Macroinvertebrate Theme Summary Pilot Audit Technical Report

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Preface

The Sustainable Rivers Pilot Audit (2002-2003) was set up to develop and agree on indicators and analytical procedures and identify costs and logistics of implementing a Basin-wide Sustainable rivers Audit. The Pilot project was completed at the end of 2003. The outcomes of the Pilot Audit are reported in 5 technical reports covering the major groups of indicators trialed in the Pilot Audit: fish, macroinvertebrates, hydrology, physical habitat and water processes.

This document is the Executive Summary only of the macroinvertebrate technical report from the Pilot Sustainable Rivers Audit. The full technical report is available on CD by contacting the office of the Commission on 02 62790100. Copies of the reports can also be loaned from public libraries throughout the Basin.

This summary outlines the major conclusions and recommendations for the macroinvertebrate theme. Subsequent to the Pilot Audit, partner governments to the Murray-Darling Basin Commission agreed to implement a Basin-wide Sustainable Rivers Audit from 2004/05 to 2010/11 with the following elements:

Three groups of indicators ("themes") for immediate implementation:

- Fish: 13 indicators derived from fish field sampling to be carried out once every 3 years in each of 23 valleys in the Basin;
- Macroinvertebrates: 3 indicators would be derived from field sampling once every 2 years in a single season in the 23 valleys of the Basin.
- Hydrology: 12 indicators to be derived from long term modeling sequences for modeled (largely regulated) areas only in each of the 23 valleys in the Basin, once each 6 years.

Three groups of indicators ("themes") for further development:

- Physical Form
- Riparian vegetation
- Floodplain ecosystems

Further information on the design and roll out of the Basin-wide Sustainable Rivers Audit will be released in the second half of 2004.

Background

Murray-Darling Basin water reforms were introduced to improve water use efficiency and to provide protection for aquatic ecosystems across the Basin. The most significant reform, the introduction of the Cap on diversions, sought to balance protection of the riverine environment with the need for consumptive water use. In 2000, the Murray-Darling Basin Ministerial Council (MDBMC) noted the absence of a long-term Basin-wide assessment that could determine the effectiveness of current management practices, including the Cap, in sustaining river health. They agreed to initiate the development of a Sustainable Rivers Audit (SRA) that would assess river health using five themes: macroinvertebrates, fish, water quality, hydrology and habitat.

The primary aim of the SRA would be to provide consistent Basin-wide information on the health of rivers (through a rigorous systematic monitoring program) to drive high level, sustainable land and water management decisions. In 2001, the Cooperative Research Centre for Freshwater Ecology developed a framework for assessing the health of the Basin's rivers with the active involvement of jurisdictional representatives (Whittington *et al.*, 2001). However, before the SRA could be implemented on a Basin-wide scale, it was agreed that a Pilot SRA be conducted in four catchments in 2002/03 (Condamine, Lachlan, Ovens and Lower Murray) to trial and refine indicators and methods, and to identify logistical constraints and indicative costs.

This document summarises the technical outcomes and development of the Macroinvertebrate Theme during the Pilot SRA. Biological communities provide an indication of river health because they respond to a range of disturbances. This response can be detected from infrequent sampling of the community, due to the effects of impacts being integrated over time. Macroinvertebrates are an ideal assessment tool for a broad scale monitoring program such as the SRA as they are abundant, diverse and sensitive to a range of changes in river health such as water quality, flow regime and habitat conditions. Impacts on macroinvertebrate communities are relatively long lasting and current communities reflect the net effect of all environmental factors over a period of weeks, months and years, effectively summarising the past history of conditions in the stream.

The Pilot sampled macroinvertebrate communities across four catchments over two seasons in 2002, with the primary emphasis on method development. The macroinvertebrate theme is one of the most progressed of the themes trialed in the Pilot, due in part to method development under the National River Health Program (NRHP). The NRHP programs were based at the site scale, while this SRA Pilot macroinvertebrate report shows that a Basin-wide audit of macroinvertebrate communities at the valley and valley process zone scales is possible and this is recommended for implementation as part of the SRA.

Design and methods

A referential framework has been adopted for the SRA. The aim is to express current river health relative to 'natural' condition (defined as 'the condition that would exist now in the absence of human influence experienced during the past two centuries'). This 'natural reference condition' is used to facilitate comparisons across the Basin. It is used as a standardisation tool and does not equate with the objective of returning rivers to a natural condition. While 'natural' is the condition with the highest ecological integrity, it should not be construed as being the 'optimum' or 'desired' condition as we often accept a departure from natural as a necessity to securing other important social and economic values.

Sampling for the Pilot focussed on the main river network, actively excluding two important components of riverine ecosystems: aquatic habitats on the floodplain and ephemeral systems.

Whilst these are very important aquatic environments in the Basin, they were excluded as robust assessment of these environments at a scale appropriate to the Basin was not considered to currently be technically feasible and would have made the initial Audit too ambitious. It is expected that these systems will be considered for inclusion in the full SRA given their importance to fish and macroinvertebrate communities.

The four Pilot river valleys were divided into three valley process zones (VPZ's) based on geomorphic characteristics. These were zones of: sediment source; sediment transport; and sediment deposition.

The total number of sites was based on the need for adequate reporting at the valley scale. Results can be reported at finer resolutions but with lower confidence. The number of sites allocated to each zone was based on the area of that zone. Sites were located at random within a zone to ensure that the sampling was unbiased and measurements could therefore be combined to infer the condition of the entire valley. Where possible, sites for fish sampling were also used in the macroinvertebrate water processes and physical themes. The number of sites sampled was determined to detect a difference of 0.1 (10%) of the mean of all sites for a valley with a power of 0.8 and significance level of 0.05. The number of 'assessment' sites is shown in *Table 1*.

Best available sites were only sampled in the Lachlan valley to provide information to build a valley scale AUSRIVAS model which was a subproject of this theme. Reference condition in other valleys was based on information collected by the States under the NRHP.

Table 1*. The number of macroinvertebrate assessment sites within each zone of each valley for the Pilot SRA.*

	Source	**Transport**	**Deposition**	**Total**
Condamine	5 (5)	12 (13)	22 (23)	39 (41)
Lachlan	5 (6)	5 (5)	29 (20)	39 (31*)
Lower Murray	-	-	36 (40)	36 (40)
Ovens	18 (17)	6 (6)	12 (13)	36 (36)

The numbers in brackets are the number of assessment sites actually sampled in the Pilot.
*In the Lachlan deposition zone less assessment sites were sampled than recommended, as a subset of sites were used as best available sites in order to have enough sites to build a valley model.

Investigations to identify the natural reference condition for macroinvertebrates took two main approaches: prediction of historical taxa for a site and comparison with best available/least disturbed sites.

Considerable investment and development of macroinvertebrate sampling and analysis techniques was conducted through the 1990's associated with the National River Health Program (NRHP). As a result, the issues facing the SRA were not so much development of methods, but how to use existing tools to provide comparable results across the Basin. Standard rapid macroinvertebrate sampling protocols were used, as developed under the NRHP.

Samples were collected in spring and autumn. Where the sites sampled in autumn did not have water in spring, a new site was selected as close as possible to the previous (now dry) site. Site size was generally 100m long and a number of discontinuous samples were taken within this to equate to a 10m kick sample. Generally riffle and edge habitat samples were collected in source and transport valley process zones (VPZs), but only edge habitat samples in deposition VPZ's. The degree of searching for microhabitats appeared to differ between States which is an issue for standardisation across the Basin. Samples were sorted using the field-pick method or by using the laboratory-sort method, depending on the standard protocols used by the State. In addition a number of environmental and locational variables were collected for each site.

The macroinvertebrate indicators that were originally proposed in the SRA framework report (Whittington *et al.*, 2001) and tested in the Pilot are listed in *Table 2*

Table 2. *Indicators used in the Macroinvertebrate Pilot*

Indicator	**Indicator explanation**
Richness (biodiversity)	Number of taxa. An indicator of biodiversity of a site. If compared to a 'reference site' can become a general river health indicator.
SIGNAL OE 50 SIGNAL OE	This is calculated the same as AUSRIVAS OE but in addition taxa are weighted according to their sensitivity to pollution. The Pilot compared the effects of using a greater than 50% (SIGNAL OE 50) and 0% (SIGNAL OE) probabilities of taxa occurring at a test site. Although a general indicator of river health its focus is on pollution sensitive taxa and therefore water quality.
SIGNAL score standalone	The invertebrate families at a site are weighted (graded) for each family's sensitivity to pollution. The average of the grades is the standalone SIGNAL score for the site. An indicator of pollution sensitive taxa. If compared to a 'reference site' can also become a general water quality indicator.
AUSRIVAS OE	This is the ratio of the number of invertebrate families observed (O) at a site to the number of families expected (E) at that site. AUSRIVAS consists of mathematical models that predict the aquatic macroinvertebrate fauna expected to occur at a site in the absence of environmental stress, such as pollution or habitat degradation. Taxa included are those calculated to have a probability of 50% or greater of occurring at a test site. AUSRIVAS OE is an indicator of biological impairment of a site, a general measure of river health.
EPT (taxa and/or abundance)	This adds together the number of taxa in Ephemeroptera, Plecoptera, and Trichoptera orders and divides by the number of Chironomid (midge) taxa. The EPT abundance includes the number of individuals. The first three orders are highly sensitive to water quality and flow changes whereas midges are not. The taxa involved means it applies mainly to upland rivers. EPT is an indicator of sensitive taxa to water quality and flow.
Filters Score	This predicts the taxa expected for a site based upon environmental Filters (water quality, geomorphology and hydrology characteristics, plus taxa in a region). Sites impacted by humans should have fewer families observed than expected. A general indicator of river health that estimates 'natural condition'.
Key families Score	This indicator focuses on taxa present in a region that are representative of 'good' habitat or water quality and their loss from a site. The key families must also be able to be collected by the sampling methods of the project. A general indicator of river health that estimates 'natural condition'.

For AUSRIVAS OE (OE is Observed/Expected) assessments used existing models, except in the Lachlan where a series of models were created from data sampled in the Pilot. Various models (eg regional and State-wide, edge and main channel, combined and single season) were compared to evaluate their usefulness. For the Pilot assessment AUSRIVAS OE scores were generated with single season models for both habitats. Habitat scores were averaged later for aggregation of indices with expert rules.

Results

Sampling methods

The Pilot results demonstrate that sampling of approximately 35 sites per river valley is required to report with confidence (± 0.1) for the three selected indicators (taxa richness, standalone SIGNAL and AUSRIVAS OE) 95% of the time. Reducing the number of sites to 15 or 20 would still achieve this level of confidence for SIGNAL and richness but would reduce the confidence in the AUSRIVAS OE score to ±0.15. Results may still be reported at the VPZ scale but with less confidence.

The results from the Pilot Audit indicate that even at the valley scale of assessment, different habitats provide different information. Therefore it appears that one habitat is not sufficient to characterise condition at large spatial scales and the SRA should measure at least two habitats. Pilot results show little effect of the season of sampling (spring or autumn) on the assessments, either season could be sampled and provide the same assessment. Sampling one season only for each sampling round is therefore recommended, with the most sensitive season for any particular valley to be decided at the discretion of the States involved.

The Pilot Audit carried out in the Lachlan demonstrated that by using a more thorough application of the existing sampling protocol (but still sampling within the protocol guidelines) it was possible to significantly increase the number of macroinvertebrate taxa and the frequency of occurrence of most of the collected taxa. This increase in taxa improved the sensitivity of regional models for the Lachlan River. More rigorous sampling and the collection of more taxa meant that useable single season models could be developed rather than using the 'combined' model (2 seasons) to increase sensitivity derived from enlarging the pool of taxa. If stricter sampling protocols are implemented (in NSW) reference sites may have to be resampled using the new protocols, although possible alternatives are suggested in the Pilot report.

Analysis methods

Two main approaches were used in the Pilot for reference condition: predicting 'natural condition' at a site, and using 'best available' or 'least disturbed' sites. Techniques for predicting natural condition were investigated using the Filters and Key Families approaches. Under natural conditions taxa likely to be found at a site are determined by the regional taxa pool, which is 'filtered' by a set of environmental factors to which these taxa are adapted. The Key Families method is very similar and is based on taxa being representative of regional characteristics, including habitats and water quality characteristics. The Pilot established that these approaches had potential, but results show they are not developed and tested to the stage where they could be applied with confidence across the entire Basin.

The second main approach tested in the Pilot compared assessment sites against 'best available' reference sites. The top 5% of reference sites (identified in the NRHP datasets) were determined to be the 'least disturbed' and therefore closest to 'natural' condition. These best available reference sites were used for comparison against standalone SIGNAL scores, EPT and Richness scores, which previously had no reference sites for comparison. Taking into account the above findings, the assessment for valleys in the Pilot (for AUSRIVAS OE, standalone SIGNAL and Richness) were referenced to 'best available' sites. It is acknowledged that this reference benchmark is not optimal: often the 'best available' sites are impacted, especially in the lower Basin, and are therefore far from natural. However, refinement of methods during the complete

Audit across the Basin should be sufficient to progress the reference condition significantly, particularly with ensuring consistency across the Basin while regionalising reference condition.

Models available for the AUSRIVAS OE indicator differ across the Basin. A comparison of regional and State-wide models showed that regional models appear to produce lower scores than State-wide models, suggesting they are more sensitive (lower scores show a bigger difference between the expected and observed taxa at a site). While regional models exist at a range of spatial scales, so do State-wide models, so standardising the scale by choosing between regional and State-wide models is not possible. In the interim, it is recommended to use the most sensitive models available and to move towards regional or more localised models where resources are available. Regional models will also need to be developed strategically to cover the whole of the geographical area of the Basin.

SIGNAL has been incorporated into the AUSRIVAS method under the NRHP program, and has been developed as a predictive indicator (SIGNAL OE). The performance of the SIGNAL OE indicator has been reassessed under the Pilot program and was found to lack in responsiveness. Therefore, the use of standalone SIGNAL is recommended for the SRA.

The Pilot highlighted the bias of the current assessment tools for macroinvertebrates towards upland streams (eg EPT, SIGNAL). While more work is needed to improve the applicability of current assessment tools to lowland streams, results from the Pilot show that this can be done. Consistency in approach between jurisdictions in the Basin is also an issue, for which some development has been costed into the proposals for a Basin-wide Audit.

Indicators

Five criteria were used to assess which indicators should be used in the Audit in the future, the criteria being: conceptual relevance, feasibility, response variability, interpretation and utility. The assessment of the indicators is summarised below:

Richness: Richness is the number of taxa at a site and when properly referenced to a predicted ‘natural’ condition for a region is widely accepted as a good indicator of health. In addition, as Richness measures biodiversity of an area it is an important characteristic in its own right.

SIGNAL: Standalone SIGNAL is recommended in preference to the SIGNAL OE indicators. SIGNAL OE was tested on it sensitivity and found to lack in response, even after using different probability levels.

AUSRIVAS: AUSRIVAS OE is recommended as an SRA indicator because it is a widely used measure of river health, models already exist across the Basin and it is believed that improvements can be made to overcome some of the current shortcomings.

EPT: EPT is accepted as a useful indicator in upland streams, for which it was developed, but is not a sensitive indicator in lowland Australian streams. Ideally a sensitive taxa index should be developed for the lowlands, to complement EPT for upland streams. Once this is done, both ‘sensitive taxa’ indices could be included in the SRA program.

Filters: The Filters analytical framework has potential, but it is not yet fully developed and tested to the stage where it could be applied with confidence across the Basin. It is also necessary for information to be available across the Basin to build the filters models and determine scores for each site. Preliminary work to check the availability and coverage of such information should be undertaken before recommending development of the Filters framework for the Basin.

Key Families: The Pilot established the potential for using the Key Families framework in the Basin. However, further development and preliminary work is required before this approach could be adopted and scores could be calculated for each site.

Further development of Filters and Key Families is recommended as these are the only methods that reference observations back to ‘natural’.

Aggregation of indicators

Expert rules were developed for combining the recommended indicators into one score to make a summary assessment of the macroinvertebrate community (Sustainable Rivers – Macroinvertebrate Index or SR-MI). This expert system technique provides an objective way of capturing the complex relationships between the indicators and river health that cannot always be expressed by a simple weighted sum.

The rules developed for the macroinvertebrate index give highest importance to biodiversity: richness ($SR\text{-}MI_r$) followed by presence of pollution sensitive taxa (SIGNAL or $SR\text{-}MI_s$) and least importance to the presence of expected taxa (AUSRIVAS OE or $SR\text{-}MI_{oe}$). The AUSRIVAS OE was only allowed to affect the overall macroinvertebrate index where the score was low. This was because of the lack of confidence in higher scores due to the lack of suitable reference sites. For consistency and simplicity, results for different habitats within a site were averaged for input into the expert rules. This is not ideal and should be revisited for the Audit.

To aid interpretation, scores can be described as a departure from natural with 0 to 0.2 described as ‘extreme modification’, 0.2 to 0.4 as ‘major modification’, 0.4 to 0.6 as ‘moderate modification’, 0.6 to 0.8 as ‘minor modification’ and 0.8 to 1 as ‘at or near natural condition’. However, it should be noted that the boundaries for these classes do not represent any known thresholds in river condition and rigid categories can lead to misleading interpretations when considering values near the boundary cut-offs.

River health assessments

The overall assessments (Sustainable Rivers – Macroinvertebrate Index, SR-MI) for the Pilot valleys were approximately the same across seasons, with the exception of the Lachlan catchment, which was classed as more impaired in Spring than in Autumn. This was most likely because of a more severe drought impact in Spring for that valley. This impairment was detected by all three indicators (*Table 3* and *Table 4*). The relatively high score for the lower Murray is a reflection of the lack of suitable lowland reference sites.

At the VPZ level, confidence intervals in the assessments were slightly lower ($SR\text{-}MI_{oe}$ can detect a 15 % change rather than 10% change with a probability of 0.05 and power of 0.8). In general, the source zones score higher than the transport or deposition zones (*Table 5*, *Table 6*). The SR-MI scores for each VPZ in Autumn are also shown in *Figure 1*. Insufficient data were available for a Lachlan transport assessment for Spring owing to dry sites as a result of the drought. The lower score for Lachlan Spring at the valley level is mainly due to a lower score for this valley for the deposition zone. In the Ovens, the scores for Spring are higher for transport and deposition areas, resulting in a marginally higher score at the valley level.

Table 3. *Valley health assessments for Autumn 2002 for combined edge and riffle habitats. Scores for both habitats were averaged before calculating the index with expert rules. Note that these scores are referenced against "best available" instead of "natural" which currently impedes the ability to make strict cross valley/zone comparisons (because the condition of best available sites varies between regions and streams).*

Valley	Season	$SR\text{-}MI_r$	$SR\text{-}MI_s$	$SR\text{-}MI_{oe}$	SR-MI *
Condamine	Autumn	0.46	0.40	1	0.53
Lachlan	Autumn	0.61	0.62	1	0.66
Murray	Autumn	0.65	0.62	1	0.7
Ovens	Autumn	0.67	0.60	0.89	0.71

* note that SR-MI is not a weighted sum and that $SR\text{-}MI_{oe}$ currently only affects the score when $SR\text{-}MI_{oe}$ is low.

Table 4. *Valley health assessments for Spring 2002 for combined edge and riffle habitats. Scores for both habitats were averaged before calculating the index with expert rules. Note that these scores are referenced against "best available" instead of "natural" which currently impedes the ability to make strict cross valley/zone comparisons (because the condition of best available sites varies between regions and streams).*

Valley	Season	$SR\text{-}MI_r$	$SR\text{-}MI_s$	$SR\text{-}MI_{oe}$	SR-MI
Condamine	Spring	0.52	0.45	1	0.56
Lachlan	Spring	0.49	0.49	0.84	0.55
Murray	Spring	0.67	0.65	1	0.73
Ovens	Spring	0.73	0.70	0.94	0.79

* note that SR-MI is not a weighted sum and that $SR\text{-}MI_{oe}$ currently only affects the score when $SR\text{-}MI_{oe}$ is low.

Table 5. *VPZ health assessments for Autumn 2002 for combined edge and riffle habitats. Scores for both habitats were averaged before calculating the index with expert rules. Note that these scores are referenced against "best available" instead of "natural" which currently impedes the ability to make strict cross valley/zone comparisons (because the condition of best available sites varies between regions and streams).*

Valley zone		SEASON	$SR\text{-}MI_r$	$SR\text{-}MI_s$	$SR\text{-}MI_{oe}$	SR-MI
Condamine	Deposition	Autumn	0.43	0.42	1	0.5
Condamine	Transport	Autumn	0.48	0.38	1	0.53
Condamine	Source	Autumn	0.70	0.35	1	0.67
Lachlan	Deposition	Autumn	0.57	0.65	1	0.64
Lachlan	Transport	Autumn	0.74	0.68	1	0.8
Lachlan	Source	Autumn	0.73	0.40	1	0.71
Lower Murray		Autumn	0.65	0.62	1	0.7
Ovens	Deposition	Autumn	0.47	0.51	0.67	0.53
Ovens	Transport	Autumn	0.60	0.60	1	0.64
Ovens	Source	Autumn	0.83	0.66	1	0.85

* note that SR-MI is not a weighted sum and that $SR\text{-}MI_{oe}$ currently only affects the score when $SR\text{-}MI_{oe}$ is low.

Table 6. *VPZ health assessments for Spring 2002 for combined edge and riffle habitats. Scores for both habitats were averaged before calculating the index with expert rules. Note there was insufficient data to assess the Lachlan Transport in the Spring. Note that these scores are referenced against "best available" instead of "natural" which currently impedes the ability to make strict cross valley/zone comparisons (because the condition of best available sites varies between regions and streams).*

Valley zone		SEASON	SR-MI_r	SR-MI_s	SR-MI_{oe}	SR-MI
Condamine	Deposition	Spring	0.48	0.51	1	0.55
Condamine	Transport	Spring	0.56	0.36	1	0.56
Condamine	Source	Spring	0.64	0.36	1	0.62
Lachlan	Deposition	Spring	0.51	0.56	0.94	0.57
Lachlan	Transport	Spring	Insuff. data	Insuff. data	Insuff. data	Insuff. data
Lachlan	Source	Spring	0.76	0.40	0.88	0.74
Lower Murray		Spring	0.61	0.67	0.82	0.73
Ovens	Deposition	Spring	0.84	0.75	1	0.67
Ovens	Transport	Spring	0.48	0.50	1	0.68
Ovens	Source	Spring	0.63	0.63	1	0.88

* note that SR-MI is not a weighted sum and that SR-MI_{oe} currently only affects the score when SR-MI_{oe} is low.

Recommendations

Sampling methods

The sampling of 35 sites per river valley is necessary to report with confidence (±0.1) at the valley scale. Results may still be reported at lower scales (e.g. Valley Process Zones) but with less confidence. In order to assess interannual variability at the VPZ level, it is recommended to include one sentinel site per VPZ, which would be sampled every year. The Pilot recommends that each site in the Basin be sampled for its macroinvertebrate community once every two years. In a six year reporting cycle this will provide three complete health assessments from which trends may be detected.

Sites sampled for macroinvertebrates should be overlapped as much as possible with site locations for other themes. The layout of sites will depend on resolution of the stratification issue, which is common to all themes and linked to the reporting. Sites will be laid out in a stratified random approach.

Habitats for which AUSRIVAS models exist should continue to be sampled in the first round of the SRA. Two habitats should be sampled per site to improve the robustness of results. If two habitats are not available, then the existing habitat should be sampled twice. The Pilot showed that sampling in Spring and Autumn yielded similar results and therefore only one season needs to be sampled. The optimal season in terms of model performance and flow conditions will be different across the Basin and up to the discretion of the States, involved in sampling the valley covered by the model.

States should implement the sampling protocol in test sites in a way that reflects the sampling undertaken for reference sites (‘natural’ sites) to allow for their comparison. The SRA is unlikely to have the capacity to fund re-sampling of reference sites and development of new models in the first round. However, a more thorough sampling protocol could be implemented in lowland streams with minimal additional cost by using a small amount of assessment sites as model of best available sites. This would improve the number of taxa collected resulting in enhanced model sensitivity and robustness. In the case of NSW, sampling of SRA assessment sites should provide sufficient sites to build a model in the first round with minimal additional cost for the SRA. Sampling protocols should be more tightly defined where they have changed or are subject to interpretation as this could improve the number of taxa collected and model performance.

Analysis methods

The Pilot showed that Filters and Key Families approaches to estimate a natural condition for comparison to a site's observed results, were not sufficiently developed at present. The development of methods that reference to natural condition should be undertaken during the first major reporting round (6 years) for the entire Basin.

It is apparent that it is particularly difficult to identify 'natural' reference sites in the lower Basin. However, because no alternatives currently exist, 'best available' sites should be used as a surrogate for 'natural' reference sites in the first round of SRA, noting that this will deliver over estimates of the health of macroinvertebrate communities. Approaches to reference condition should be reviewed after the first major reporting round (6 years).

The scale at which AUSRIVAS 'State-wide' and 'regional' models exist varies considerably. Therefore, optimal models using criteria of sensitivity and robustness should be identified by each State. For the first round of SRA reporting, where a number of models exist, results from all models should be reported, with the model considered optimal identified.

Recommended Indicators

The Pilot recommends the use of the following indicators: AUSRIVAS OE, SIGNAL score and Richness for use in the SRA. SIGNAL OE is not recommended. EPT (percent and abundance), Filters and Key Families are indicators that may have potential but would require further method development before they can be used at a Basin-wide scale. For more detail see the results section, above.

Table 7. *Indicators recommended for the Sustainable Rivers Audit*

Indicator	**Indicator explanation**
Richness biodiversity	Biodiversity indicated by the number of taxa.
SIGNAL score standalone	The invertebrate families at a site are weighted (graded) for each family's sensitivity to pollution. The average of the grades is the standalone SIGNAL score for the site.
AUSRIVAS OE	Australian Rivers Assessment System (AUSRIVAS). This is the ratio of the number of invertebrate families observed (O) at a site to the number of families expected (E) at that site if there was no human disturbance.

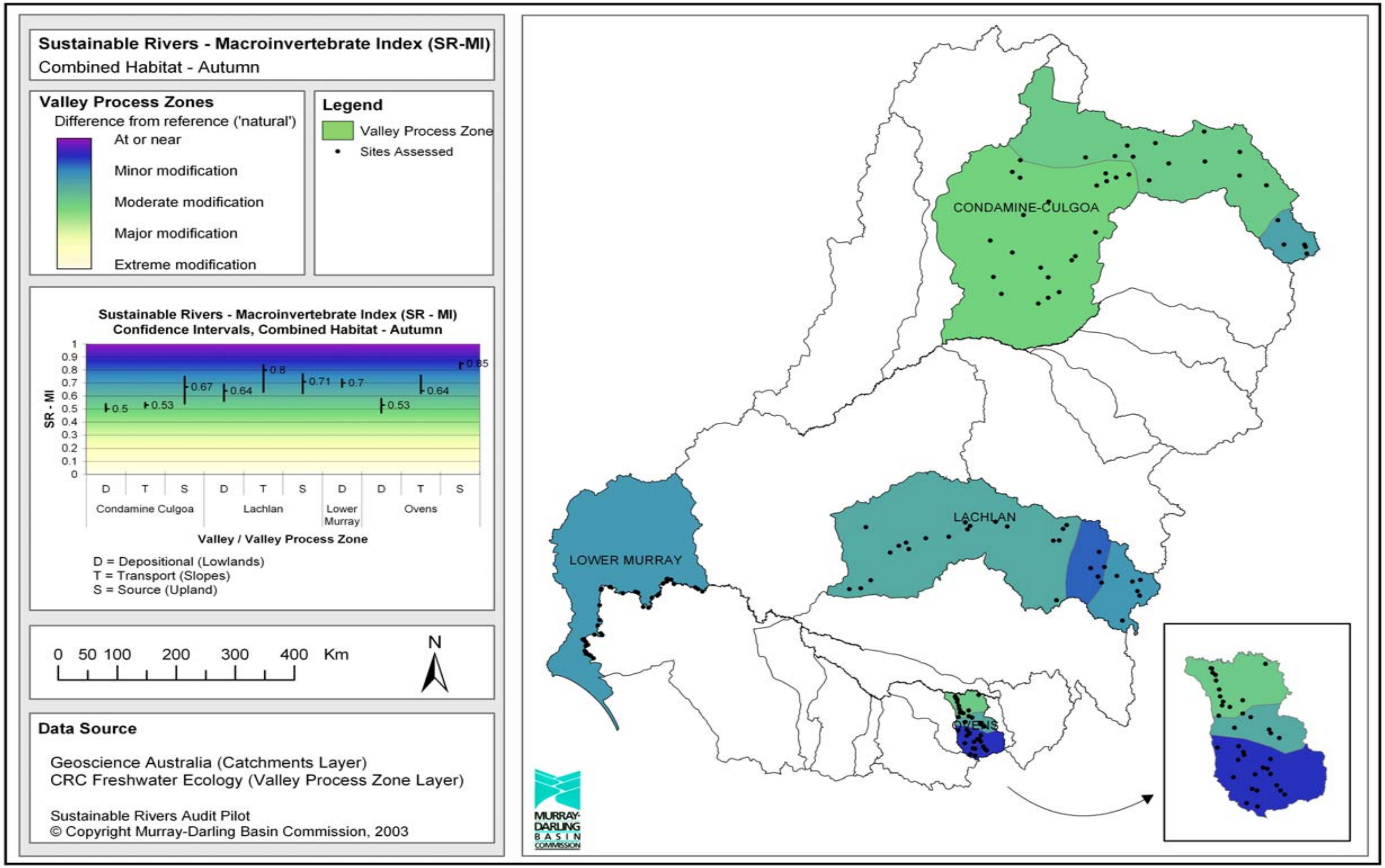

Figure 1. *Condition assessment of SR-MI$_e$ in catchments assessed during the Pilot SRA (associated confidence in data displayed in legend). Colouring indicates the overall VPZ condition assessment.*