, upstream from Waterfall Gully	ER, ER	2	1	–	–	–	Very Good
2013.KI04	[1]Ravine des Casoars, south from Cape Borda	ER, E	–	3	–	–	–	Good
2013.KI23	[3]De Mole River, upstream from estuary	E, E	–	3	–	–	–	Good
2013.KI27	[3]North West River, north from Karatta	E, E	1	2	–	–	–	Good
2013. WMLR01	[1]First Creek, Waterfall Gully	ER, ER	–	3	–	–	–	Good
2013. WMLR02	[1]Scott Creek, Scotts Bottom	ER, ER	–	3	–	–	–	Good
2013. WMLR03	[1]Deep Creek, middle of park at culvert	E, ER	–	3	–	–	–	Good
2013. WMLR04	[1]Brownhill Creek	ER, ER	–	2	1	–	–	Good

Site code	Site name	Habitats[4]	Very Good	Good	Fair	Poor	Very Poor	Final rating
2013. WMLR15	[3]Callawonga Creek, near Callawonga	ER, ER	1	2	–	–	–	Good
2013. WMLR16	[3]Sixth Creek, upstream from junction with Torrens River	ER, ER	–	2	1	–	–	Good
2013. WMLR22	[3]Boat Harbour Creek, Boat Harbour	E, ER	1	2	–	–	–	Good
2013. WMLR24 (SO1)	Unnamed creek, south from Mount Bold Reservoir	Dry, Dry	–	2	1	–	–	Good
2013. WMLR36 (SO5)	Little Para River, southeast from Little Para Reservoir	ER, ER	–	3	–	–	–	Good
2013. WMLR43	[3]Jacob Creek, gauge station	ER, ER	–	2	1	–	–	Good
2013.KI03	[1]Cygnet River, west from Parndana	E, E	–	–	3	–	–	Fair
2013.KI05	[1]South West River, west from Kelly Lodge	E, E	–	1	2	–	–	Fair
2013.KI06	[2]Middle River, upstream from Lagoon Flat	E, E	–	–	3	–	–	Fair
2013.KI10	[2]Springy Water Creek	E, E	–	–	2	–	–	Fair
2013.KI11	[3]Middle River, NNW from Gosse	E, E	–	–	3	–	–	Fair
2013.KI12	[3]Middle River, north from Bangor	E, E	–	1	2	–	–	Fair
2013.KI13	[3]Tributary of Middle River, north from Bangor	E, E	–	–	3	–	–	Fair
2013.KI14	[3]Middle River, upstream from Middle River Reservoir	E, E	–	–	3	–	–	Fair
2013.KI16	[3]Cygnet River, Huxtable Forest Gauge Station	ER, ER	–	1	2	–	–	Fair
2013.KI17	[3]Harriet River, west from Vivonne Heights	E, E	–	–	2	1	–	Fair
2013.KI18	[3]Stun'sail Boom River, Stun'sail Boom Gauge Station	E, E	–	–	2	1	–	Fair
2013.KI21	[3]Smith Creek, southwest from Smith Beach	Dry, E	–	–	3	–	–	Fair

Site code	Site name	Habitats[4]	Very Good	Good	Fair	Poor	Very Poor	Final rating
2013.KI22	[3]Western River, upstream from estuary	ER, ER	–	1	2	–	–	Fair
2013.KI24 (SO3)	Tributary of Western River	Dry, Dry	–	–	2	1	–	Fair
2013.KI26	[3]Harriet River, northeast from Mount Taylor	E, E	–	–	3	–	–	Fair
2013. WMLR07	[2]Sturt River, Sturt Road	E, E	–	–	3	–	–	Fair
2013. WMLR12	[3]Tanunda Creek, Bethany Reserve	Dry, ER	–	–	3	–	–	Fair
2013. WMLR14	[3]Brownhill Creek, downstream from caravan park	E, ER	–	1	2	–	–	Fair
2013. WMLR18	[3]Aldgate Creek, Mylor	ER, E	–	–	3	–	–	Fair
2013. WMLR26 (SO2)	Tributary of Scott Creek, southeast from Cherry Gardens	E, E	–	–	3	–	–	Fair
2013. WMLR28 (SO2)	Tributary of Bungala River, south from Yankalilla	Dry, Dry	–	–	2	1		Fair
2013. WMLR30 (SO2)	Unnamed creek, Talisker Conservation Park	Dry, Dry	–	1	2	–	–	Fair
2013. WMLR33 (SO4)	Hindmarsh River, upstream from Hindmarsh Falls	ER, E	–	1	2	–	–	Fair
2013. WMLR34 (SO4)	Tributary of South Para River, east from Williamstown	E, E	–	–	3	–	–	Fair
2013. WMLR38 (SO6-7)	Onkaparinga River, south from Bradbury	E, E	–	–	3	–	–	Fair
2013. WMLR40 (SO6–7)	Onkaparinga River, west from Woodside	E, E	–	–	3	–	–	Fair
2013. WMLR42	[3]North Para River, north from Penrice	Dry, E	–	–	3	–	–	Fair
2013. WMLR44	[3]Jacob Creek, upstream from junction with North Para River	E, E	–	–	3	–	–	Fair

Site code	Site name	Habitats[4]	Very Good	Good	Fair	Poor	Very Poor	Final rating
2013 WMLR45	[3]North Para River, Angaston	E, E	–	–	2	1	–	Fair
2013.KI07	[2]Willson River, west from Woodleigh	ER, ER	–	–	1	2	–	Poor
2013.KI08	[2]Timber Creek, downstream from gauge station	E, E	–	–	1	2	–	Poor
2013.KI09	[2]Chapman River, east from Woodleigh	E, E	–	–	1	2	–	Poor
2013.KI15	[3]Cygnet River, Koala Lodge gauge station	E, E	–	–	1	2	–	Poor
2013.KI19	[3]Chapman River, downstream from Lashmar Lagoon	Dry, E	–	–	–	3	–	Poor
2013.KI20	[3]Tributary of Cygnet River, northwest from Kerribbee Park	E, E	–	–	–	3	–	Poor
2013.KI25	[3]Emu Bay Creek, upstream from estuary	Dry, E	–	–	–	3	–	Poor
2013.KI28	[3]Timber Creek, southeast from Parndana	E, E	–	–	1	2	–	Poor
2013.KI29	[3]Little Timber Creek, north from Murray Lagoon	E, E	–	–	–	3	–	Poor
2013.KI30	[3]Chapman River, southwest from Lashmar Lagoon	E, E	–	–	1	2	–	Poor
2013 WMLR06	[2]South Para River, southeastern edge of Gawler	Dry, E	–	–	1	2	–	Poor
2013 WMLR08	[2]Cox Creek, Uraidla	E, E	–	–	1	2	–	Poor
2013 WMLR09	[2]Inverbrackie Creek, Woodside	E, E	–	–	1	2	–	Poor
2013 WMLR11	[3]North Para River, near Chateau Yaldara Winery	E, ER	–	–	1	2	–	Poor
2013 WMLR17	[3]Back Valley Creek, upstream from junction with Kirk Road	E, E	–	–	1	2	–	Poor
2013 WMLR19	[3]Millers Creek, south from Forreston	E, E	–	–	1	2	–	Poor
2013 WMLR20	[3]Torrens River, north from Mount Pleasant	E, E	–	–	1	2	–	Poor
2013 WMLR21	[3]Pedler Creek, upstream from Landcross Farm	E, Dry	–	–	–	3	–	Poor

Site code	Site name	Habitats[4]	Very Good	Good	Fair	Poor	Very Poor	Final rating
2013 WMLR23 (SO1)	Tributary of Bungala River, east from Yankalilla	Dry, Dry	–	–	1	2		Poor
2013 WMLR27 (SO2)	Unnamed Creek, southeast from Sellicks Hill	Dry, Dry	–	–	–	2	1	Poor
2013 WMLR29 (SO3)	Tributary of Bungala River, SSW from Yankalilla	Dry, E	–	–	–	3	–	Poor
2013 WMLR31 (SO3)	Tributary of Pedler Creek, northeast from McLaren Flat	Dry, Dry	–	–	1	2	–	Poor
2013 WMLR32 (SO4)	Bungala River, Yankalilla	E, E	–	–		3	–	Poor
2013 WMLR35 (SO5)	Tributary of Maslin Creek, southeast from Maslin Beach	E, Dry	–	–	1	2	–	Poor
2013 WMLR37 (SO1)	Tributary of Victoria Creek, east from Williamstown	Dry, Dry	–	–	–	3	–	Poor
2013 WMLR39 (SO6–7)	South Para River, Gawler	Dry, Dry	–	–	–	3	–	Poor
2013 WMLR41	[3]North Para River, southwest from Mount McKenzie	E, E	–	–	1	2	–	Poor
2013.W46	[3]Greenock Creek, Greenock	E, E	–	–	–	3	–	Poor
2013 WMLR10	[2]Walkers Creek, southeast from Freeling	E, E	–	–	–	1	2	Very Poor
2013 WMLR25 (SO1)	Tributary of Yankalilla River, southeast from Torrens Vale	Dry, Dry	–	–	–	1	2	Very Poor

Table 6 Water chemistry and algal summary statistics from sites sampled from each region during 2013 (units given are mg/L unless otherwise indicated)

(a) Kangaroo Island

Parameter	Autumn (n = 26 wet sites)				Spring (n = 30 wet sites)				Combined autumn + spring (n = 56 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)	10.22	1.23	2.92	5.86	5.43	0.73	1.77	4.78	7.65	0.90	2.01	5.40
Chlorophyll *b* (ug/L)	0.69	0.10	0.10	0.94	0.68	0.10	0.19	0.39	0.69	0.10	0.10	0.46
Oxidised N (NOx)	0.16	0.01	0.02	0.15	0.11	0.01	0.02	0.05	0.13	0.01	0.02	0.07
Total Nitrogen	1.09	0.61	0.85	1.18	0.97	0.72	0.84	1.01	1.03	0.67	0.85	1.06
Total Phosphorus	0.03	0.01	0.02	0.03	0.03	0.02	0.02	0.03	0.03	0.01	0.02	0.03
Water temperature (degrees Celcius)	13.68	13.12	13.73	14.40	15.33	14.14	15.09	16.08	14.56	13.33	14.31	15.40
Conductivity (uS/cm)	5,297.38	1,406.25	2,615.50	9,914.50	4,556.23	655.75	2,191.50	7,957.25	4,900.34	947.50	2,480.50	8,488.50
Dissolved Oxygen	9.01	7.81	8.99	10.29	9.25	8.35	9.11	11.23	9.14	7.98	9.11	10.55
pH (pH units)	7.35	7.17	7.40	7.64	7.31	7.01	7.33	7.67	7.33	7.07	7.35	7.66

(b) Adelaide and Mount Lofty Ranges

Parameter	Autumn (n = 33 wet sites)				Spring (n = 35 wet sites)				Combined autumn + spring (n = 69 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)	14.60	0.49	1.76	5.84	7.15	0.56	1.23	4.76	10.76	0.54	1.50	5.31
Chlorophyll *b* (ug/L)	1.71	0.10	0.10	1.04	0.44	0.10	0.10	0.30	1.06	0.10	0.10	0.56
Oxidised N (NOx)	0.17	0.00	0.01	0.12	0.04	0.00	0.01	0.02	0.10	0.00	0.01	0.03
Total Nitrogen	1.43	0.59	1.01	1.67	1.01	0.61	0.91	1.16	1.21	0.60	0.95	1.23
Total Phosphorus	0.12	0.02	0.06	0.13	0.06	0.02	0.04	0.07	0.09	0.02	0.05	0.08
Water Temperature (degrees Celcius)	12.45	10.30	12.90	14.36	17.83	16.06	17.50	18.67	15.22	12.98	15.89	17.53
Conductivity (uS/cm)	3,170.79	705.00	1,091.00	2,410.00	2,531.57	730.00	1,252.00	2,205.50	2,841.78	712.50	1,209.50	2,307.25
Dissolved Oxygen	8.78	7.15	9.32	9.82	10.69	9.31	10.96	12.27	9.76	8.76	9.74	11.26
pH (pH units)	7.59	7.24	7.52	7.85	7.83	7.65	7.83	8.06	7.71	7.42	7.74	8.01