The use of rapid environmental assessment techniques to monitor the health of Australian rivers

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Abstract River managers require tools to assess the ecological condition of waterways and prioritise management strategies. As benchmarking the condition of an entire waterway with detailed surveys is often not practical, Rapid Environmental Assessment Techniques have been developed to provide an indication of the state of a river’s health, both rapidly and at a low cost. In this investigation, three such techniques, developed recently in Australia, are applied to the same creek in order to compare the outcomes and the levels and types of resources required for their application.

The output from the three indices ranges from descriptive to statistically analysed data, making them difficult to compare directly. Overall, the three indices all report that the sample creek had relatively poor health. The results from the Victorian Index of Stream Condition and New South Wales’ Pressure, Biota, Habitat Stream Assessment appear to correlate well.

An important finding of the investigation is the variation in the resources required to apply each assessment technique. Generally, the resource demands increase with the requirement for a higher level of scientific rigour. The methods are either relatively inexpensive and rapid to undertake or more resource intensive, yet thorough in the data collected. A two step process incorporating the techniques in a cost-effective manner is recommended.

Keywords Environmental assessment; rapid environmental assessment techniques; river health; river management

Introduction

The concept of river health has developed in recent years to help the scientific community communicate complex physical and ecological interrelationships to river managers and the public. Being largely a subjective term, conflict can arise when defining “a healthy river”, as environmental, societal, economic and political goals are often different. In an endeavour to standardise data collection and enable systematic comparison of the environmental component, results of river health assessments are often compiled into various indices referred to as Rapid Environmental Assessment Techniques.

More than 100 river health indices have been developed worldwide. Three such indices currently used in Australia are Queensland’s Anderson Method, Victoria’s Index of Stream Condition (ISC) and New South Wales’ Pressure, Biota, Habitat Stream Assessment (PBH). These indices were developed to separately satisfy river management requirements of the respective States. As a result, each has a different structure, level of detail and final presentation of results.

The objectives of this investigation were to compare outputs from the three indices and assess the relative strength of each to achieve particular criteria. River managers are likely to be interested in a comparison of resources required to apply each of these indices and the resultant scientific rigour and detail expected in the results. An additional objective was to recommend a method for prioritising management of Australia’s rivers using the currently available techniques. The investigation should initiate discussion of the ways in which Australian river health is assessed and managed.
Methods
Rapid Environmental Assessment Techniques to measure river health involve collection of data:
• in a short time frame;
• of reliable quality;
• to identify the parts of a river system which are at risk;
• to identify where rehabilitation is required;
• to allow prioritisation of reaches within the catchment; and
• to give managers direction in detailed planning and allocation of resources.

River management authorities in Australia currently use the three Rapid Environmental Assessment Techniques investigated to evaluate the condition of local river systems. Each technique has been developed in a different state and whilst their general objectives are similar, their specific outcomes are quite different.

The Anderson Method was developed in Queensland as a tool for rapid assessment of a waterway condition. Similarly, the Victorian ISC was designed to be an inexpensive, rapid management tool to provide a general assessment of the condition of a waterway and to identify major problems. It is designed for use over time to evaluate the change in river condition due to management actions. The PBH however, is a scientifically rigorous method that provides comprehensive information about the state of a stream and is thus a relatively resource, time and skill intensive method.

The three indices were applied to the Burrangong Creek catchment in Young, New South Wales. The Anderson method (Anderson, 1993) was applied in 1998 and the results were extracted from the report by Massey (1998). During June and July 2000, the PBH and ISC were applied to the same reaches as part of a Department of Land and Water Conservation project. The ISC was applied according to Ladson and White (1999 a,b,c) and the PBH was carried out in accordance with Chessman (1999 a,b).

Results and discussion
Each method requires that data be collected in a different manner and in a range of levels of detail. The Anderson Method data are grouped by tributary whilst the PBH data is grouped by geomorphic zones defined by the RiverStyles™ framework (Chessman, 1999a). These sets of data were thus not easily comparable. The ISC data can be grouped by both methods and are therefore able to be compared to the other two techniques.

Results from the Anderson Method and the ISC are compared in Table 1. Only the Streamside Zone and Physical Form sub-indices of the ISC are comparable to attributes of the Anderson Method. There was no comparable ISC measurement for Anderson Method attributes such as “Quality of scenic and recreational value”.

Table 1 shows that the Anderson Method generates a descriptive output whilst the ISC data is processed to create a singular numeric value. In this summary table the Anderson Method output appears more comprehensive than the ISC results, which have been grouped for comparison. However, the standard presentation of ISC results is much more detailed and grouping the results as seen in Table 1 is not prescribed in the ISC method. It is clear that, although both techniques generated an overall score of “poor”, the correlation between the results for each attribute is not strong. For example, a Streamside Zone ISC score of 4 is not directly comparable to the Anderson method descriptive scores ranging from low to extreme/very high. This illustrates the different output of each method due to their different objectives.

The ISC and PBH are compared in Table 2, in a summary of one of three large tables used for PBH reporting. It is important to note that the way in which both the ISC and PBH data were summarised for this comparison was not prescribed by the methods’ authors, but was carried out to enable comparison of the outcomes of the two indices.
The PBH aims to generate a detailed data set of a creek’s characteristics. It attempts to identify the cause of a particular condition in a creek and aims to accommodate the value system of social, economic and political attitudes by putting weighting on what is deemed important in a particular region. Consequently, the results are extensive, making them difficult to compare directly to those of the other indices. The data in Table 2 are generated from the details in the Indicators of Conservation Significance table in which those values lying above the nominated Threshold value are considered important. That information is not portrayed in this summary table.

Using average values for the various PBH classifications in each ISC category, as shown in Table 2, enabled overall comparison of outcomes. The results appear to be moderately consistent between the indices, with values lying within small ranges. For example, the Physical Form score ranges from 4 to 6 out of 10 for the ISC and 24 to 30 out of 100 for the PBH, with values over 65 considered to have conservation significance. Although the values are not directly comparable, they can generally be seen to show little variation throughout the six creek zones.

Tables 1 and 2 show the different types and complexities of output that are generated using the three techniques. Once river managers have determined their preferred structure and detail of output from a Rapid Environmental Assessment Technique, they would need
to consider the resource demands of each option. Table 3 is intended to aid river managers in their selection process of the most appropriate technique. Whilst the PBH could be considered to be the most scientifically rigorous of the three techniques, with its highly specialised staff and collection of primary data, it is resource intensive.

Table 3 includes a breakdown of the Human, Skill, Time, Equipment and Financial requirements of each technique. Several are divided into the costs of fieldwork, laboratory analysis and data analysis. At the time of the research, only the ISC data were able to be analysed by a non-specialist. The Anderson Method results had to be processed by Dr. John Anderson and Dr. Bruce Chessman compiled the PBH data into three large tables. Relying on the methods’ authors to analyse data restricts the use of the techniques and considerably increases the financial costs of the process.

The fieldwork is also seen to require a range of resources. Trained people who do not necessarily have a scientific background can carry out the Anderson Method and ISC. The PBH, however, relies upon specialist scientists to collect reliable and extensive primary data. Being aware of these resource demands is essential to river managers in their decision making process to select the most appropriate technique, which is also affordable.

If each technique produced a similar result for the same river, river managers would be able to select the most appropriate tool for their needs by comparing the resources required. The research shows that the three indices are very different in their background and objectives.

A summary of the benefits and limitations of each method is as follows.

**Anderson Method**
- Rapid
- Low resource requirements
- Observational data collected, some components assessed subjectively
- Descriptive output

**Index of Stream Condition**
- Rapid
- Low resource requirements
- Observational data collected, subjectivity reduced with the aid of reference photos and diagrams in the field manual
- Existing data from external sources incorporated
- Numerical output

**Pressure, Biota, Habitat Stream Assessment Method**
- Less rapid than the other techniques
- High resource requirements
- Scientific assessment of a broad range of characteristics
- Primary data used in analysis
- Numerical and statistically analysed output

The Anderson Method and ISC are relatively simple, efficient and cost effective methods of benchmarking the health of a catchment. Their resource requirements are low and data collectors need not be scientists. Both methods are useful in collecting data over a range of spatial and temporal zones that may be used in benchmarking and evaluation programs. The PBH is a different level of assessment. It involves the thorough collection of primary data by professional scientists with high quality equipment. As a result, the data produced by the resource intensive PBH could be expected to have a high level of scientific rigour.

With this basic summary of the methods in mind, a two-stage approach to prioritising management of Australian rivers is recommended.
Stage one. Use the Anderson Method, the Index of Stream Condition or a similarly rapid and low cost technique to assess the rivers in a catchment. Use the results to prioritise areas in the catchment and flag those reaches where the condition is at medium to high risk of deterioration. This will enable river managers to screen out low risk areas that do not require short-term attention.

Stage two. Use a detailed technique such as the Pressure, Biota, Habitat Stream Assessment, which relies on scientifically rigorous primary data, to assess the high and medium risk areas, depending on the resources available.

By using this process, river managers could substantially reduce the cost of applying a detailed assessment to an entire catchment. The data collected by a rapid technique will screen for those areas that are of concern to undergo further, more detailed assessment. This will reduce the overall cost of a program to assess the condition of rivers in a catchment and

Table 3 A comparison of the three indices on the basis of the resources required in their application

<table>
<thead>
<tr>
<th>Resources</th>
<th>Anderson Method</th>
<th>ISC</th>
<th>PBH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Fieldwork</td>
<td>• Two people</td>
<td>• Two to three people</td>
<td>• Five to six people</td>
</tr>
<tr>
<td></td>
<td>• One supervisor</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>available by phone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Human Data Analysis</td>
<td>• Dr. John Anderson</td>
<td>• One person using</td>
<td>• Dr. Bruce Chessman</td>
</tr>
<tr>
<td></td>
<td>• DLWC staff member</td>
<td>reference manuals and</td>
<td>Computer program to be</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Excel spreadsheets</td>
<td>developed</td>
</tr>
<tr>
<td>Skill Fieldwork</td>
<td>• Two trained non-experts</td>
<td>• One trained non-expert</td>
<td>Hydrographer, vegetation</td>
</tr>
<tr>
<td></td>
<td>• One experienced</td>
<td>• One untrained non-expert</td>
<td>expert, fluvial geomorphology and/or macroinvertebrates</td>
</tr>
<tr>
<td>Skill Data Analysis</td>
<td>• Dr. John Anderson</td>
<td>• Several experts at</td>
<td>• Dr. Bruce Chessman</td>
</tr>
<tr>
<td></td>
<td>• DLWC staff member</td>
<td>agencies</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• One non-expert to compile</td>
<td></td>
</tr>
<tr>
<td>Time Training</td>
<td>• Two people, two day training course</td>
<td>• One person, two day training course</td>
<td>Training was carried out in situ for the first four days of fieldwork by Dr. Bruce Chessman</td>
</tr>
<tr>
<td>Time Fieldwork</td>
<td>• 1 hour per site, maximum 6–7 sites per day</td>
<td>• 1 hour per site, maximum 6–7 sites per day</td>
<td>• 2–2.5 hours per site, maximum 3 sites per day</td>
</tr>
<tr>
<td>Time Lab. Analysis</td>
<td>• n/a</td>
<td>• Pre-existing data from established programs used, 2 weeks to collect for 20 sites</td>
<td>• Over 2 months for 20 sites</td>
</tr>
<tr>
<td>Time Computer Analysis</td>
<td>• Time frame not specified in report</td>
<td>• 1 week using spreadsheets and basic equations from manual</td>
<td>• Over 2 months for 20 sites</td>
</tr>
<tr>
<td>Equipment</td>
<td>• Minimal</td>
<td>• Minimal</td>
<td>• Extensive</td>
</tr>
<tr>
<td>Financial Fieldwork</td>
<td>• One 4WD vehicle, petrol, two-way radio, maps</td>
<td>• One 4WD vehicle, petrol</td>
<td>• Three 4WD’s petrol</td>
</tr>
<tr>
<td></td>
<td>• Accommodation and wages for 2 DLWC staff</td>
<td>• Accommodation and wages for 2–3 non-experts</td>
<td>Accommodation and wages for 5–6 DLWC staff</td>
</tr>
<tr>
<td>Financial Lab. Analysis</td>
<td>• n/a</td>
<td>• n/a</td>
<td>20 water quality samples, 20 diatom samples, 60 macroinvertebrate samples identified</td>
</tr>
</tbody>
</table>
help river managers to make informed decisions about the allocation of their resources in an efficient manner.

Conclusions
As seen with the three methods investigated, Rapid Environmental Assessment Techniques are developed for many different reasons and within a variety of management structures. The Anderson Method, Index of Stream Condition (ISC) and Pressure, Biota, Habitat Stream Assessment (PBH) have all been developed within the politically defined boundaries of Australia’s state system. Each is tailored to contribute to a particular state’s water management system and the results from each technique are structured in such different forms that correlation between them is problematic.

A hybrid strategy involving at least two of the three indices was suggested for evaluating stream health Australia-wide. Alternatively, a new index could be developed for use within appropriate geomorphological regions. Until such time, we must determine both the benefits and limitations of the methods currently available and decide whether they meet our management needs.

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References