Scope of the Sustainable Rivers Audit

June 2000

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CRC for Freshwater Ecology

The Cooperative Research Centre for Freshwater Ecology improves the health of Australia's rivers, lakes and wetlands through research, education and knowledge exchange. It was established in 1993 under the Australian Government's Cooperative Research Centre Program.

The Cooperative Research Centre for Freshwater Ecology is a collaborative venture between:

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- Department of Natural Resources, Queensland
- Department of Natural Resources and Environment, Victoria
- Environment ACT
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EXECUTIVE SUMMARY

The Sustainable Rivers Audit (SRA) is proposed to provide a comparable means of reporting river health across the Murray-Darling Basin as the basis for an informed discussion on this matter. It is our view that such an audit is quite feasible and would fill a major feedback gap in the existing management of the Basin. With water becoming an increasingly scarce and valuable resource, people seek assurance that water allocated to the environment is delivering real environmental benefits. The SRA can be designed as a comprehensive annual review of the condition of waterways to inform debate amongst the Basin community.

All jurisdictions are already collecting considerable data to help them with management of water resources. Some additional effort will be required to make the sampling effort more comprehensive, and further effort will be needed to develop reporting approaches that allow an assessment of the ecological outcomes resulting from land and water management in each jurisdiction. As part of the Audit process we envisage States collecting and reporting data on an annual basis as the SRA. This data would provide the foundation for an annual dialogue between the State and the Independent Sustainable Rivers Audit Group (ISRAG). The dialogue would cover the reported indicators, the conditions affecting the indicators, and what actions the States have taken in its management of land and water and how these are expected to alter the indicators.

We envisage a more comprehensive process at the beginning, and thereafter every five years, where additional data on biological outcomes and the habitat is presented, along with a compilation of the annual data and an attempt to identify trends. We have termed this the Comprehensive Sustainability Assessment (CSA).

Some principles have emerged in this scoping process that should be explicit.

- The Audit process must have clear and explicit objectives.
- The Audit process should be a comprehensive assessment of the health or condition of the rivers of the Basin including regulated and unregulated rivers and is not simply an assessment of the Cap and the environmental flow allocations being put in place by the States.
- It must not be excessively demanding on data and should build on what is being collected already in State and National programs.
- It must provide clear information to the Basin community about the health of the rivers.
- It must provide a basis for an annual dialogue about the health of the rivers, on a river valley basis, where the condition of the rivers and the water management actions in place or proposed are discussed.
- It must emphasise ecological outcomes rather than just factors like flow and water quality which determine those outcomes. These are not effective surrogate measures of river health, although they are important drivers of river health.
- We do not have a simple measure of river health any more than we have a simple scale of human health. However, there are a range of indicators which, if taken together, allow judgements of overall health or condition to be made.

We make the following specific recommendations to guide this Audit Process.

Objectives

> The Sustainable Rivers Audit (SRA) is to be a comprehensive assessment of river health across all the major river valleys of the Basin, rather than just an assessment of the impact of the Cap or environmental allocations. It is to provide an annual report that allows a dialogue on the condition and the factors affecting it. It is further informed by a

Comprehensive Sustainability Assessment (CSA) undertaken at the start of this process and thereafter every five years.

Framework

States are to collect and present data on the agreed indicators in an agreed format. The MDBC, and if required the CRC for Freshwater Ecology, will work with the States to reach agreement on these issues. The Audit document is to form the basis for the annual dialogue with an Independent Sustainable Rivers Audit Group, the findings of which are to publicly available to the Basin community.

Indicators

The Annual Audit needs to report on measures of biota, which reflect ecological outcomes, and measures of flow regime and water quality, which represent important drivers of the biological outcomes. The five yearly CSA will report as well on measures of habitat and will include more comprehensive information on biological outcomes.

Biological Indicators

The biotic measures of the SRA should be based in the first instance on aquatic invertebrates and fish communities. Much information has already been collected under State and National programs, and expertise exists to collect and interpret the data. The National River Health Program (AUSRIVAS) provides the basis for the aquatic invertebrates. Some negotiation is required to resolve how to address the fish issue.

Other biological measures should be reported in the five yearly CSA. These might include information on algal growth, algal blooms, riparian vegetation, aquatic plants, aquatic and riparian weeds, wetland area and condition and water birds. Negotiations with the States on availability of usefulness of information is now required. It is not essential that each State report on every biological element in the CSA, and States should be encouraged to report on additional indicators they are collecting to address specific issues, or in attempt to develop new and more robust indicators. We need to encourage further innovation in this area.

Hydrological Indicators

There is extensive hydrological data and modelling already available and used in assessing the compliance with the Cap. Some further work is required to get agreement on the most useful way to present this existing information from an ecological perspective, but the CRC has a project (CRCFE, 2000) on this nearing completion which can inform discussions. These can be reported annually as part of the SRA and would require no additional data collection.

Water Quality Indicators

There is extensive information on water quality already being collected throughout the Basin. We propose a water quality index incorporating four elements - Total Phosphorus, electrical conductivity (salinity), turbidity and pH be developed and reported annually.

Habitat Structure Index

Habitat, along with flow and water quality, is the other major determinant of biological outcomes. It is a complex area, and we propose developing an index with five elements reflecting connectivity (weirs and levees blocking water movement), riparian condition, woody debris in stream, geomorphic and wetland elements. Most States are attempting some assessments in these areas, and considerable progress is being made in the NLWA which will guide the development of this Index. The habitat index is to be reported five yearly as part of the CSA.

Sampling Intensity

The number of sampling stations, and the frequency of sampling, is driven by the errors that are acceptable in the estimates rather than cost or convenience. Spending half the amount required to get no useful information is just misleading. Existing information is available on sampling and associated errors to inform this discussion. Indicative estimates suggest that for each of the major river valleys we might require five fish sampling stations and 20 invertebrate stations, although a technical workshop with appropriate statistical expertise is required to resolve this issue.

Reporting

Reporting the variety of information from the Audit is a complex task and there are no simple solutions. We do believe an aggregated measure that gives an overall impression, such as the red-amber-green traffic light system being developed in the Queensland WAMP process is attractive for macroinvertebrates and fish, the indices that measure outcomes. This form of reporting is less attractive for drivers of river condition like water quality, which can have high inter-annual variability. The Victorian Index of Stream Condition also aggregates indicators, but ensures individual measures are also reported to allow interpretation of what has been changing.

Interpretation

The audit will produce information on a series of indicators and indices (groups of indicators combined). These will allow considered judgements as to the health or otherwise of the system. We are not in a position to prejudge any of the indicators and say this is healthy and this is not. The group of indicators need to be considered as a whole, with a consideration of the type of river we are considering. Appropriate levels for indicators for the Upper Murrumbidgee would probably not be appropriate for the Lower Murray. This is comparable to a medical practitioner considering a range of measures such as weight and blood pressure in coming to a judgment of health where the judgement is informed by averages but made in an individual case by case basis.

We see the States making interpretations of the various indicators to the Independent Sustainable Rivers Audit Group. These interpretations might compare indicators with national Guidelines (for water quality for instance), or with river valley objectives set by the various community processes already in place. It may be possible to identify trends in the five yearly CSA, but the data is very variable and this is not a trivial task unless there is extensive monitoring. The connection between the land and water management activities in the river valley and the biological outcomes will be an important part of this process.

The Next Steps

If the Murray-Darling Basin Ministerial Council accepts our view that this is a useful and feasible task, there are a number of actions required to bring it to fruition. Most of these require collection of more information on how States are collecting and interpreting information, and working with various experts to get agreement on what is most appropriate for this task. We have identified a series of action tasks that identify the main areas that must be addressed. Most of this requires detailed negotiation with State experts and officials, with input from some other sources as required.

The CRC for Freshwater Ecology would be in a position to facilitate and contribute expertise to these tasks and report on them in detail as required.

Task 1. Collation of Existing Methods

Collate and review existing State and National approaches to assessing river health, collating and comparing information from each as to objectives, underlying logic and assumptions, indicators, scales, statistical foundations and reporting protocols, as well as costs.

Task 2. Selection of Indicators

Arrange a workshop with the key State players and other experts as to what should be taken from the existing effort (Task 1 report) and used as the basis for the SRA and what additional work has to be undertaken. In particular, this workshop is to get agreement on the required biological measures and water quality indicators for the annual SRA and the five yearly CSA and to finalise details of the other indicators and indices for the SRA and CSA.

Task 3. Develop Aquatic Invertebrate Protocols

Review existing experiences with the use of AUSRIVAS in lowland rivers and agree on best sampling and reporting approaches. Advise on sampling intensity and the desirability of developing one or more specific Murray-Darling Basin models for AUSRIVAS, and of the relative merits of using these rather than existing State models.

Task 4. Develop Fish Community Assessment

Conduct a specialist workshop of State representatives on fish assessments, along with others skilled in survey design to determine the sampling procedures and approach to sampling and reporting fish community information. This workshop to advise on sampling effort as well as reporting protocols.

Task 5. Develop a Hydrologic Index

Review approaches to reporting hydrological information in an ecologically useful way and negotiate the development of the Hydrological Index with relevant State and Murray-Darling Basin experts.

Task 6. Develop a Water Quality Index.

Review approaches to reporting water quality information in an ecologically useful way and negotiate the development of the Water Quality Index with relevant State and Murray-Darling Basin experts.

Task 7. Develop a Habitat Structure Index

Develop a Habitat Structure Index based on work underway as part of the NLWA and other State efforts. This index to have five elements reflecting connectivity (weirs and levees blocking water movement), riparian condition, woody debris in stream, geomorphic and wetland elements. Consider how these elements might be weighted and aggregated in a meaningful way.

Task 8. Development and presentation of combined index of River Health

Conduct a specialist workshop to develop ways of combining the various outcome and input indicators and presenting them in a useful way (traffic light diagrams or something similar for outcome indicators). This will require developing bands for indicators of appropriate health. It will also require a review of error bands and the required sampling frequency.

Task 9. Comprehensive Sustainability Audit

Once the above tasks are completed, the decision then needs to be made to test the approach by conducting the First Comprehensive Sustainability Audit. This would require a central reference group to work with States in further refining the audit process, and then reporting to the Independent Sustainable Rivers Audit Group.

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1 PREAMBLE

Over the last decade, extensive reforms of the Australian water industry have been introduced to improve efficiency in the way water is used, and to provide basic protection for the aquatic ecosystems on which we all depend. The Cap imposed by the Murray-Darling Basin Ministerial Council ("the Ministerial Council") on extraction of water from the Basin was introduced in 1995 as a holding strategy to stop further allocation of water until a better understanding of the impact of the level of extraction was obtained.

It is now generally accepted that water must be allocated to the environment, although there is less agreement on how much, and how it should be delivered. With water now an increasingly scarce and valuable resource, it is necessary to demonstrate that water allocated to the environment does deliver useful ecological outcomes. This is a difficult challenge in the Murray-Darling Basin given the natural variability in climate and flow, the often long time-lags between a change in management and an ecological response and the lack of baseline data on river health.

The CRC for Freshwater Ecology has been asked to undertake this scoping study to provide this framework for consideration of the Ministerial Council at its August 2000 meeting.

2 APPRECIATION OF TASK

The Ministerial Council seeks to undertake a regular audit of the condition of the rivers of the Basin to inform the community and to provide a basis for ongoing dialogue on the sustainability of the rivers, and the appropriateness of various management actions. This dialogue will include economic and social factors, but needs to be informed by reliable and valid assessments of river health coming from this audit process.

River health is influenced by many factors including landuse and vegetation clearance in the catchment, chemical and thermal pollution, and by changes in flow regime associated with water resource development. The framework developed in this project is therefore not just about assessing the ecological outcomes of the Cap on diversions or on specific environmental allocations, but is a comprehensive assessment of river health across the Basin.

Much of the water in the Basin's rivers originates as runoff into upland streams in the higher ranges along the eastern edge of the Basin. These streams combine to form large lowland rivers that flow across the extensive inland plains where the rivers usually have extensive floodplain and wetland systems with numerous billabongs. In some places the rivers have multiple channels and some have a large terminal wetland. A comprehensive Basin-wide assessment of river health requires that all of the differing aquatic environments be considered.

Recommendation 1. That the Audit process be a comprehensive audit of the health of the rivers of the Basin, including regulated and unregulated rivers and is not simply an assessment of the Cap and the effects of the environmental flow allocations being put in place by the States.

The rainfall and streamflow variation across the Murray-Darling Basin is well appreciated, and this might lead to the view that the audit should report over periods when there this variation can be averaged out to some extent. We reject this reasoning and believe the audit should be carried out annually to enable an effective dialogue with the partner governments to be led by an independent group of auditors with relevant ecological expertise. This group could be known as the Independent Sustainable Rivers Audit Group and could be modelled along similar lines to the current IAG that monitors Cap implementation. This dialogue might trigger specific investigations where it identifies aspects of concern. Similar to the audit of the Cap, this discussion will need to focus on biological outcomes that are reported, and on the processes that States have put in place in each valley to improve the condition of the water where this is required.

Recommendation 2. That an annual Sustainable Rivers Audit of the rivers of the Murray-Darling Basin be undertaken, and that an Independent Sustainable Rivers Audit Group be established to report publicly on the findings of the audit. To start this process, and every five years thereafter, a Comprehensive Sustainability Assessment (CSA) be undertaken and reported using a similar mechanism. Reporting and assessments would be on the basis of defined river valleys.

3 ELEMENTS OF THE AUDIT

There are six elements that must be considered in designing an appropriate audit process.

- Agreeing on clear objectives for the audit (Section 4);
- Identifying and building on what has already been achieved (Section 5);
- Selecting indicators that reflect the condition of the waters (Section 6);
- Deciding on appropriate spatial and temporal scales for assessment and reporting (Section 7);
- Agreeing on methods for data collection and for appropriate quality assurance procedures and developing meaningful ways of presenting multiple indicators (Section 8); and,
- Selecting benchmarks or objectives through which the indicators can be interpreted (Section 9).

4 OBJECTIVES OF THE SRA

The purpose of the annual Sustainable Rivers Audit (SRA) and the five yearly Comprehensive Sustainability Assessment (CSA) is to provide a report in an agreed format on the selected indicators of health of the rivers of the Basin. This report is to provide the basis for discussions with the States about the current condition, any trends that are apparent, the desired condition for the river valley as well as any management actions that might have or be expected to impact on the condition of the rivers.

The annual Sustainable Rivers Audit (SRA) should provide information on each of the specified indicators. It should comment on rainfall and other seasonal conditions as they affect natural flows and diversions from the system. They should compare each indicator with what the jurisdiction believes to be desirable for that river valley from the long term sustainability of the valley and the system as a whole. The annual audit would provide data for the major five yearly review. The review could trigger special investigations of matters of concern.

The initial and thereafter five yearly Comprehensive Sustainability Assessment (CSA) should provide information on each of the specified indicators. It should specify targets on a river valley basis for each of the indicators and what actions are planned to ensure targets are met. It should also include optional indicators that States may have adopted for development reasons or to address specific issues, and an interpretation of them. The five yearly report is to comment on any trends over the reporting period. The five-year review would also draw upon other assessments of river health in the Basin, including outputs from the ISC, IMEF, PBH and MDBC Water Quality Monitoring Program etc. There is scope for the CSA to assess other reports of river health, for example monitoring regional media reports (MDBC News scan), fish kill databases, Landcare and Streamwatch reports and outputs from land and water management plan reports.

The Sustainable Rivers Audit seeks to:

- provide a common reporting framework and "common language" to facilitate debate;
- provide an early warning signal when some aspect is deteriorating and needs further investigation or direct management action;
- do this at the Basin scale, informed at a river valley level;
- build upon available information and draw upon existing activities in the States;
- ensure a better connection between the health of the river system and water management activities; and
- assist in the development of targets for river health on a river valley basis.

5 IDENTIFYING AND BUILDING ON WHAT HAS ALREADY BEEN ACHIEVED

Existing State and National programs provide strong foundations for a Basin-wide Audit of river health. Much has already been achieved through State of the Environment reporting (SoE), the National Land and Water Audit being undertaken through the Natural Heritage Trust, and through various assessments undertaken in each State and Territory. Basin Governments have invested considerable resources in assessment programs and in some cases, this has led to strong community ownership and acceptance of the assessment outcomes, for example with the ISC in Victoria. In developing the scope of this audit we have been concerned to ensure we build upon existing achievements and use data that is already being collected as much as possible.

To achieve an informed Basin-wide dialogue of river health, a common assessment and reporting framework is required, and in our view should be undertaken annually over the first five years with a review then of appropriate time intervals. Despite the fact that each jurisdiction is collecting at least some of the information required for a comprehensive audit the design of the various programs is not consistent and there is no agreed way of reporting that readily allows comparison and discussion of performance.

Given what has now been learned from State and National efforts it is timely to look at how they can all be improved to meet State needs better as well as the needs of the Basin. The critical issues require:

- Agreement on appropriate indicators;
- Agreement on scale – how many stations need to be sampled, how they are distributed and at what frequency;
- Agreement on methods to ensure comparability of data; and
- Agreement on how the data is reported.

Each State has already made decisions on these matters, and has in place a system for collecting and reporting data to meet State needs. There are some common indicators in use in almost all jurisdictions, although each State may well have additional indicators it is trialing for development purposes or to address specific problems. There are differences in the scale of sampling and of methods, some of which reflects the different objectives in each State and some reflects the availability of resources that have been made available for the task.

State and National assessment programs that already collect data of value in informing the SRA are described below.

5.1 MDBC Water Quality Monitoring Program

The Commission has a long standing monitoring program, which includes water quality monitoring at 35 sites since 1978, and since 1980 macroinvertebrates at 7 sites and phytoplankton at 12 sites. Most of the sites are located along the River Murray between Jingellic in NSW and Tailem Bend in SA. The MDBC does not yet appear to have developed interpretations of this data, however the data were reviewed in 1988 and another review of the data is now underway. Following the current review of data, the actual monitoring program will itself be reviewed to assess if it is meeting its objectives.

5.2 National River Health Program (NRHP)

The National River Health Program has developed the Australian River Assessment Scheme (AUSRIVAS) as a nationally consistent and standardised method of assessing river health. AUSRIVAS is a rapid bioassessment method, which utilises macroinvertebrates as sensitive indicators of in-stream health. In conjunction with collection of macroinvertebrate data, the AUSRIVAS protocol requires some physical and chemical habitat data to be collected at each site. All States and Territories are contributing to Australia's First National Assessment of River Health (FNAR) using the AUSRIVAS approach.

5.3 National Land and Water Audit Ecosystem Health – Waterway Condition

The waterway condition component of the NLWA is developing an Australia wide approach for waterway classification, is reporting on the condition of waterways in Australia and aims to identifying waterways where remedial or protective actions are of high priority. The NLWA uses the following indices:

- Hydrology;
- Physical habitat (Geomorphology, riparian vegetation, and connectivity);
- Water quality (conductivity, pH, TP, TN, turbidity, bacteria);
- Biotic (Macroinvertebrates – AUSRIVAS); and
- Catchment - (land use and catchment condition).

Indicators of river condition are being reported separately and are being aggregated into a single score of river health. A multivariate approach is being used to aggregate the individual indicators.

5.4 State of the Environment Reporting (SoE)

The first national SoE report was released in 1996 with a key objective being to provide accurate, timely and accessible information about the condition and prospects of the Australian environment and to provide an early warning of potential problems. SoE reports are generally based on the OECD ‘pressure-state-response’ model. Causal factors (e.g. human activity) put pressures on the environment, which are reflected in state or condition of the environment to which the community may respond by implementing policy or management actions. The next SoE report is due in 2001 and will again report on inland waters using indicators related to groundwater, human health, environmental water quality, surface water chemistry, physical change, biotic habitat quality and effective management. This work is connected with the NLWA.

5.5 Integrated Monitoring of Environmental Flows (IMEF)

This is a major NSW program developed to assess the effectiveness of environmental flow allocations in regulated rivers and wetlands and to inform management agencies and the broader community of this. The aim of IMEF is to measure changes in hydrology, habitats, biota and ecological processes in the major regulated river systems following application of environmental flows. To undertake an IMEF, inspections are undertaken to select suitable hypotheses for each river, from the 14 generic hypotheses. Study designs are then developed using a selection of the approximately 40 methods available to IMEF to test these specific hypotheses. This program is costing around $1 million a year for 60 sites. The methods provide information on:

- hydrology
- geomorphology;
- riparian vegetation;
- water quality;
- macro-invertebrates;
- fish; and
- aquatic plants and algae.

5.6 Pressure- Biota-Habitat (PBH)

This is a NSW approached designed as an assessment method for stressed river ecosystems in small to medium rural unregulated inland streams. PBH incorporates three types of indicators:

- Measurements of human pressure on river systems (14 indicators);
- Measurements of aquatic biota (algae, macrophytes, macroinvertebrates and fish); and
- Measurements of habitat (11 indicators).

PBH scores for individual indicators are retained in a "scorecard" for each site assessed rather than combined for a single score of river condition. This is to increase the diagnostic ability of the approach. Whilst PBH is designed as a rapid assessment technique, the detail and density of sampling requires considerable resources. Some $500,000 a year is being invested in this program.

5.7 Index of Stream Condition (ISC)

This has been developed in Victoria over five years as a tool for Catchment Management Authorities to assist broad scale management of waterways by providing an integrated measure of their environmental condition. The ISC scores five components of stream condition:

- Hydrology (an assessment of flow);
- Physical form (channel and physical habitat);
- Streamside zone (quantity and quality of streamside vegetation and wetlands);
- Water quality; and
- Aquatic life (macroinvertebrates – AUSRIVAS).

For each sub index a score is made, and reported, and these are aggregated into a single score. The scoring is based on “naturalness” in comparing current condition with what it is thought the stream would have been like in pre-European times.

5.8 Ecological Condition Assessment of the WAMP's

Rapid appraisal methods have been developed to assess stream condition in the WAMPs. Condition assessments included:

- Hydrology;
- Geomorphology;
- Floodplain and riparian vegetation;
- Water quality;
- Fish (AREPO); and
- Macroinvertebrates (AUSRIVAS).

Values for these indicators, referenced against minimally disturbed conditions, are reported individually using 'traffic light diagrams'. The traffic light diagrams developed in the WAMP process provide a readily understood visual representation of river condition.

5.9 Index of Biotic Integrity (IBI)

An international assessment method developed for the Murray-Darling Basin in the NSW Rivers survey. The IBI uses eleven fish community metrics based on abundance, diversity, proportion of alien fish and health of individuals.

This summary of major programs assessing aspects of river health in the Murray-Darling Basin shows that several indicators of river health are collected in common across the Basin. These indicators however, are collected for the specific purposes of the particular programs, consequently the indicators are not always collected at the appropriate time and space scales for the audit. The availability of existing and future data from these programs is a major criterion for selection of indicators for the SRA

It is important that the SRA learn from these existing activities and build upon them to provide a cost-effective audit process. A comprehensive comparative review of the currently used approaches is required.

Task 1. Collation of Existing Methods

Collate and review existing State and National approaches to assessing river health, collating and comparing information from each as to objectives, underlying logic and assumptions, indicators, scales, statistical foundations and reporting protocols, as well as costs.

6 SELECTING APPROPRIATE INDICATORS

We believe the key indicators of the SRA need to reflect the ecological condition of the rivers. Ideally, these indicators are measures of biological outcomes, rather than simply the physical, chemical and biological processes that cause those outcomes. There are many indicators which can be thought of as inputs – flow and water quality being obvious ones. There is value in reporting input indicators because they have important diagnostic value when river condition is not acceptable. Diagnostic indicators can help when determining potential management interventions.

Recommendation 3. The annual Sustainable Rivers Audit should be made up of indicators reflecting biota (aquatic invertebrates and fish communities), a measure of flow regime and an index of water quality. The five yearly Comprehensive Sustainability Assessment should include these measures, along with some further measures of biological outcome and a Habitat Structure Index.

These indicators are recommended for the SRA because they (after Norris and Hawkins unpub):

- Quantify and simplify complex ecological phenomena;
- Provide easily interpretable outputs;
- For the most part utilise existing information and skills;
- Respond predicably to damage caused by humans while being less sensitive to natural spatial and temporal variation;
- Relate to an appropriate scale;
- Relate to management goals; and
- Are scientifically defensible.

6.1 Measures of Biota

Extensive work undertaken by the States and the CRC for Freshwater Ecology indicates that currently indices of fish and macroinvertebrates are the most advanced biotic measures available. Therefore, these indicators should provide the key biological measures of the SRA.

The conservation of biodiversity is of concern to Basin Governments. We have not proposed a comprehensive assessment of biodiversity since, as yet, there is no widespread acceptance of how this might be achieved. The SRA framework is based on a working assumption that reporting on two major groups of biota provides a reasonable surrogate for more comprehensive analysis of other groups. This assumption needs to be periodically reviewed.

There are other indicators of biological outcomes that are valuable and should be included in the CSA if possible, including:

- Algal blooms – spatial and temporal extent of nuisance algal bloom;
- Algae – for example, attached diatom populations (Chessman et al 1999);
- Riparian vegetation;
- Aquatic plants;
- Wetland area and condition;
- Birds, especially relating to the health of wetland areas (Kingsford 1999); and
- Ecosystem processes – for example, Production:Respiration ratios, P/R (Bunn et al 1999)

Task 2. Selection of Indicators

Arrange a workshop with the key State players and other experts as to what should be taken from the existing effort (Task 1 report) and used as the basis for the SRA and what additional work has to be undertaken. In particular this workshop to get agreement as to the biological measures and water quality indicators to be included as required indicators in the annual SRA and the five yearly CSA and to finalize details of the other indicators and indices for the SRA and CSA.

6.1.1 Aquatic Invertebrates

The National River Health Program has developed the AUSRIVAS approach with macroinvertebrates to assess river health. Currently, approximately 2000 sites across the Murray-Darling Basin have been sampled. Each jurisdiction in the Basin has collected macroinvertebrate data for the NRHP and has developed the experience and models to use AUSRIVAS assessment. States have also used this method in their own river health assessment programs. For example, it is included in the ISC, WAMP assessments, IMEF and PBH assessments. The NLWA is currently using AUSRIVAS data supplied by the States for a nationwide assessment of river health.

AUSRIVAS assesses site condition by comparing the number of macroinvertebrate taxa predicted to occur at a test site with the number actually collected at the test site. The difference between the number of taxa expected to occur and the number actually observed (observed:expected ratio, O/E) is the measure of ecological condition. The O/E score ranges from 0 to >1 and can be broken into bands to delineate ecological health: impoverished, well below reference, below reference, reference, richer than reference.

Separate methods and models have been developed by each State for collecting and interpreting AUSRIVAS data. However, the resultant O/E scores are comparable between models and methods, and therefore States. Over time it is recommended that the production of Basin-specific models for AUSRIVAS be investigated (see Appendix). Basin-specific models would be designed for use in lowland river systems. Until these models are available it is recommended that for lowland rivers an edge sampling and a combined season (autumn and spring) model should be used.

The number of sites required to be sampled for a desired confidence level can be determined from the existing AUSRIVAS data sets for the Murray-Darling Basin (see Section 7.3).

Task 3. Develop Aquatic Invertebrate Protocols

Review existing experiences with the use of AUSRIVAS in lowland rivers and agree on best sampling and reporting approaches. Advise on sampling intensity and the desirability of developing one or more specific Murray-Darling Basin models for AUSRIVAS rather than use existing State models.

6.1.2 Fish Assessments

Each of the Basin's Governments has undertaken some form of fish population assessment for various purposes including assessment of river health, monitoring of recreational and commercial fisheries and assessing the success of fish stocking. An Index of Biotic Integrity (IBI), which is based on fish community assessment, has been used to assess river health at 40 sites in the NSW Murray-Darling Basin, 20 in the Darling and 20 in the Murray region. The IBI was adapted and validated for use in the relatively low diversity and unspecialised fish communities of south-eastern Australia (Harris and Silveira 1999). Similar data, though analysed within a different framework to IBI, have been collected at sites in the Queensland Murray-Darling Basin and have been used in the assessment of river health for the development of WAMPs.

The IBI adapted for south-eastern Australian streams uses 11 metrics which incorporate richness and composition, trophic composition and fish abundance and condition. Metrics are standardised for catchment area. The values for these metrics are summed to give an IBI score. The score is usually reported as a qualitative rank: excellent, good, fair, poor, or very poor. The index indicates relative river health within and among regions.

IBI has been validated for rivers in NSW, including the Murray-Darling Basin. The validation process found good repeatability of the score from year to year. However, there is limited knowledge of the inter-annual variability in fish communities, therefore it is recommended that sampling occurs annually during the summer months for at least the first five years of SRA.

In the first instance, IBI models developed for the NSW Murray and Darling Regions can be used for the Murray and Darling regions in other jurisdictions. These models can be validated and modified as necessary as data are collected. Further refinement of the IBI depends upon a data stream which would need to be provided by the States.

Task 4. Develop Fish Community Assessment

Conduct a specialist workshop of State representatives on fish assessments, along with others skilled in survey design to determine the sampling procedures and approach to sampling and reporting fish community information. This workshop to advise on sampling effort as well as reporting protocols.

6.1.3 Other Biotic Measures

There are other biological measures being collected in most jurisdictions, although not necessarily in a comprehensive manner. This information needs to be collected and brought together, initially in the Comprehensive Sustainability Assessment. This can be achieved by conducting a workshop of State representatives involved with river health assessments and document what other biological measures are being collected in a systematic way in each State. This forms part of Task 9.

6.2 Measures of Flow Regime

Suitable hydrological data for determining a hydrological index for rivers in the Murray-Darling Basin are currently being collated by the NLWA. In unregulated catchments, 100 years of daily flow data are being modelled. For regulated rivers, the States are providing similar flow data to the NLWA.

Ideally, hydrological indices provide measures of the deviation from natural of flow volume, duration and seasonal pattern. Such indices have been developed for the NLWA, ISC, WAMP, IMEF and PBH. A major gap in our understanding of river health is the linking of hydrology to ecology and this is an area of active research. A soon to be completed report by the CRC for Freshwater Ecology "Characterisation of Flow in Regulated and Unregulated Streams in Eastern Australia" describes a new method for assessing the hydrology of rivers in a way that is relevant to the ecology of the rivers. This report will aid in developing an ecologically relevant hydrological index.

A Hydrological Index should be calculated and reported annually as part of the SRA.

Task 5. Development of Hydrologic Index

Review approaches to reporting hydrological information in an ecologically useful way and negotiate the development of the Hydrological Index with relevant State and Murray-Darling Basin experts.

6.3 Measures of Water Quality

Since 1978, water quality monitoring at 35 sites in the Basin has been coordinated by the MDBC. The MDBC is currently developing a network of salinity monitoring sites across the Basin as part of the development of the Salinity Management Strategy (SMS). (It is not the intention of SRA to re-examine the progress made in the development of the SMS rather to entrain this work in the annual and five yearly audits presently being scoped). Each of the Basin Governments also have extensive water quality monitoring networks. The NLWA is assembling data provided by state agencies and modelled data on conductivity, pH, phosphorus, nitrogen and turbidity. Water quality data are also available from AUSRIVAS sampling. The Victorian ISC reports total phosphorus, turbidity, electrical conductivity and pH.

A water quality index will encompass a range of chemical variables and may include salinity, turbidity, phosphorus, and pH, which are important aspects of aquatic health. Consideration needs to be given to incorporating other measures, including total nitrogen.

A Water Quality Index should be calculated and reported annually as part of the SRA.

Task 6. Develop a Water Quality Index.

Review approaches to reporting water quality information in an ecologically useful way and negotiate the development of the Water Quality Index with relevant State and Murray-Darling Basin experts.

6.4 Measures of Habitat

The number and types of biota that can potentially live in an area are determined by the available habitat: the local physical, chemical and biological features that provide living space and resources. Habitat assessments provide information about the possible causes of the condition of the biotic community. Most river assessment programs in Australia use some form of habitat indicator.

The habitat structure index should be reported each five years in the Comprehensive Sustainability Assessment. We have identified five sub-indices, some already in use for this measure, and they need to be reported individually as well as in an aggregated form.

The CSA habitat structure index will include assessments of connectivity, riparian and aquatic vegetation, in-stream habitat, geomorphology and wetlands. It is proposed that the CSA use similar indices for connectivity and riparian condition as those being developed for the NLWA. Within the Murray-Darling Basin there is substantially better geomorphic information than is available to the NLWA and a more robust indicator of channel stability is proposed for the geomorphic index. The five sub-indices should be reported individually and be integrated into a habitat index using a multivariate method.

6.4.1 Connectivity sub-index

This refers to the longitudinal and lateral linkages between different parts of the river. Longitudinal connectivity is directly influenced by the presence of dams and weirs. Lateral connectivity is directly influenced by the presence of levees and block banks. The Wild Rivers Database provides information on connectivity (dams and levees) at a suitable scale. These data are being collated by the NLWA.

6.4.2 Riparian and aquatic vegetation sub-index

The riparian zone is the link between streams and their surrounds. The vegetation in this zone provides habitat, influences bank stability and contributes nutrients and wood to the streams. The ISC assesses the quality (structural intactness, percentage cover which is indigenous, regeneration of indigenous species, condition of billabongs), and quantity of riparian vegetation (width, continuity). The NLWA is using the riparian data collected for AUSRIVAS, which is essentially the same as what is measured in ISC. AUSRIVAS data is available throughout the Murray-Darling Basin. The riparian sub-index will report similar information to the ISC including extent of riparian zone weeds, including willows. The influence of aquatic weeds will also be determined.

6.4.3 Woody debris sub-index

Snags or coarse woody debris are often a key habitat for fish and invertebrates, particularly in lowland streams. The origin of snags is also an issue. Snags from alien species, such as willows, do not have the same characteristics as those from native vegetation. The ISC includes an indicator of the density and origin of snags which is only assessed in lowland rivers and streams. The assessment is carried out by visual inspection under low flow conditions. Visual assessment of snags is also carried out in PBH, IMEF and in the WAMP ecological assessment.

6.4.4 Geomorphic Sub-index

The geomorphic sub-index assesses channel stability, which is a critical aspect of aquatic habitat. It gives an indication of the condition of the physical template on which the biological processes occur. Channel cross-section data exists widely across the Murray-Darling Basin (the CRCFE has data for >500 cross sections, many of which have been recently resurveyed). Appropriate auditing and assessment of existing channel cross-sections will provide a benchmark to assess channel stability.

6.4.5 RAMSAR and Wetland Site Assessments

Currently there are few biotic assessment techniques for assessing the health of wetlands. Assessments have been attempted using waterbird numbers, however this technique is still in an experimental stage. Annual assessments of the health of wetland vegetation in the Naomi River Valley and the Barmah-Millewa Forest, and the impacts of flooding are regularly made, however to our knowledge there is no coordinated assessment of ecological health of RAMSAR sites in the Basin. It is likely that both AUSRIVAS and IBI techniques could be successfully applied to wetlands if appropriate models were developed.

The CSA can report hydrological surrogates for wetland condition, for example wetting and drying frequency and time since last inundation. Connectivity with the river system and riparian vegetation will also be useful indicators.

Task 7. Develop a Habitat Structure Index

Develop a Habitat Structure Index based on work underway as part of the NLWA and other State efforts. This index to have five elements reflecting connectivity (weirs and levees blocking water movement), riparian condition, woody debris in stream, geomorphic and wetland elements. Consider how these elements might be weighted and aggregated in a meaningful way.

6.5 Summary of Indicators and Reporting Frequency

It is proposed that the following indicator types be used in the SRA and the CSA. There is still further work and negotiation on the detail of each indicator.

Indicator	Annual SRA	Five Yearly CSA
Biota		
Aquatic invertebrates	X	X
Fish	X	X
Other biota		X
Hydrological Index of Flow regime	X	X
Index of Water Quality	X	X
Habitat Structure Index		X
Connectivity sub-index		X
Riparian and Aquatic Vegetation sub-Index		X
Woody debris sub-index		X
Geomorphic sub index		X
Ramsar and Wetland Site Assessment		X

7 SPATIAL AND TEMPORAL SCALES

The Murray-Darling Basin covers an area of 1.061 million square kilometres. Experience with salinity has shown that targets and assessment need to be set at a river valley scale, rather than attempting assessments at a single downstream station.

7.1 River Valleys

Cap compliance is reported for 21 designated river valleys across the Murray-Darling Basin. However, the designated river valleys in Schedule F of the *Murray-Darling Basin Agreement* are not an ideal reporting unit for the SRA for a number of reasons including:

- River valleys with different levels of development are combined – eg. Kiewa, Ovens and Murray Valleys;
- State boundaries are used to define river valleys – eg NSW portion of Paroo and Queensland portion of Paroo;
- NSW and Vic have different Murray Valleys – NSW includes Lower Darling and Victoria includes Kiewa and Ovens; and
- Designated river valley does not always define a river valley – eg. Metropolitan Adelaide and other uses of the River Murray in SA.

While there is a strong desire to keep the SRA framework compatible with the Independent Audit Group's reporting of Cap compliance, it is important that SRA reports in an ecologically defensible framework.

Recommendation 4. For the purpose of reporting the SRA, and CSA, we recommend the use of a modified set of river valleys to those specified as Designated River Valleys in Schedule F of the *Agreement*. This modified set of river valleys would remove the influence of State boundaries evident in Schedule F, to separate aggregated river valleys, and to separate the Murray into zones.

Proposed River valleys for reporting in the SRA and the CSA.

The Condamine/Balonne river system (QLD)
Border Rivers (NSW / QLD)
Moonie River (NSW / QLD)
Warrego River (NSW / QLD)
Paroo (NSW / QLD)
Culgoa/Birrie/Bokhara/Narran (NSW / QLD)
Gwydir (NSW)
Namoi (NSW)
Macquarie (NSW)
Castlereagh (NSW)
Bogan (NSW)
Lachlan (NSW)
Murrumbidgee (NSW)
The Barwon/Upper Darling (NSW)
Lower Darling from the furthest upstream reach of the Menindee Lakes to the furthest upstream reach of the Wentworth Weir Pool. (NSW)
Great Darling Anabranch (NSW)
Kiewa (VIC)
Ovens (VIC)
Goulburn (VIC)

Broken (VIC)
Campaspe (VIC)
Loddon (VIC)
Wimmera/Mallee (VIC)
River Murray (SA / VIC / NSW) - *the River Murray Scientific Panel for Environmental Flows separated the Murray into six major river zones based on similar environmental problems and issues, consideration should be given to reporting these zones individually:*

- *Above Hume Dam;*
- *Hume Dam to Tocumwal;*
- *The Barmah Choke Area (including the Edward River);*
- *Torrumbarry Weir to Wentworth;*
- *Wentworth to Wellington;*
- *Wellington to Barrages*

7.2 Reaches Within River Valleys

The primary assessment for the ISC and the river assessment component of the NLWA is the reach scale. For the ISC, a reach is defined as a contiguous section of stream that is homogeneous in terms of hydrology, physical form, streamside zone, water quality and aquatic life. The NLWA defines reaches as sections of stream with similar stream power. Major features, such as weirs, dams and major tributary inputs are also used to define a reach. Reaches in the ISC are typically greater than 5 km, and for the NLWA are from 2km in the upland areas to greater than 50 kilometres in the major lowland rivers. The NLWA identifies approximately 2000 reaches in the Murray-Darling Basin. The NLWA will evaluate river health for each reach, however for many reaches only modelled data is available. Integrating scores of component reaches into an overall average score will be undertaken to make larger scale assessments, for example at the catchment scale.

7.3 Sampling

The statistical validity of sampling and reach selection is critical to the success of the SRA. It is likely that some form of stratified random sampling will be required. Stratification may be based on major geomorphic process zones within river valleys, with site(s) selected randomly within these. Geomorphic process zones have been identified for a number of river valleys in the Murray-Darling Basin. Once chosen, reaches should remain static to allow comparisons from year to year. Reach locations may need to be kept obscure to avoid bias.

River health at the valley scale is determined by averaging sampled reaches in the river valley. The number of reaches sampled in a river valley will determine the confidence limit for that indicator for the river valley. The confidence limits indicate the minimum difference in an indicator that could be confidently detected from year to year. The number of reaches required to achieve a set level of confidence depends upon the index measured. Because fish distribution is generally more homogeneous than macroinvertebrate distribution, fewer sites need to be sampled for the same confidence in the reported health.

Existing databases for biotic and physical habitat indices can be used to determine the number of sites required to achieve a desired confidence level, or the confidence level for the number of sites selected can be determined. Tests for sample sizes have been performed on AUSRIVAS data from the Upper Murrumbidgee Catchment and other sub-catchments. Preliminary analysis indicates that about 100 sites per river valley would be required for a precision of 5% of the mean and about 20 sites per river valley would be recommended for a precision of about 10% of the mean[1]. Indicative

[1] A precision of a confidence limit of ±0.05 of the mean for a river valley would mean that differences from year to year in AUSRIVAS O/E score of 0.1 (range: 0 to >1)could be confidently detected. A precision of

sampling density, derived from previous experience in the NSW Rivers Survey, is that five reaches in the larger river valleys and three on the smaller river valleys would be required.

Some of the biotic measures will not be required at all sites, and judgements will have to be made to guide the invertebrate and fish sampling, as well as the water quality monitoring. It is important that some reaches have a full suite of measurements taken.

7.4 Timing

It is proposed that a Comprehensive Sustainability Assessment be undertaken as the first step in the process of auditing the health of the Basin's rivers and would be repeated every five years. In between these years, an annual Sustainable Rivers Audit would be undertaken which would be reviewed through an Independent Audit process. The annual SRA should trigger a more comprehensive investigation if it identifies aspects of concern.

The frequency of biological collection still needs further assessment, but considerable data is now available from existing studies to inform this judgement. It is likely fish sampling will be required annually and invertebrate sampling twice a year. Many of the existing water quality programs are based on monthly sampling and this will probably be adequate.

8 DATA COLLECTION, INTERPRETATION AND REPRESENTATION

8.1 Quality assurance

Once indicators for the SRA are agreed to, discussions with State agencies are needed to ensure that methods of collection, analysis and reporting are consistent with the SRA framework and that quality assurance procedures are in place.

8.2 Presenting the Results

Scores for indices (and sub-indices that make up indices) are often combined to make single river health scores. For example, indices used in the ISC are reported individually and are summed. Similarly, the NLWA will proposes to report indicators individually and will also present a combined river health score using a multivariate approach to combine individual indices.

Consideration needs to be given to how to scale, aggregate and report sub-indices. For example, the water quality index will include data on pH, salinity, nutrients and turbidity: simply adding values for each parameter is not an option. A protocol for scaling these water quality parameters will need to be developed and agreed upon by the States. Successful attempts at scaling and aggregation of these data have been undertaken in various assessments, including ISC.

Whilst indices of river health can be combined to make an overall score it is important to ensure that they are also displayed individually. This will provide the SRA with some diagnostic ability.

Combining scores of indices requires a decision on the relative importance of each index. Availability and quality of data and the perceived importance of an indicator can influence this. For example, biotic indices because they measure the outcome of river management, may be weighted higher than input variables, such as flow and water quality.

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confidence limits of ±0.1 of the mean for a river valley would mean that differences from year to year of 0.2 in AUSRIVAS O/E score could be confidently predicted.

We have recommended that biotic and other indicators and measured at a number of reaches within river valleys. How to aggregate reach scores for indicators into a river valley score remains to be determined and will be undertaken as part of Task 8.

8.3 Selecting Reference Conditions

Most river assessment methods compare the measured condition to the predicted natural (pristine) condition. This is usually determined by measuring similar undisturbed sites. For example, assessments made using the ISC, the NLWA and in the WAMP process all report departure from natural. However, for the lowland rivers in the Murray-Darling Basin it is impossible to find undisturbed sites with which to compare test sites. In these cases the best available sites are used to define reference condition.

There are other methods for choosing reference conditions by which measurements are assessed. These include using sites of good management practice, using a negative reference (highly disturbed sites), or simply using a proportion of the best sites from the randomly selected sites. Definition of reference condition requires further work in the context of the audit, especially with the range of flow regimes and the mix of upland and lowland rivers in the Basin.

Comparability of assessments is a challenge, especially when comparing upstream and downstream reaches, winter rainfall and summer dominated rainfall streams and rivers that are naturally ephemeral with those that are permanent. The IBI approach achieves a standardised approach by comparing within river type (montane, slopes, unregulated and regulated lowland) in ecological regions and in the ISC reaches are divided into three categories – mountain, valley or plain.

Further discussion is required to get agreement on how to define base measures from which departures can be identified and reported, to allow for meaningful discussion. One approach is to estimate "pristine" conditions, and this is the basis for the Victorian ISC. Another is to identify minimally disturbed sites and use those as a baseline. It might be possible to define reference conditions in terms of what is achievable (good management practice) rather than speculating as to what pristine conditions might have been like. For some indicators of water quality there are already nationally agreed Guidelines and criteria. There are considerable difficulties with selecting "pristine" as a reference condition, including:

- there are few, if any, undisturbed sites in lowland rivers to provide a pristine reference; and
- it is likely that lowland river sites in areas of heavy water resource development will repeatedly fail against a pristine reference that may be at odds with societies agreed river health objectives.

8.4 Displaying SRA output

From a management perspective, the traffic light system being developed in Queensland for the WAMP's may be an attractive output of the SRA for measures of outcomes – fish and macroinvertebrates. The red, amber and green approach signifies poor, threatened and good condition in a readily understood way. However, there is considerable subjectivity required in determining where the boundaries between colour bands lie and this will require an understanding of both the reference condition and what the desired river health objectives for the valley are.

Task 8. Development and presentation of combined index of River Health

Conduct a specialist workshop to develop ways of combining the various outcome and input indicators and presenting them in a useful way (traffic light diagrams or something similar for outcome indicators). This will require developing bands for indicators of appropriate health. It will also require a review of error bands and the required sampling frequency.

9 SETTING RIVER HEALTH OBJECTIVES FOR THE RIVER VALLEYS

We do not believe it is essential to establish the goals for reaches or river valleys at the start of the SRA process, and to use the SRA to measure their achievement. It is not necessary to have a goal when we set out to measure the height or weight of a human being; we use an agreed measure and note the result which can then be used in a number of ways.

We believe the SRA must provide a robust and valid measure of the condition of the rivers. It is a value judgement by Governments and local communities where along this scale they wish to position any particular valley.

The process of identifying and setting of river health objectives should be undertaken by governments in partnership with the community. The CRCFE understands that the process of setting river health objectives is well advanced in most jurisdictions through:

- Community Advisory Panels of the Water Allocation Management Planning and Water Management Planning process in Queensland;
- Catchment and Water Management Boards in SA;
- River Management Committees' environmental flow setting as part of the NSW Water Reforms; and,
- Catchment Management Authorities in Victoria; and
- Community Advisory Committee of the Murray-Darling Basin Ministerial Council (CAC)

Once Government and local communities have agreed on river health objectives there is a need for a clear and robust Basin-wide procedure for reporting against agreed objectives that is consistent between jurisdictions.

Government and community aspirations may change over time, and we believe it is important to have a system of measuring river health that enables these value judgements to be made in terms of the various economic and social trade-offs that may have to be made.

10 LIST OF MAJOR RECOMMENDATIONS

Recommendation 1. That the Audit process be a comprehensive audit of the health of the rivers of the Basin, including regulated and unregulated rivers and is not simply an assessment of the Cap and the effects of the environmental flow allocations being put in place by the States.

Recommendation 2. That an annual Sustainable Rivers Audit of the rivers of the Murray-Darling Basin be undertaken, and that an Independent Sustainable Rivers Audit Group be established to report publicly on the findings of the audit. To start this process, and every five years thereafter, a Comprehensive Sustainability Assessment be undertaken and reported using a similar mechanism. Reporting and assessments would be on the basis of defined river valleys.

Recommendation 3. The annual Sustainable Rivers Audit should be made up of indicators reflecting biota (aquatic invertebrates and fish communities), a measure of flow regime and an index of water quality. The five yearly Comprehensive Sustainability Assessment should include these measures, along with some further measures of biological outcome and a Habitat Structure Index.

Recommendation 4. For the purpose of reporting the SRA, and CSA, we recommend the use of a modified set of river valleys to those specified as Designated River Valleys in Schedule F of the *Agreement*. This modified set of river valleys would remove the influence of State boundaries evident in Schedule F, to separate aggregated river valleys, and to separate the Murray into zones.

11 INDICATIVE COSTING

Indicative costing for the development of an SRA framework and the annual cost of data collection for the SRA is presented in Tables 1 and 2.

The approximate cost of developing the SRA and the required indicators is $185,000. The cost would increase by a further $208,000 if it was deemed that a Murray-Darling Basin species-level AUSRIVAS model is required.

The approximate annual cost for data collection for the SRA is $1,044,000. This represents the cost for all data collection. Considerable data is already collected by the States and Territory that are likely to significantly reduce the number of new sites at which data is collected. Consequently, the extra cost imposed by the annual SRA data collection will be less than indicated below. There is an additional cost of analysis and reporting of the SRA. Under the proposed model, this will be the responsibility of the ISRAG.

Table 1. Indicative cost of development of the SRA

Task		**Indicative cost**
Development of agreed SRA indicators and reporting format **Tasks 1, 2, 5 – 8**	Development of coordinated data collection and reporting framework, including issues of collating existing methods, selection of reference, index and sites and development of a suitable reporting framework. Development and agreement on water quality, hydrologic and habitat structure indices. This will involve several workshops with key State and Federal agencies.	$140,000
Biotic Indicator *Macroinvertebrates* **Task 3**	Extension of basic family-level AUSRIVAS models to produce a Murray-Darling Basin Model with existing data. Development and validation of Murray-Darling Basin species-level AUSRIVAS Models – including species level identifications of existing samples.	$10,000 $208,000*
Biotic Indicator *Fish* **Task 4**	Develop an agreed Basin-wide fish sampling protocol - includes workshop of key fish biologists (includes agency and academic representatives). Extension of existing IBI models and production of IBI manuals.	$25,000 $10,000
TOTAL		**$185,000 - $393,000***

*Development of species specific lowland river AUSRIVAS model should not be attempted unless outputs from family-level Murray-Darling Basin AUSRIVAS models are not acceptable. See Appendix for further information.

Table 2. Indicative annual cost of SRA data collection

Task		**Indicative cost**
Biotic Indicator *Macroinvertebrates* *AUSRIVAS*	20 sites * 29 river valleys * 2 visits each year = 1160 site visits at $650 site visit***	$754,000**
Biotic Indicator *Fish* *IBI*	5 sites * 29 river valleys * 1 visit each year = 145 site visits at $2000 site visit***	$290,000
Hydrological Indicators	Data from existing hydrological modelling for Cap compliance etc.	–
Water Quality Indicator	Data collected as part of biotic sampling	–
ANNUAL TOTAL		**$1,044,000**

**Some costs associated with AUSRIVAS program are already covered in existing State and national programs.

***Site visit costs will depend upon remoteness and distance between sites. These reported costs are averaged across the Basin for example, AUSRIVAS data collection cost varies between $500 and $800 per site.

12 GLOSSARY

AUSRIVAS	Australian River Assessment Scheme which is a tool for undertaking macroinvertebrate based assessment of river condition
AREPO	A protocol for assessing river health using fish developed in Queensland
CRCFE	Cooperative Research Centre for Freshwater Ecology
CSA	Comprehensive Sustainability Assessment proposed to be undertaken five-yearly.
FNAR	First National Assessment of River Health
IAG	Independent Audit Group of the Murray-Darling Basin Ministerial Council
IBI	Index of Biotic Integrity is an international assessment method developed for NSW using fish
IMEF	Integrated Monitoring of Environmental Flows is a NSW designed assessment to determine effectiveness of environmental flows in regulated rivers.
ISC	Index of Stream Condition used of river health assessment in Victoria to assess river management priorities.
ISRAG	Independent Sustainable Rivers Audit Group
MDBC	Murray Darling Basin Commission
MDBMC	Murray Darling Basin Ministerial Council
NLWA	National Land and Water Audit which has a waterway condition component.
NRHP	National River Health Program
O/E score	Output of AUSRIVAS and is the ratio of observed to expected macroinvertebrate taxa
PBH	Pressure - Biota - Habitat is a NSW designed assessment for unregulated streams
SoE	State of the Environment Reporting. Undertaken nationally each five years.
SMS	Salinity Management Strategy
SRA	Sustainable Rivers Audit proposed to be undertaken annually

TN	Total Nitrogen
TP	Total Phosphorous
WAMP	Water Allocation Management Plan

13 APPENDIX

Development of Murray-Darling Basin-specific AUSRIVAS models.

Currently, each State has developed models for AUSRIVAS assessment. While the resultant O/E score derived by the different models is comparable it is desirable to develop standard models for the lowland rivers of the Murray-Darling Basin. Using existing data that has been collected by the States, development of Murray-Darling Basin AUSRIVAS models could be achieved for approximately $10,000.

A difficulty with the use of AUSRIVAS in the Basin is the relative lack of taxa in the lowland rivers. Further enhancement of AUSRIVAS in lowland rivers could be achieved by developing species-level models. This could be achieved by reanalysing previously collected samples from reference sites. Species-level Murray-Darling Basin models could be developed for approximately $48,000. The next stage would be to test these models thoroughly by sampling using an optimised method for lowland rivers at sites specifically selected as reference sites throughout the Basin (about 200). This would cost approximately $160,000.

The advantage of species-level Murray-Darling Basin AUSRIVAS models is that they provide more sensitive and comparable outputs throughout the Basin. The disadvantage is that they will not be able to use existing data and each State will have to adopt standard methods for future sampling which may not match what they do elsewhere for AUSRIVAS.

The CRCFE recommends looking at outputs from current state combined season models first, then assessing data for Basin-specific models, possibly coalescing State data where methods are compatible.

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