National River Health Program

healthy rivers   living rivers
rivers for life

MONITORING RIVER HEALTH INITIATIVE TECHNICAL REPORT
REPORT NUMBER 22

Australian River Assessment System: AusRivAS Physical Assessment Protocol

Authors: Melissa Parsons
Martin Thoms
Richard Norris

Natural Heritage Trust
Helping Communities Helping Australia
A Commonwealth Government Initiative

Environment Australia
Department of the Environment and Heritage

COOPERATIVE RESEARCH CENTRE FOR FRESHWATER ECOLOGY

Published By: Environment Australia
GPO Box 787
CANBERRA ACT 2601

Authors: Melissa Parsons, Martin Thoms and Richard Norris
Cooperative Research Centre for Freshwater Ecology
University of Canberra
ACT 2601
Telephone: 02 6201 5408
Fax: 02 6201 5038

The information contained in this work has been published by Environment Australia to help develop community, industry and management expertise in sustainable water resources management and raise awareness of river health issues and the needs of our rivers. The Commonwealth recommends that readers exercise their own skill and care with respect to their use of the material published in this report and that users carefully evaluate the accuracy, currency, completeness and relevance of the material for their purposes.

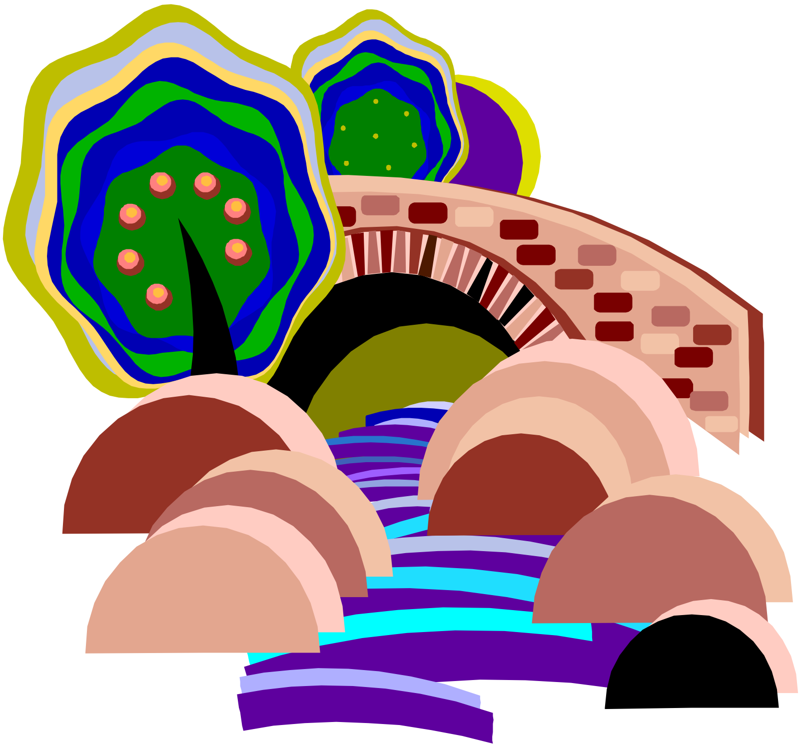
Citation: For bibliographic purposes this report may be cited as:
Parsons, M., Thoms, M. and Norris, R., 2002, *Australian River Assessment System: AusRivAS Physical Assessment Protocol*, Monitoring River Heath Initiative Technical Report no 22, Commonwealth of Australia and University of Canberra, Canberra.

ISBN: 0 642 54888 9

ISSN: 1447-1280

Information: For additional information about this publication, please contact the author(s). Alternatively, you can contact the Community Information Unit of Environment Australia on toll free 1800 803 772.

AUSRIVAS PHYSICAL ASSESSMENT PROTOCOL



Melissa Parsons **Martin Thoms** **Richard Norris**

Cooperative Research Centre for Freshwater Ecology

University of Canberra

February 2001

Environment Australia
Department of the Environment and Heritage

Cooperative Research Centre for Freshwater Ecology

Natural Heritage Trust
Helping Communities
Helping Australia

ACKNOWLEDGMENTS

This document draws heavily on published stream assessment methods currently in use in Australia and overseas. Thus, we would like to acknowledge the authors of these methods because this document is somewhat a summary of their expertise. These authors are:

River Habitat Audit Procedure	John Anderson
Index of Stream Condition	Tony Ladson, Lindsay White, CRC for Catchment Hydrology and Department of Natural Resources and Environment, Victoria.
River Styles	Gary Brierley, Kirstie Fryirs, Tim Cohen and others at Macquarie University
Habitat Predictive Modelling	Nerida Davies, Martin Thoms, Richard Norris
River Habitat Survey	P. Raven, N. Holmes, F. Dawson, P. Fox, M. Everard, I. Fozzard, K. Rouen and others at the UK Environment Agency and Scottish Environment Protection Agency
AUSRIVAS	All involved with the AUSRIVAS component of the National River Health program at both a State and Federal level. Particular thanks to members of the current AUSRIVAS team at the CRCFE in Canberra for help with the construction of this document: Julie Coysh, Phil Sloane, Sue Nichols, Nerida Davies and Gail Ransom.
USEPA Habitat Assessment	James Plafkin, Mike Barbour, Kimberley Porter, Sharon Gross, Robert Hughes, Jeroen Gerritson, Blaine Snyder, James Stribling

Participants in the Habitat Assessment Workshop also provided ideas for the development of this protocol. These people are: John Anderson, Rebecca Bartley, Andrew Boulton, Gary Brierley, Nerida Davies, Jenny Davis, Barbara Downes, Fiona Dyer, Wayne Erskine, Judy Faulks, Brian Finlayson, Kirstie Fryirs, Chris Gippell, Bruce Gray, Kathryn Jerie, Tony Ladson, Richard Marchant, Leon Metzeling, Richard Norris, Melissa Parsons, Mike Stewardson, Mark Taylor, Jim Thompson, Martin Thoms, Simon Townsend and John Whittington.

John Foster, Heather McGinness, Vic Hughes, Andrew Pinner and Fiona Dyer of the River and Floodplain Laboratory, University of Canberra, provided advice on several of the variables included in this protocol, and also provided many photographs. Desley Ferguson and Melanie Saxinger provided administrative support.

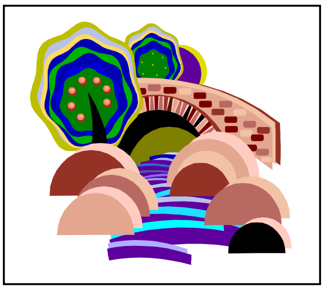
Environment Australia
Department of the Environment and Heritage

Cooperative Research Centre for Freshwater Ecology

Natural Heritage Trust
Helping Communities
Helping Australia

TABLE OF CONTENTS

Table of contents (cont.)



1 INTRODUCTION

1.1 BACKGROUND

1.1.1 The need for a physical assessment protocol

The physical assessment of stream condition lies within a broad framework of environmental restoration. Most river rehabilitation methods recommend the use of a pre and post-restoration assessment of condition. For example, the 12-Step rehabilitation process of Rutherfurd *et al.* (2000) includes description of present stream condition and evaluation of the success of the rehabilitation process. Similarly, Kondolf (1995) recommends the collection of baseline data that can be used to evaluate change caused by rehabilitation projects and Hobbs and Norton (1996) stress the importance of identifying the processes leading to degradation or decline, and of developing easily observable measures of the success of restoration interventions. The assessment protocol described in this document addresses these aspects of river rehabilitation by providing a quantitative approach to the physical assessment of river condition.

The Australian River Assessment System (AUSRIVAS) is a nationally standardised approach to biological assessment of stream condition using macroinvertebrates, that was developed under the auspices of the National River Health Program (NRHP). Within the AUSRIVAS component of the NRHP a suite of 'toolbox' projects have been commissioned with the aim of either refining the existing assessment techniques, or developing additional aspects of river health assessment. One of these toolbox projects is the physical assessment module, which involves development of a standardised protocol for the assessment of stream physical condition. Construction of such a protocol requires simultaneous consideration of stream condition from a physical and a biological 'habitat' perspective. While there would seem to be obvious interdependencies between the physical and biological components of streams, merging them is a complex task because of the different paradigms that exist in the disciplines of fluvial geomorphology and stream ecology. However, it is envisaged that the incorporation of a physical assessment module into AUSRIVAS will provide a tool for evaluating and understanding the physical condition of streams that is complementary to measures of stream condition that are made using the biota (Maddock, 1999). This tool can be used to enhance the AUSRIVAS assessments of stream condition, and also to evaluate physical condition within a stream restoration framework.

1.1.2 Aim and scope of the physical assessment protocol

The AUSRIVAS physical assessment protocol is a method for assessing the physical condition of streams and rivers. The protocol is a 'stand alone' method of physical and geomorphological assessment, however, it also has the capability to complement the biological assessments of stream condition that are made using AUSRIVAS.

This document is essentially a 'field manual' that presents the background information to the method and instructions for the selection of reference sites and collection of physical data. Full implementation of the protocol involves collection of reference site information from both the field and the office, and subsequent development of predictive models. This document describes methods for reference site selection and field and office data collection only. It does not describe methods for the construction of predictive models, because these closely follow the AUSRIVAS procedures described in Simpson and Norris (2000). **To make an assessment of physical stream condition using the protocol, a large number of reference sites must be sampled and predictive models generated. Then, the condition of test sites can be determined using these models.** This is the same process that was used in the National River Health Program to develop AUSRIVAS.

The protocol follows the Habitat Predictive Modelling approach of Davies *et al.* (2000) that in turn, is similar to AUSRIVAS in both data collection and analytical procedure (Simpson and Norris, 2000). This approach has advantages over other physical assessment methods in use in Australia because it allows prediction of the stream features expected to occur at a sampling site and generates quantitative assessments of physical condition (ie. observed/expected ratios). However, achievement of robust predictions relies on the inclusion of a wide range of physical and geomorphological factors. Thus, the Habitat Predictive Modelling approach of Davies *et al.* (2000) will be strengthened with sampling design, data collection and analytical components derived from other physical and geomorphological stream assessment methods presently in use in Australia.

Additionally, it should be noted that this protocol is for use in freshwater rivers and streams only and NOT for use in estuaries or tidal sections of lowland rivers.

1.1.3 Structure of this document

This document is divided into seven parts. This section, **Part 1**, describes the background and derivation of the protocol and also gives an overview of how the protocol works. **Part 2** provides information and instruction on the procedure that will be used to select reference sites. These reference sites are then used in the construction of predictive models. **Part 3** gives an overview of the requirements for collecting field and office based data and **Part 4** contains the data sheets for use in the field. **Part 5** is used in conjunction with Parts 3 and 4 and gives detailed technical instructions for the collection or measurement of each field based and office based variable used in the protocol. **Part 6** is the reference list and **Part 7** contains various appendices to the text.

The protocol has been written with the assumption that the reader is familiar with AUSRIVAS sampling procedures, model development and model outputs. General information on AUSRIVAS can be obtained at http://ausrivas.canberra.edu.au/ and technical information can be found in the papers collected together in Wright *et al.* (2000).

1.2 DEVELOPMENT OF THE PHYSICAL ASSESSMENT PROTOCOL

Development of the physical assessment protocol involved three stages: evaluation of physical stream assessment methods currently in use in Australia, a habitat assessment workshop and derivation of final recommendations for a standardised assessment protocol. Each of these stages will be discussed briefly in the following sections.

1.2.1 Evaluation of existing stream assessment methods

The Index of Stream Condition (Ladson and White, 1999; Ladson *et al.*, 1999; White and Ladson, 1999), River Habitat Audit Procedure (Anderson, 1993a; Anderson, 1993b; Anderson, 1993c; Anderson, 1999), River Styles (Brierley *et al.*, 1996; Cohen *et al.*, 1996; Fryirs *et al.*, 1996; Brierley *et al.*, 1999; Brierley and Fryirs, 2000) and Habitat Predictive Modelling (Davies, 1999; Davies *et al.*, 2000) methods were evaluated against a set of criteria that represent the desirable requirements of a standardised physical assessment protocol (Table 1.1).

The Index of Stream Condition, the River Habitat Audit Procedure, River Styles and Habitat Predictive Modelling were designed for slightly different purposes and subsequently, each of these methods differ in their compatibility with the requirements of a standardised physical assessment protocol (Table 1.1). Each method performed equally well against criteria such as 'ability to assess stream condition against a desirable reference state', and 'applicability to all stream types within Australia'. However, only one or two methods performed well against criteria such as 'ability to predict physical stream features that should occur in disturbed rivers and streams' and 'outputs of physical condition that are comparable to AUSRIVAS outputs of biological condition' (Table 1.1). Overall, no one method met all the requirements for a stand-alone stream assessment protocol. However, each method contains important individual components that will be combined into a comprehensive protocol for assessing stream physical condition (see Section 1.2.3).

1.2.2 Habitat Assessment Workshop

Twenty-two leading ecologists, geomorphologists and hydrologists attended a workshop titled "Stream Habitat Assessment: Integrating Physical and Biological Approaches", that was held at the University of Canberra on May 2-3, 2000. Broadly, the workshop was designed to provide the rationale and background information upon which to build a standardised physical assessment module. Several critical areas of the development of the physical assessment protocol were identified at the workshop. These were:

- Study design issues, including division of the catchment into homogeneous stream sections and definition of the geomorphological reference condition;
- Scale of focus issues, including grain and extent and the spatial and temporal scales at which physical variables should be measured;
- Choice of overall assessment method; and,
- Use of rapid data collection philosophies for physical variables.

In addition, the Habitat Assessment Workshop also examined the types of physical variables that would be useful for inclusion in the protocol.

Table 1.1 Evaluation of river assessment methods against desired criteria of the physical assessment protocol. The representation of each of the criteria by the methods is designated as yes (Y), no (N) or potentially (P).

Criteria required for the physical assessment protocol	**Existing physical assessment methods**			
	River Habitat Audit Procedure	Index of Stream Condition	River Styles	Habitat Predictive Modelling
Ability to predict the physical features that should occur in disturbed rivers and streams	**N**	**N**	**P**[1]	**Y**
Ability to assess stream condition relative to a desirable reference state	**Y**	**Y**	**Y**	**Y**
Use of a 'rapid' data collection philosophy	**Y**	**Y**	**N**	**Y**
Use of physical variables that do not require a high level of expertise to measure and interpret	**Y**	**Y**	**P**[2]	**Y**
Use of variables that represent the fluvial processes that influence physical stream condition	**Y**	**Y**	**Y**	**P**[3]
Outputs that are easily interpreted by a range of users	**Y**	**Y**	**N**	**Y**
Applicability to all stream types within Australia	**P**[4]	**P**[4]	**P**[4]	**P**[4]
Incorporation of a scale of focus that matches the scale of biological collection within AUSRIVAS	**Y**	**Y**	**P**[5]	**Y**
Collection of physical parameters that are relevant to macroinvertebrates	**P**	**P**	**P**	**Y**
Outputs of physical condition that are comparable to AUSRIVAS outputs of biological condition	**N**	**N**	**N**	**Y**

1. Predictive ability relies on expert knowledge of the geomorphological behaviour of river systems.
2. Variables may not require a high level of expertise to measure, but a high level of expertise to interpret.
3. Currently uses physical data collected in AUSRIVAS, but can be modified to incorporate other types of variables.
4. There is no existing Australia wide system for assessing the physical condition of rivers. All methods are potentially modifiable for use in different river types across Australia.
5. River Styles uses a multi-scale approach to characterise and assess river systems.

1.2.3 Final recommendations for the physical assessment protocol

The areas of concern identified at the Habitat Assessment Workshop were considered alongside the evaluation of existing stream assessment methods to make a final set of recommendations for the content and philosophy of the physical assessment protocol. These recommendations were:

- The overall approach of the physical assessment protocol will be based on Habitat Predictive Modelling (Davies *et al.*, 2000). This method confers three main advantages in that it has predictive capabilities, it can be modified to incorporate components from other stream assessment methods and it is highly compatible with AUSRIVAS;
- Habitat Predictive Modelling will be augmented with sampling design, data collection and analytical components from other stream assessment methods;
- A hierarchical approach will be incorporated into the design of the protocol. The use of a hierarchical approach will potentially improve prediction of stream habitat features by encompassing geomorphological processes operating over a range of scales, and by incorporating the link between large scale 'control' variables and local scale habitat features;
- The broad geomorphological processes occurring in river systems will be incorporated into the reference site selection procedure to ensure coverage of a range of different river zones; and,
- The variables measured in the protocol will be critical to the assessment of stream condition and to the construction of predictive models. Thus, variables from existing stream assessment methods will be included to encompass the hierarchical linkages between large and small-scale factors, and also to encompass a range of indicators that may change with degradation. The collection of field based information will use a rapid collection philosophy.

These recommendations were then used to formulate the content of the physical assessment protocol (see Section 1.3), including the reference site selection procedure (Part 2) and the methods for field and office based data collection (Part 3).

1.3 DESCRIPTION OF THE PHYSICAL ASSESSMENT PROTOCOL

1.3.1 Philosophy of the protocol

The philosophy of the physical assessment protocol generally follows the same fundamental principles as rapid biological monitoring programs such as AUSRIVAS. These principles are predictive capability, use of the reference condition concept and use of rapid survey techniques. However, it is also important to incorporate principles of fluvial geomorphology into the protocol because there are fundamental differences between the properties of biological and physical information, and also between the way that information is used within a physically based predictive model. In a biological model, the relationship between physical information and biological information is fundamental whereas in a physical model, the relationship between large scale and small scale physical factors is fundamental (see Section 1.3.2 and Davies *et al.*, 2000). Thus, the incorporation of geomorphological principles that relate small scale and large scale factors underpins the physical model in the same way that the deterministic link between macroinvertebrates and environmental features underpins the biological model. The founding principles of the physical assessment protocol are discussed in the following sections.

1.3.1.1 Predictive capability

RIVPACS is a predictive modelling technique that was developed in the United Kingdom as a tool for the biological assessment of stream condition using macroinvertebrates (Wright, 2000). The predictive modelling approach used in RIVPACS (Wright *et al.*, 1984) forms the basis of AUSRIVAS, the Australian biological assessment scheme that has been used successfully to assess the condition of several thousand sites nationwide (Davies, 2000; Simpson and Norris, 2000). The same predictive technique has also been used for development of the Canadian BEAST predictive models for rivers and lakes (Reynoldson *et al.,* 1997; Reynoldson *et al.,* 2000; Rosenberg *et al.*, 2000) and for the prediction of macroinvertebrate composition using microhabitat features (Evans and Norris, 1997).

Recently, the predictive modelling approach has been applied to the assessment of stream habitat condition (Davies *et al.*, 2000). This study used catchment scale features to successfully predict the occurrence of local scale habitat features and will be used as the basis for the physical assessment protocol. The major advantage to using predictive modelling for assessment of physical stream condition is the ability to predict the local scale habitat features that should be present at a site. Subsequently, it is then possible to compare what is expected to occur at a site, against what was actually observed at a site, with the deviation between these two factors being a quantitative indication of physical stream condition.

1.3.1.2 Hierarchical approach

There are many interrelated geomorphological factors that operate within a river system. These geomorphological factors sit within a hierarchy of influence (Figure 1.1), where certain factors set the conditions within which others can form (de Boer, 1992; Bergkamp, 1995). Geology and climate are considered ultimate factors because they directly or indirectly control the formation of all other factors in the cascade (Schumm and Lichty, 1965; Lotspeich, 1980; Knighton, 1984; Frissell *et al.*, 1986; Naiman *et al*, 1992; Montgomery, 1999). Geology and climate act to control to physiography of the catchment, the types of vegetation and soils that are present in a catchment, and the uses to which humans put the land. These factors control sediment and discharge regimes which in turn, sets the morphology and dynamics of the river system (Figure 1.1). Thus, in a fluvial system, physical and geomorphological factors operating at one level of the hierarchy directly influence the formation of factors at successively lower levels.

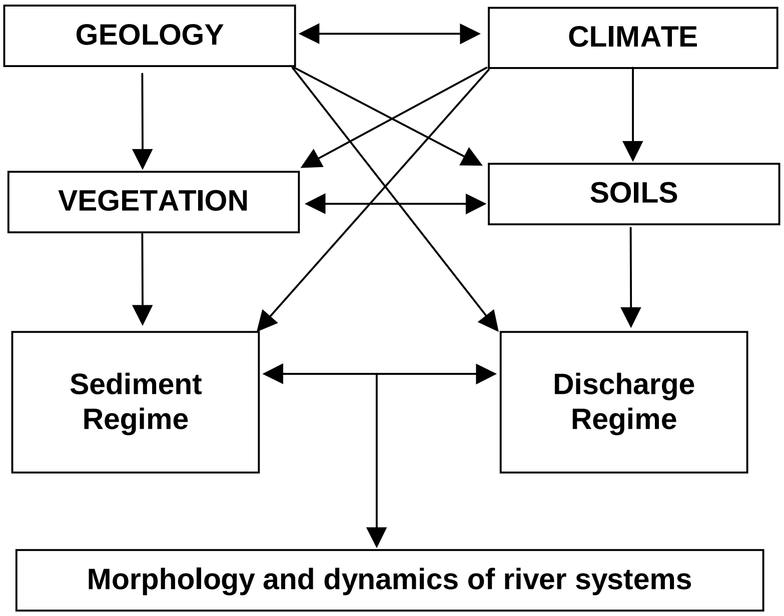


Figure 1.1 Interrelationships in a fluvial system. After Thoms (1998) and ideas presented in Schumm (1977) and Knighton (1984).

As a result of this hierarchy of influence within a river system, the deterministic links between different hierarchical levels, or scales, can be harnessed into ‘raw material’ for a predictive model. For example, Davies *et al.* (2000) used large-scale catchment characteristics to predict local-scale habitat features in an AUSRIVAS style predictive model and hence, was able to assess habitat condition. Similarly, Jeffers (1998) examined the River Habitat Survey Data (Raven *et al.*, 1998) and was able to predict local-scale habitat features from the map-derived large-scale factors of altitude, slope, distance to source and height of source. The physical protocol will incorporate the hierarchical links within a river system by using large-scale characteristics (or control variables) to predict local-scale habitat features (or response variables, and See Part 3).

In addition to the deterministic links between geomorphological factors at different scales, the hierarchy of geomorphological interrelationships within a river system gives rise to the concept of hierarchical organisation of river systems. Probably the most familiar application of this concept is the stream classification framework of Frissell *et al.* (1986), which was designed to encompass the relationships between a stream and its catchment at a range of spatial and temporal scales. Five hierarchical levels were named in this scheme: stream systems, segment systems, reach systems, pool-riffle systems and microhabitat systems (Figure 1.2). Each system develops and persists at a characteristic spatial and temporal scale and smaller-scale systems develop within the constraints set by the larger-scale systems of which they are a part (Frissell *et al.*, 1986). The spatial and temporal scales associated with each system subsequently translate into a set of defining physical factors that can be used to identify the hierarchical boundaries of each system within a watershed (Figure 1.2). For example, at the top of the hierarchy, stream systems within a watershed persist at large spatial scales and long time-scales (Figure 1.2) and are defined partly by ultimate factors such as geology and climate. This pattern of characteristic scales of persistence and physical factors continues through the hierarchy of segment, reach and pool/riffle systems until at the bottom of the hierarchy, microhabitats persist at small temporal and spatial scales and are defined by dependent factors such as substrate, water velocity and water depth (Figure 1.2). Thus, the division of a catchment into component hierarchical systems provides a practical representation of the complex interrelationships that exist between physical and geomorphological factors across different spatial and temporal scales.

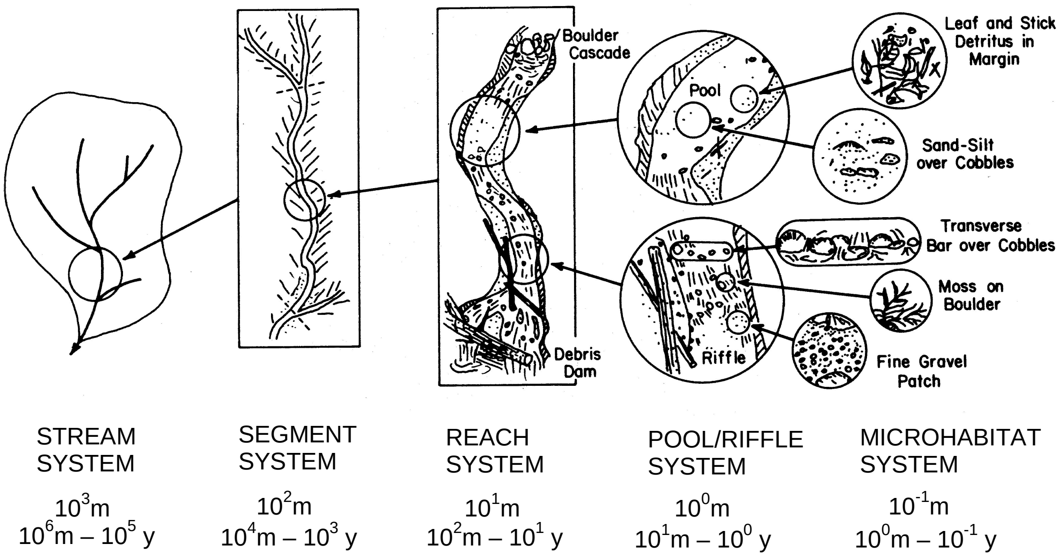


Figure 1.2 Hierarchical organisation of a stream system, and its habitat sub-systems. The approximate linear spatial scale (metres) and time scale of persistence (years) for a second or third-order mountain stream is also indicated for each system. After Frissell *et al.* (1986).

In the physical assessment protocol, data are collected at two spatial scales: a large catchment or segment-scale and a small sampling site scale. As mentioned above, large-scale factors are then used to predict the occurrence of small-scale factors. While these scales of measurement represent the deterministic links between geomorphological factors at different scales, they also correspond to the stream system or stream segment, and reach or pool/riffle scales of Frissell *et al.* (1986; and see Figure 1.2). Thus, the scales of measurement used in the protocol target differences between these specific hierarchical levels. The microhabitat is not considered as an explicit scale of measurement, because the protocol does not aim to predict physical factors at this level of detail. Additionally, the stratification of reference sites by regions and functional zones (see Part 2) is a function of the hierarchical organisation of river systems. Geomorphological processes related to the formation of regions and functional zones operate over large spatial scales and long time-scales and thus, sit at the top of the hierarchy (Figure 1.2). As a result, reference site stratification is targeted at the catchment and segment scales, because it is desirable to identify the broad (rather than fine) differences in river types that occur at these relatively large scales. Stratification of reference sites across a framework derived from geomorphological process will also ensure coverage of a range of deterministic linkages between large and small scale variables, that may change across regions and functional zones (Schumm, 1977).

1.3.1.3 Reference condition concept

The physical assessment protocol uses the reference condition concept. The reference condition concept underpins many biological assessment programs including the United Kingdom's RIVPACS, Australia's AUSRIVAS and Canada's BEAST predictive models (Reynoldson *et al.*, 2000). The reference condition concept circumvents reliance on single control sites, and instead, aims to derive large sets of minimally disturbed reference sites that are formed into groups with similar biological and physical features (Reynoldson and Wright, 2000). Hence, the reference condition is defined as 'the condition that is representative of a group of minimally disturbed sites organised by selected physical, chemical and biological characteristics' (Reynoldson *et al.,* 1997). Assessment of condition is subsequently achieved by comparing a test site against a group of multiple reference sites that would be expected to have similar features in the absence of degradation. Comparison of a test site against a reference condition derived from multiple sites improves confidence that observed degradation results from anthropogenic factors, rather than from inherent natural variation.

The reference condition concept was derived from work in the field of biological assessment of stream condition (Reynoldson and Wright, 2000), and has been applied successfully to the development of models that assess habitat condition (Davies *et al.*, 2000). However, in applying the reference condition concept to physical assessment of stream condition there are two specific aspects that need to be considered: coverage of a range of different river types and definition of 'minimally disturbed' conditions. Reynoldson and Wright (2000) warn that the population of reference sites must represent the full range of conditions that are expected to occur at all other sites to be assessed. The physical assessment protocol addresses this aspect by stratifying reference sites on the basis of climatic and geological regions, and on the basis of geomorphological river types within regions (see Part 2). Selection of reference sites that represent 'minimally disturbed' conditions is also central to the reference condition concept, and requires consideration of the factors that may be acting to influence stream condition (Hughes *et al.*, 1986; Hughes, 1995; Reynoldson and Wright, 2000). The physical assessment protocol addresses this by examining the large scale and local scale activities that may potentially be impacting the river system (see Part 2).

1.3.1.4 Rapid survey methods

In the last three decades biological monitoring has moved away from the use of intensive quantitative surveys, toward the use of rapid, semi-quantitative stream assessment methods (Resh and Jackson, 1993). There are two main advantages of rapid survey techniques. Firstly, the effort and cost required to assess environmental condition is reduced relative to that needed in quantitative approaches, by using simplified sampling and sample processing techniques. Secondly, the results of these surveys can be summarised into a form that is easily understood by a range of non-specialists (Resh and Jackson, 1993; Resh *et al.*, 1995). However, in achieving these advantages, the design of rapid methods must maintain an ability to detect a continuum of impaired and unimpaired conditions. Examples of rapid biological monitoring techniques that have been used successfully to examine stream condition include the United Kingdom's RIVPACS (Wright *et al.*, 1984; Wright 2000), the United States' Rapid Bioassessment Protocols (Plafkin *et al.*, 1989; Barbour *et al.*, 1999) and Australia's AUSRIVAS predictive models (Marchat *et al.*, 1999; Smith *et al.*, 1999; Turak *et al.*, 1999; Davies, 2000; Simpson and Norris, 2000).

In recent years, rapid assessment principles have been applied to physical stream assessment methods. Examples include Australia's River Habitat Audit Procedure (Anderson 1993a, 1993b, 1993c) and Index of Stream Condition (Ladson and White, 1999), the United Kingdom's River Habitat Survey (Raven *et al.*, 1998) and the United States' HABSCORE habitat assessment, that is used to support the Rapid Bioassessment Protocols (Plafkin *et al.*, 1989; Barbour *et al.*, 1999). These assessment methods incorporate a range of physical characteristics, representing major geomorphological and habitat-template components. Variables included in these methods are measured using simplified techniques such as visual assessment and overall estimation, rather than the more time-consuming quantitative techniques such as surveying, replicated sedimentological particle size analysis, historical interpretation and transect vegetation surveys. The methods described above have demonstrated that it is possible to achieve a robust assessment of physical stream condition using data collected with rapid survey techniques, and as such, the physical assessment protocol will also use rapid techniques.

1.3.1.5 Includes geomorphologically and biologically relevant physical features

River systems can be viewed at distinctive hierarchical levels that represent a cascade of geomorphological interrelationships (see Section 1.3.1.2). The characteristic geomorphological processes that operate at each hierarchical level within a river system create the physical structure of a river (Frissell *et al.*, 1986; Harper and Everard, 1998; Brierley *et al.*, 1999) and in turn, the physical structure of a river provides a habitat matrix within which biophysical processes occur (Swanson, 1979; Brierley *et al.*, 1999; Montgomery, 1999). Biologically, it has been proposed that habitat provides the templet on which evolution acts to forge characteristic life history strategies (Southwood, 1977; Southwood, 1988; Hildrew and Giller, 1994; Townsend and Hildrew, 1994). Accordingly, the environmental properties of any given habitat within a stream system will determine the types of macroinvertebrate communities found there. Therefore, stream habitat forms as a result of characteristic geomorphological processes and so conveniently sits between the physical forces which structure river systems and the biological communities that inhabit them (Harper and Everard, 1998).

There is much evidence to suggest that macroinvertebrates are strongly and deterministically linked to the availability of suitable habitat features. These features include substrate, discharge, hydraulics, riparian vegetation and water chemistry (Giller and Malmqvist, 1998). The physical assessment protocol is designed to complement biological assessments made using AUSRIVAS and thus, it will include factors that are important components of macroinvertebrate habitat. However, most of these environmental factors do not occur randomly within a river system, but rather, exist as a result of a suite of geomorphological processes that operate across a continuum of scales (Figure 1.1). The physical assessment protocol is also designed as a stand-alone method of physical stream assessment and as such, it will include geomorphological aspects of channel character. These channel characteristics may not appear to be directly related to macroinvertebrates, but are important structural and functional components of a river system.

1.3.2 How the physical assessment protocol works

As an overall method of stream assessment, the physical protocol works in a similar manner to AUSRIVAS (Figure 1.3). Physical, chemical and habitat information is collected from reference sites and used to construct predictive models, which are in turn, used to assess the condition of test sites. The physical assessment protocol comprises the following major components:

Reference site selection	Reference sites representing 'least impaired' conditions are selected, and stratified to cover a range of climatic regions and geomorphological river types (see Part 2).
Data collection	Each reference site is visited once and physical, chemical and habitat variables are measured using standardised methods (see Parts 3, 4 and 5). In the office, a suite of

	predictor variables is measured using standardised methods (see Parts 3 and 5).
Model construction	Predictive models are constructed using the same processes and analyses used in AUSRIVAS (Figure 1.3). However, in the physical assessment protocol, large-scale catchment characteristics are used to predict local scale features (Davies *et al.*, 2000). Thus, the outputs of a physical predictive model are based on the occurrence of local scale features, rather than the occurrence of macroinvertebrate taxa (Figure 1.3).
Assessment of test sites	Assessment of stream condition involves the collection of local scale and large-scale physical, chemical and habitat information from test sites (Figure 1.3). This information is then entered into the predictive models and an observed:expected ratio is derived by comparing the features expected to occur at a site against the features that were actually observed at a site. The deviation between the two is an indication of physical stream condition.

As mentioned in Section 1.1.2, this document contains information on the selection of reference sites, and on the collection of field and office data. It does not provide technical information on the analytical procedures used to construct predictive models from reference site data, because these are documented in Simpson and Norris (2000).

1.3.3 Comparison of the physical assessment protocol and AUSRIVAS

There are several similarities and differences between the AUSRIVAS sampling protocol and the physical assessment protocol. In addition to the elements described in Section 1.3.1, similarities between the two protocols include measurement of similar types of habitat variables (see Part 5), use of some of the same reference sites (see Part 2), use of the same analytical techniques to build predictive models and production of the same model outputs (Figure 1.3). The experiences gained during the seven years of the National River Health Program will be invaluable throughout all stages of the physical assessment protocol.

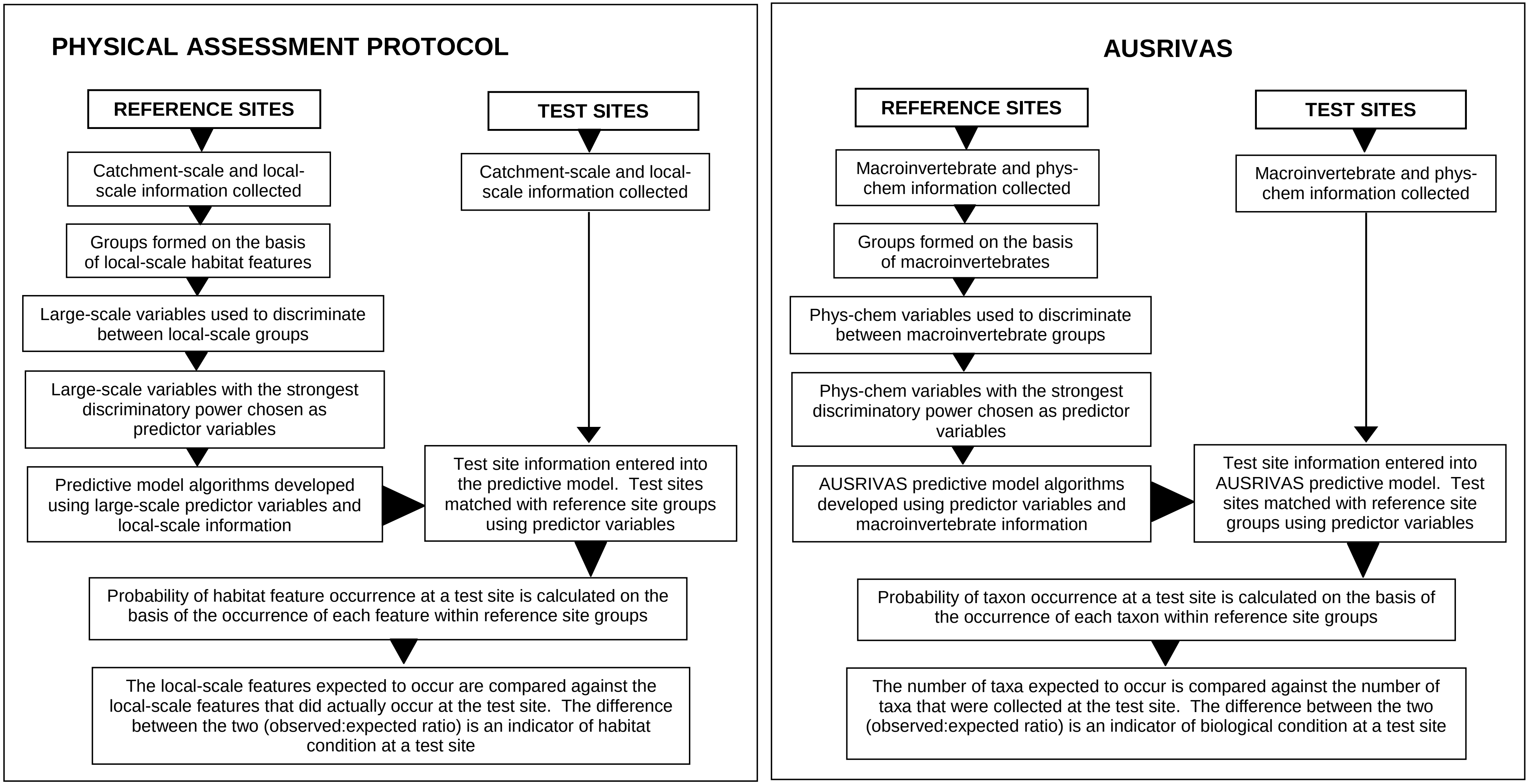


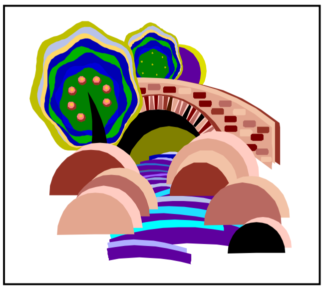
Figure 1.3 Overview of the analytical and assessment process used in the physical assessment protocol (left) and AUSRIVAS (right).

Although the outputs of the physical assessment protocol are complementary to the biological assessments made using AUSRIVAS, the protocol is designed to be a stand-alone stream assessment method. Thus, there are several unique preparation, sampling, processing and analytical aspects of the physical assessment protocol that should be noted. The physical assessment protocol differs from AUSRIVAS in the following ways:

- Reference sites only have to be sampled once to develop an effective predictive model. This is because most physical factors do not change across seasons. Local scale physical factors with a high temporal or seasonal variability (e.g. detritus, periphyton and instantaneous water chemistry measurements) are not used to construct the predictive models. However, these factors are measured in the protocol because they are strongly linked to macroinvertebrates, and may provide additional information on site condition;
- Field data collection for the physical assessment protocol requires slightly more time in the field than an AUSRIVAS assessment. The protocol has been designed to cover a wide array of local scale factors that show a response to anthropogenic influences. These local scale data are analogous to the macroinvertebrate data collected in AUSRIVAS and as such, it is important to measure a comprehensive set of local scale stream features at every site. The collection of a comprehensive data set increases the time needed per site, although this is offset by the reduced need for office based processing of local scale information. Once the field data have been collected they require minimal processing, save for some minor calculations from the cross-sections. Overall, the method can still be considered a rapid assessment technique;
- Sampling site sizes in the physical assessment protocol are a function of stream size and thus, can be several kilometres long for larger streams. It is important to examine physical features within the entire length of the sampling site and thus, the protocol may require walking longer distances than for AUSRIVAS sampling. However, the use of cumbersome sampling equipment has been kept to a minimum (see Part 3) to facilitate ease of movement through a site. Additionally, a boat will be needed to collect cross-sectional profiles from non-wadeable streams;
- The physical assessment protocol has a more intensive office based data collection component than AUSRIVAS. Office data collection consists of two parts: the selection of reference sites (see Part 2) and the derivation of catchment scale control variables (see Part 3). The control variables cover

potential hierarchical links between large scale and local scale habitat factors, so it is important to measure all of the control variables. However, many of these control variables can be measured easily and quickly using a GIS; and,

- Some of the variables included in the physical assessment protocol may be unfamiliar because they are geomorphologically based. These variables include cross-sectional measurements, sinuosity, some sediment measurements and some channel morphology measurements. However, these variables are an important part of the physical characterisation of rivers and thus, it is vital that they are measured at each sampling site. The method used to measure each of these variables has been adapted to suit a rapid sampling philosophy and detailed instructions on the measurement of each of these variables are provided in Part 5.



2 REFERENCE SITE SELECTION PROCEDURE

2.1 INTRODUCTION

The reference site selection procedure for the physical assessment module considers humans to be part of the landscape (Norris and Thoms, 1999) and thus, is based on the concept of 'least disturbed' condition. Collection of reference site information is central to the construction of a predictive model and in turn, this information is used as the baseline against which the condition of test sites is assessed (see Part 1). A reference site selection procedure that uses the concept of least disturbed condition essentially allows for the careful inclusion of sites that have inevitably been affected by humans, but which are considered to be the best available representatives within a certain area or of a specific river type.

The reference site selection procedure described here is similar to that used in the AUSRIVAS program (see Davies, 1994). However, slight modifications have been added to allow for the stratification of reference sites across a range of geomorphological river types. This stratification step ensures that sites from different 'functional zones' are included in the reference site database. Given that local scale habitat features will differ among functional zones (Schumm, 1977), the stratification of reference sites across these zones will ensure representation of the characteristic habitat features that are associated with each zone type. In turn, inclusion of reference sites from different functional zones will strengthen the robustness of predictive models for assessing a range of test sites and human impacts (Reynoldson and Wright, 2000). The existing AUSRIVAS reference sites will be overlain across the zone types and used wherever possible, although additional reference sites may be required in zone types that are currently under-represented.

In addition, the reference site selection procedure has been designed to accommodate several levels of heterogeneity, as a 'safety-net' for the robust construction of predictive models. The site selection procedure will incorporate a regional stratification element as well as a functional zone stratification element, because it is not known in advance whether groups of reference sites will classify on the basis of State or Territory wide regional patterns or on zone type patterns. Thus, regardless of whether reference sites are grouped on the basis of regional or zone type patterns, enough sites will exist in each group to allow the construction of robust predictive models.

2.2 OVERVIEW OF THE REFERENCE SITE SELECTION PROCEDURE

The reference site selection procedure assumes that like AUSRIVAS, sampling will be conducted by State or Territory agencies and that ultimately, the predictive models will be set up on a State or Territory basis. Thus, the steps described below should be applied in each State or Territory. The following sections also assume a general familiarity with the concept of 'least impaired condition', as used in the National River Health Program and the development of AUSRIVAS predictive models. The reference site selection procedure consists of six steps:

1. **Identify broad regions on the basis of climate and geology**
2. **Divide the rivers in each region into functional zones**
3. **Examine the disturbances occurring in and around each functional zone**
4. **Plot the location of AUSRIVAS biological monitoring sites**
5. **Identify the least impaired areas in each region and zone**
6. **Stratify reference sites equally across zone types**

Each of these steps will be explained in detail in the following sections.

2.3 IDENTIFY BROAD REGIONS ON THE BASIS OF CLIMATE AND GEOLOGY (STEP 1)

2.3.1 Why?

The division of each State or Territory into broad regions allows the stratification of sampling sites across areas with different climatic and geological characteristics.

2.3.2 How?

Within each State or Territory, identify broad climatic regions which have markedly different rainfall and temperature regimes. These broad climatic regions may also have characteristic vegetation patterns. Then, identify broad geological regions. Maps of geological regions can be found on the Australian Geological Survey Organisation's website at http://www.agso.gov.au.

Using primarily the information on broad climatic patterns, and secondarily on geological patterns, delineate a final set of regions that characterise State or Territory wide differences in both factors. The scale of resolution for the final regions should be kept large and broad. For example, a State may contain four major climatic regions, two of which encompass two major geological regions (Figure 2.1). Thus, the State should be divided into six broad climatic and geological regions. The broad climatic and geological regions should be marked onto topographic maps.

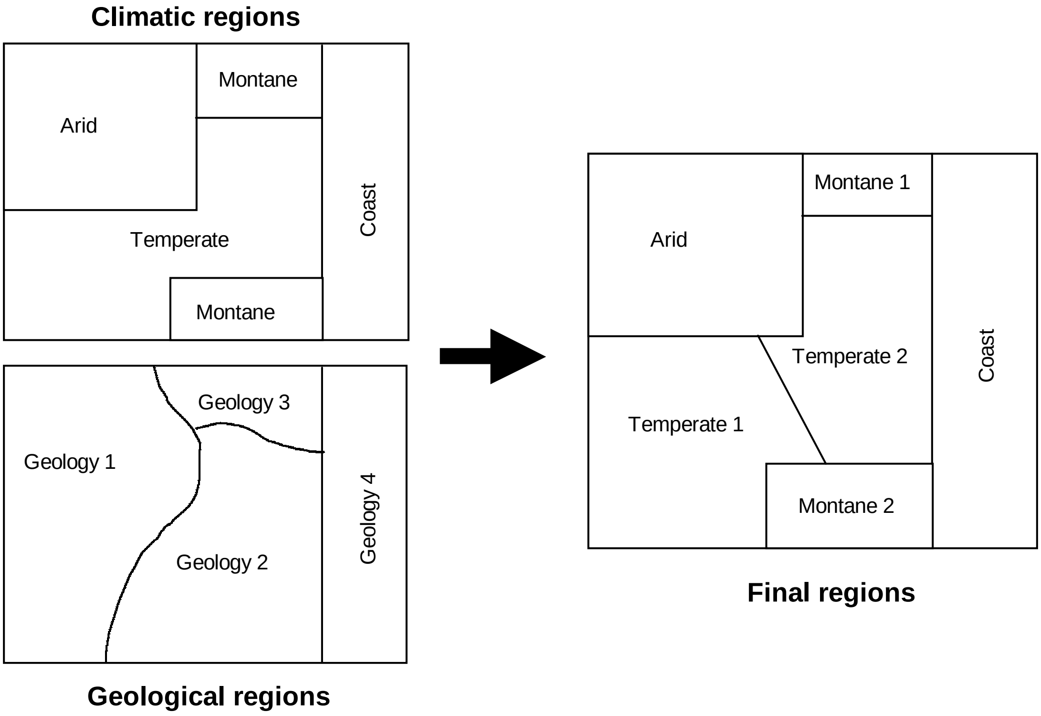


Figure 2.1 Example delineation of broad climatic and geological regions within a hypothetical State or Territory.

2.4 DIVIDE THE RIVERS IN EACH REGION INTO FUNCTIONAL ZONES (STEP 2)

2.4.1 Why?

River characterisation requires the ordering of sets of observations or characteristics into meaningful groups based on their similarities or differences (Naiman *et al.*, 1992; Wadeson and Rowntree, 1994). Implicit in this exercise is the assumption that relatively distinct boundaries exist and that these may be identified by a discrete set of variables. Although river systems are continuously evolving and often display complexity, the grouping of a set of elements with a definable structure can aid in examining the physical structure of river systems. It may also assist in understanding why rivers have certain biological characteristics.

Geomorphological analyses of river systems often reveal a continuum of functions that change in an upstream-downstream direction. For example, headwater regions often provide a net supply of water and sediment to the river network, while through deposition, lowland alluvial river channels store sediment in vast floodplains. Changes in the flow and sediment regime throughout a catchment will be manifested by changes in river morphology and behaviour. Schumm (1988) suggests that there are three broad functional zones within a catchment:

- The headwaters of a river catchment are a primary area of sediment supply (Figure 2.2). The controlling processes are weathering and the down slope movement of this weathered material. The lack of floodplains in this upland area provides a high connectivity between the hillslopes and channel.
- As river slopes reduce and the valley floor widens at the boundary between the upland and lowland area, the dynamic nature of the river increases. This is the sediment transfer (Figure 2.2) area, where there can be high rates of sediment movement and the temporary storage of sediment both within and next to the river channel.
- Further downstream, as river slopes and associated stream energies decrease dramatically, sediments are generally deposited to form large floodplain surfaces. These floodplains are sediment storage (Figure 2.2) areas. The wide floodplain surfaces are often dissected by a variety of river channel patterns.

The geomorphological processes conveyed through these functional river zones will be incorporated into the reference site selection procedure and together with the climatic and geological regions, will form the basis for stratification of sampling sites across the landscape.

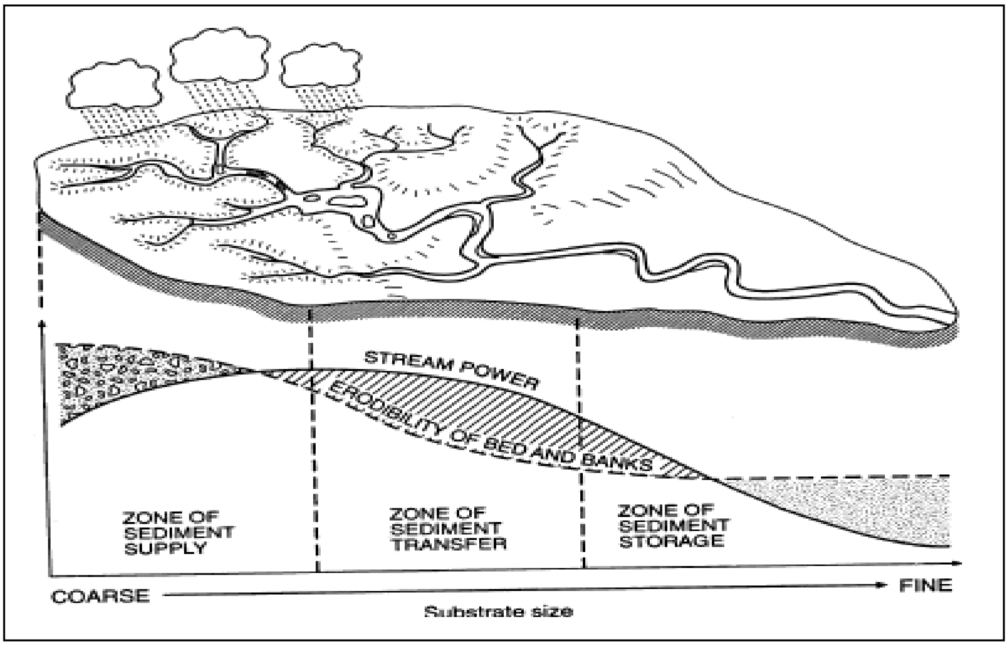


Figure 2.2 Broad functional zone types within a river system. After Schumm (1988).

2.4.2 How?

For the purposes of the physical assessment protocol, functional zones are defined as lengths of river that have similar water and sediment discharge regimes. Four zone types are recommended in the reference site selection procedure: upper zone A (low energy unconfined), upper zone B (high energy confined), transition zone and lower zone. Water and sediment discharge regimes manifest distinctive geomorphological characteristics in each of these zone types and thus, rivers can be divided into zones using three key indicators of channel character: channel slope, valley character and river channel or planform pattern. This section describes the four functional zone types, and the method used to divide rivers into these zones.

2.4.2.1 Step 2a. Functional zone type descriptions

Reference sites will be stratified across four functional zone types. These zone types represent a broad continuum of geomorphological processes occurring within a catchment and thus, will be applicable and valid in the majority of river systems found in Australia. Each zone type will be described in more detail in the following pages.

Upper zone A (low energy unconfined)

Upper zone A is characterised by long pools that are separated by short channel constrictions (ie. chain of ponds morphology). The pools form upstream of the channel constrictions, and are the dominant morphological feature in this zone type (Figure 2.3). Channel constrictions are generally associated with major bedrock bars that extend across the channel, or substantial localised gravel deposits that act as riffle areas. Local riverbed slopes increase significantly at these constrictions, representing small areas of relatively high energy that contrast with the relatively low bed slopes and energies of the pool environment. Overall, bed slope in upper zone A is in the order of 0.0001, with a corresponding stream power in the order of 1.5 W/m^2. Stream power (ω) is related to the rate at which 'work' (sediment movement) is done or at which energy is expended in a stream or river.

The planform channel configuration of upper zone A is controlled by the valley morphology. Generally, the river channel has a small flanking floodplain (up to 30m) because of the narrow valley floor configuration. Hence, valley conditions limit floodplain development. Bankfull channel dimensions can be up to 30m in width, 3-4 metres in depth/height and may have a width to depth ratio of up to 10. Bankfull channel capacities do not generally exceed 30 $m^3 s^{-1}$.

The nature of channel sediment or substratum in upper zone A consists of fine silt/clay material overlying a bedrock/cobble base in the pools. However, gravel/cobble or bedrock substrates dominate the short constricted riffle areas. Bankfull flows have the competence to entrain the finer bed substratum, however, discharges in excess of 50 $m^3 s^{-1}$ are required to initiate motion of the coarser material. Thus, the riverbed in this zone type is relatively stable because discharges large enough to move coarse materials rarely occur.

Figure 2.3
Typical example of an upper low energy unconfined zone.

Upper zone B (high energy confined)

Upper zone B is a high energy zone dominated by bed slopes greater than 0.002 and often by steep bed slopes greater than 0.010. Bankfull stream power is generally in excess of 250 W/m^2 and can exceed 400 W/m^2 in steeper sections. Bedrock chutes, large boulder/cobble/gravel accumulations and scour pools dominate in the channel. Bed sediments are relatively immobile because the streambed tends to be armoured (ie. the coarse surface layer sediments shield the finer sediments beneath it). However, cobble and gravel accumulations are highly mobile during flood flows. The lack of any major sedimentary deposits, together with the high energy environment, suggests that upper zone B is an important source of sediment for the downstream river system (Figure 2.4).

Planform channel pattern in upper zone B is confined and controlled by valley morphology, and the river channel generally exhibits an irregularly meandering pattern that is superimposed on a larger valley pattern. Hence, channels in this zone have limited floodplain development. In highly confined sections, the floodplain will be absent and sediments will be added directly to the channel from adjacent valley side slopes. However, in less confined sections, small floodplain formations may be present and are characterised by a series of floodplains of different ages, inset into higher level terraces.

Figure 2.4
Typical example of an upper high energy confined zone.

Transition zone

The transition zone is characterised by mobile bed sediments, large sediment storage areas within the channel and an active channel (Figure 2.5). The presence of well developed inset floodplain features such as benches, point bars, cutoffs and levees signify the relatively active and unrestricted nature of this river-floodplain environment. Valley floor widths of up to 10km enable floodplain development and stream migration.

In the transition zone, the river channel is freely meandering with an irregular planform pattern. Sinuosity is generally between 1.7 and 1.95, and stream power generally ranges from 8 to 20 W/m^2. Meander wavelengths are generally less than 2km.

The morphology of the channel environment is extremely variable with bars (point and lateral), benches (at various levels) and riffle/pool sequences present alone or in combination. These in-channel storage features reflect high rates of sediment transport. Riverbed sediments typically have a bimodal distribution (median grain size of 64 to 100mm) and the bed is usually highly mobile.

Figure 2.5
Typical example of
a transition zone.

Lower zone

A distinguishing feature of the lower zone is the significant increase in the width of the valley floor (>15km) and associated floodplain surface (Figure 2.6). There are strong and active links between the river and the floodplain, and the lower zone may contain well developed features such as distributary or flood channels (channels that carry water onto the floodplain), former or paleo channels, avulsions, cut-offs or anabranches (channels that dissect the floodplain and rejoin the main channel). The channel displays a typically unrestricted meandering style, with a relatively high sinuosity of about 1.8 to greater than 2.3. Meander wavelengths are approximately 200-700m.

The appreciable fining of bed sediment is a clear distinguishing feature between the transition zone and the lower zone. Bed sediments in the lower zone are typically composed of fine materials such as sand, silt and clay. The bank sediments are also composed of fine materials. As a result, stream banks are often steep in the lower zone and may be naturally susceptible to erosion. The bankfull channel has widths that range between about 30-100m and bankfull depths that range between 3 and 15 metres.

Figure 2.6

Typical examples of a lower zone.

Figure 2.6 (continued) Typical examples of a lower zone.

2.4.2.2 Step 2b. Construction of long profiles

Functional zone types are identified by drawing up long profiles of slope, valley width and planform channel pattern (Figure 2.7). A long profile is a plot of the character of interest against downstream river distance. **Long profiles are constructed for EACH river within EACH region**, using topographic maps.

2.4.2.3 Step 2c. Identification of zone types from long profiles

The completed long profiles for each river are examined simultaneously to identify the presence of one or more functional zone types (Figure 2.8), according to the characteristics described in Section 2.4.2.1. Supplementary information such as aerial photographs, satellite images, sediment data or local knowledge can also be used to confirm the interpretations of functional zone types from the long profiles. Once identified from the long profiles, the zone types that occur along each river are marked onto topographic maps.

There can be a high level of variability and complexity in the arrangement of functional zone types. The four zone types are **broadly** sequential along the river continuum, however, the same zone type may be identified more than once in the same river (Figure 2.8). Additionally, it is common for rivers to contain only one or two functional zone types. It is recommended that the division of rivers into functional zone types should proceed according to the above instructions, but in consultation with a geomorphologist.

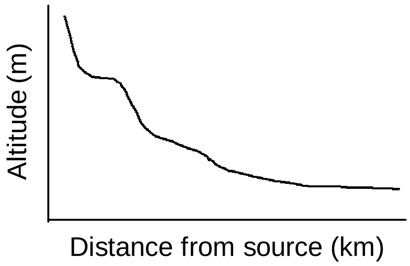
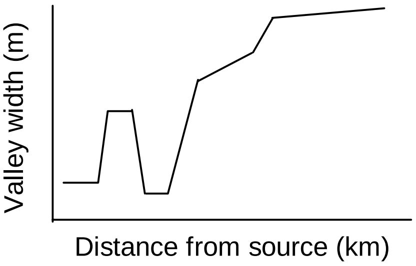
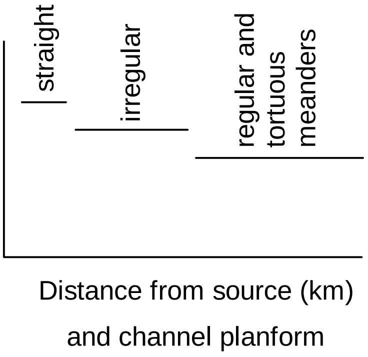
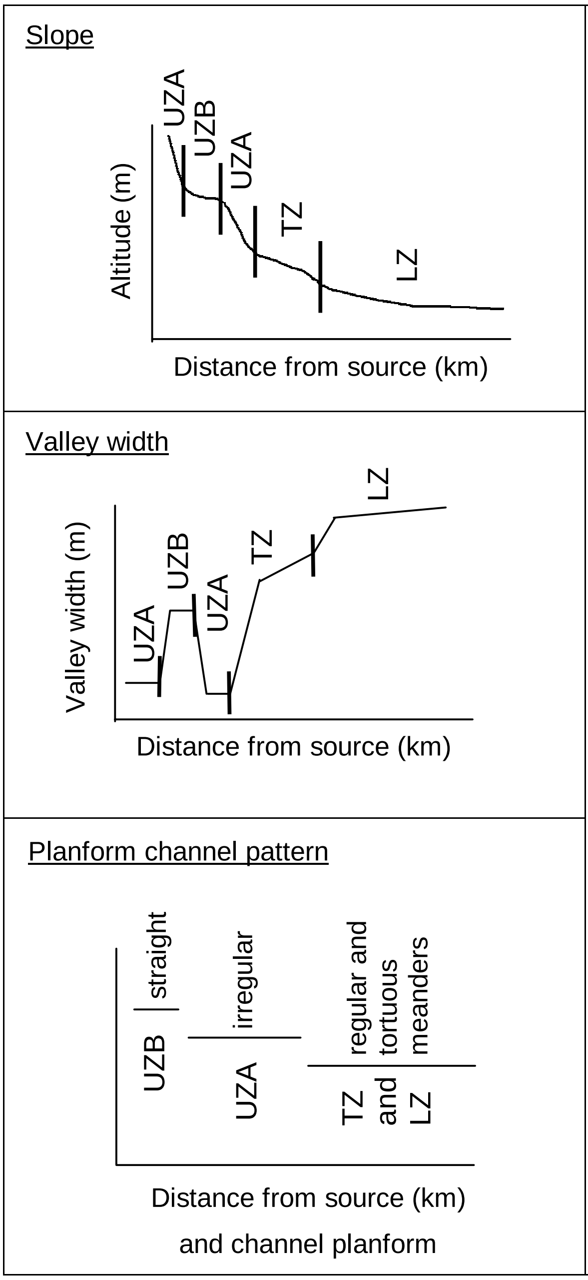
Long profile	**Method**	**Example profile**
SLOPE	Plot altitude against distance downstream. Altitude (m) and distance from source (km) can be measured off topographic maps.	
VALLEY CHARACTER	Plot valley width against distance downstream. Valley width is the distance (m) between the first topographic contours, on either side of the channel. Valley width should be measured off the lowest map scale possible.	
PLANFORM CHANNEL PATTERN	Determine the channel patterns that occur along the length of each river, according to the following categories:  straight or mildly sinuous	
	 irregular pattern	
	 regular meanders	
	 tortuous meanders	
	 braided or anabranching	

Figure 2.7 Construction of long profiles for slope, valley width and planform channel pattern. Assessments of each variable are made using topographic maps. Measurements should be taken at regular intervals along the river, according to size and variability. For example, in a 60km long river, measurements should be made every 5km but in a 250km long river, measurements should be made every 10km.



Breaks in slope, valley width and planform channel pattern are marked on the long profiles. Then, these breaks are assigned to functional zone types, according to the descriptions given in Section 2.4.2.1 and any supplementary information that is available (see Section 2.4.2.3).

The final sequence of functional zone types for this example is UZA – UZB – UZA – TZ – LZ.

The start and endpoints of these functional zones should then be marked on topographic maps.

Figure 2.8 Interpretation of functional zone types from long profiles. For the zone types, UZA = Upper Zone A, UZB = Upper Zone B, TZ = transition zone and LZ = lower zone. More information on zone types is provided in Section 2.4.2.1.

2.5 EXAMINE THE DISTURBANCES OCCURRING IN AND AROUND EACH FUNCTIONAL ZONE (STEP 3)

2.5.1 Why?

Identification of areas that are potentially impacted by large scale and local scale activities allows the elimination of these areas as potential sources of reference sites.

2.5.2 How?

Disturbances that may potentially be impacting the river system are examined at a large catchment scale and at a local scale (see Sections 2.5.2.1 and 2.5.2.2). Sources for obtaining this information on potential disturbances include local managers, experience of agency staff, aerial photographs, hydrology records, GIS maps, and previous data collected for programs such as AUSRIVAS, individual State or Territory projects or the National Land and Water Audit.

2.5.2.1 Large scale activities

Large scale activities are those which have the potential to effect whole catchments within a river system (Table 2.1).

Table 2.1 Large scale activities to be considered when identifying least impaired areas within river systems.

Activity	**Factors to consider**
Landuse	Percent cover of native vegetation, percent cover of agricultural or grazing land, time since land clearance, degree of impact of land clearance on the downstream river system, percent cover of urban areas, degree of impact of urban areas on the downstream river system, presence of active (<5 years) logging areas, degree of catchment erosion, degree of sedimentation
Hydrological regime	Presence of major impoundments, downstream effects of major impoundments, degree of change to flooding regime including magnitude and timing, degree of change to flow seasonality, water extraction activities, reductions or increases in velocity, reductions or increases in discharge size It will be difficult to avoid regulated segments of river in some areas, particularly in lower zones. Where it is impossible to avoid regulation in identifying reference conditions, the overall magnitude of impoundment effects should be considered.
Current and historical mining activity	Degree of impact of current mining activities on the downstream river system, degree of impact of historical mining activities on river system character

2.5.2.2 Local scale activities

Local scale activities are those that may cause localised disturbance to rivers (Table 2.2).

Table 2.2 Local scale activities to be considered when identifying least impaired areas within river systems.

Activity	**Factors to consider**
Riparian zone characteristics	Presence or absence of riparian vegetation, type of riparian vegetation (native or exotic), influence of exotic vegetation on channel character
Channel modification	Channel realignment (straightening or widening etc.), historical incision (ie. severe erosion) of channel, historical infilling (ie. sediment build up) of channel, presence of bridges, fords and culverts and the effects of these on channel character, presence of minor weirs and the effects of these on channel character
Desnagging and instream vegetation removal	Historical or recent desnagging, removal of other instream vegetation such as macrophytes
Floodplain condition	Connectivity between the river and the floodplain, floodplain erosion, floodplain landuse
Human access	Density of public access tracks and roads, location of recreational areas such as camp grounds and picnic areas, presence of road crossings
Stock access	Extent of stock access to the channel, impact of stock access on bank condition, impact of stock access on bed condition
Bank condition	Extent of non-natural bank erosion, presence or absence of riparian vegetation
Point source impacts	Presence of discharge pipes, mining, stormwater discharges, construction sites etc.

This information on large and local scale activities will be used in Step 5 to determine areas of least impaired condition that are potential sources of reference sites. When using this information it is important to consider the different effects of large scale and local scale impacts. For example, significant forestry activities may occur across a wide area, however, a riparian buffer may exist to protect the stream on a local scale. Conversely, stock may have access to localised patches of river within an otherwise least impaired area and thus, reference sites should not be placed in these localised patches.

2.6 PLOT THE LOCATION OF AUSRIVAS BIOLOGICAL MONITORING SITES (STEP 4)

2.6.1 Why?

Sites assessed by AUSRIVAS as being in good biological condition can be used to indicate areas of river in least impaired condition. It can also be assumed that sites with a healthy biota will have a healthy supporting habitat.

2.6.2 How?

Plot the location of AUSRIVAS **reference** sites (ie. those sites used to construct the predictive models) and any Band A **test** site (ie. those sites assessed in the First National Assessment of River Health). Mark these sites onto topographic maps.

2.7 IDENTIFY THE LEAST IMPAIRED AREAS IN EACH REGION AND ZONE (STEP 5)

2.7.1 Why?

The identification of 'least impaired' areas within each region and zone will highlight river sections where reference sites can be placed.

2.7.2 How?

Least impaired areas are identified using the information collected in Steps 3 and 4. In each region and zone, mark onto topographic maps the sections of river that are least impaired. **These areas are the sections of river where reference sites can be placed**.

It is important to include least impaired areas from all the zone types present within a region. However, it is recognised that in comparison to the upper zones, the transitional and lower zone types will contain lower numbers of least impaired areas because it is usually these latter zone types that are most subject to impact. Thus, stringency of the criteria for determining least impaired areas may change among zone types. Relaxation of least impaired status in the transitional and lower zones should be done using supplementary information from previous biological, chemical or physical surveys, or using best professional judgement.

2.8 STRATIFY REFERENCE SITES EQUALLY ACROSS FUNCTIONAL ZONE TYPES (STEP 6)

2.8.1 Why?

Stratification of reference sites equally across regions and zones within regions will ensure coverage of a range of geomorphological river types. In turn, this coverage will improve the analytical robustness of the physical predictive models (see Section 2.1).

2.8.2 How?

The recommended total number of reference sites to be sampled in each State or Territory is given in Section 2.9. Regardless of the total number of reference sites used, sampling effort should be divided equally among regions and then among functional zones, according to the relative proportion of each zone type in each region. An example stratification of sampling effort across regions and zones is given in Table 2.3.

The final selection of reference sites is achieved by allocating the desired number of sites across zone types located within the least impaired areas identified in Step 5. Existing AUSRIVAS reference sites should be used where possible, however, additional sites may be required in particular zone types that are not adequately represented in the AUSRIVAS database. Reference sites should also be spread across a range of different rivers within the region.

2.9 NUMBER OF REFERENCE SITES AND FREQUENCY OF SAMPLING

The number of reference sites required to construct the physical predictive models is roughly the same as that used to construct the AUSRIVAS predictive models. **The larger States (NSW, QLD, WA, VIC) should sample 230-250 reference sites (minimum 230) and the smaller States and Territories (ACT, SA, TAS, NT) should sample 180-200 reference sites (minimum 180)**. These figures represent the number of sites required to build the final predictive models. However, it may be necessary to sample additional reference sites to account for situations where sites are excluded post-hoc because of unexpected impairment.

As there are no strongly overriding temporal or seasonal aspects to the measurement of most physical and habitat features, **each reference site only needs to be sampled**

once. Predictive models can be constructed after a single visit to each sampling site, and the subsequent collection of additional office based information (see Part 3).

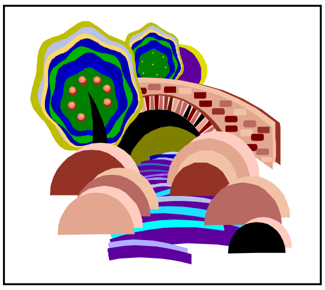
Table 2.3 Example stratification of sampling sites across zones and regions, for a hypothetical State or Territory containing four regions and a total of 200 reference sites. For the zone types, UZA = upper zone A, UZB = upper zone B, TZ = transition zone and LZ = lower zone.

Total of 200 sampling sites

Region	**Number of sites in each region**	**Zone type**	**% zone type in region**	**Number of sites in each zone**
1	50	UZA	20	10
		UZB	40	20
		TZ	30	15
		LZ	10	5
2	50	UZA	10	5
		UZB	10	5
		TZ	70	35
		LZ	10	5
3	50	UZA	10	5
		UZB	0	0
		TZ	30	15
		LZ	60	30
4	50	UZA	0	0
		UZB	70	35
		TZ	25	12
		LZ	5	3

2.10 COLLECTION OF TEST SITES TO VALIDATE PREDICTIVE MODELS

Once the predictive models are constructed using the reference site information, it will be necessary to 'validate' assessments of physical stream condition using information collected from a small set of test sites. A test site is defined as any site at which condition is assessed using the predictive models. **The larger States (NSW, QLD, WA, VIC) should sample 20-30 test sites (minimum 20) and the smaller States and Territories (ACT, SA, TAS, NT) should sample 15-20 test sites (minimum 15)**. Test sites should initially be stratified across the different regions and zones. Within these areas, test sites should then be located to represent a range of disturbances that may potentially influence physical stream condition.



3 DATA COLLECTION

The sampling design for the physical assessment protocol consists of two aspects. First, reference sites are stratified across the landscape according to broad climatic regions and geomorphological zones (see Part 2). Then, physical, chemical and habitat information is collected locally from each reference site, and in future, each test site. **Any site at which data are collected is called a sampling site, and will be referred to by this name throughout this document.**

3.1 SAMPLING SITE DIMENSIONS

The length of a sampling site is a function of stream size (Table 3.1), and is defined as **10 times the channel bankfull width**. Upon arrival at each sampling site, bankfull width of the channel should be measured or estimated (see Part 5) and the length of the sampling site calculated. Use a tape measure to quantify the sampling site length, until distances can be estimated accurately by eye.

Table 3.1 Example calculation of sampling site length for streams of various bankfull widths.

Bankfull width	Sampling site length
110m	1100m
100m	1000m
80m	800m
50m	500m
20m	400m
10m	100m
5m	50m
2.5m	25m

To facilitate ease of movement along the length of the sampling site, the protocol has been designed in a manner that minimises the transportation of heavy or cumbersome sampling equipment over long distances (see cross-section variables section in Part 5).

More information about field sampling is provided in Section 3.4.1 and a list of recommended field sampling equipment is provided in Appendix 2.

3.2 OVERVIEW OF THE VARIABLES INCLUDED IN THE PHYSICAL ASSESSMENT PROTOCOL

Variables for inclusion in the protocol were selected using a three-step process. Firstly, a comprehensive list of the physical and chemical variables collected in the Index of Stream Condition (Ladson and White, 1999), the River Habitat Audit Procedure (Anderson, 1993a), the River Habitat Survey (Raven *et al.*, 1998), AUSRIVAS, River Styles (Brierley *et al.*, 1996) and Habitat Predictive Modelling (Davies *et al.*, 2000) was drawn up. The variables suggested at the Habitat Assessment Workshop (see Section 1.2.2) were also included. Then, each variable was examined in light of what it indicates about river condition, or how it relates to geomorphological process. Lastly, the list was trimmed of duplicated, highly variable, hard to measure and redundant variables, to form a final set for inclusion in the protocol.

Over 90 field and office based variables are included in the protocol (Table 3.2). The variables are divided into control and response types (see Section 3.3) and are grouped according to broad categories (Table 3.2). These broad categories represent the main physical components of river systems, and also incorporate factors that are important for ecological function. Site observations include factors that are collected in AUSRIVAS to indicate the general condition of a sampling site.

Additionally, there is a small amount of repetition in the choice of some variables. The repetition has been deliberately incorporated into the protocol and is analogous to the social survey practice of asking the same question in several differently worded versions. Repetition of some variables will ensure that a large set of high quality data, that covers all the important physical components, is available to construct the predictive models (see Section 3.4.1).

Table 3.2 Summary list of control and response variables included in the physical assessment protocol. Office or field collection indicates whether the variable is collected in the field, or collected in the office. A description of the method used to collect each variable is provided in Part 5.

CONTROL VARIABLES

Category	**Variable**	**Office or field collection**
Position of the site in the catchment	Latitude	Field
	Longitude	Field
	Altitude	Office
	Distance from source	Office
	Link magnitude	Office
Water chemistry	Alkalinity	Field
Catchment characteristics	Total stream length	Office
	Drainage density	Office
	Catchment area upstream of the site	Office
	Elongation ratio	Office
	Relief ratio	Office
	Form ratio	Office
	Mean catchment slope	Office
	Mean stream slope	Office
	Catchment geology	Office
	Rainfall	Office
Valley characteristics	Valley shape	Field
	Channel slope	Office
	Valley width	Office
Planform channel features	Sinuosity	Office
Landuse	Catchment landuse	Office
	Local landuse	Field
Hydrology	Index of mean annual flow	Office
	Index of flow duration curve difference	Office
	Index of flow duration variability	Office
	Index of seasonal differences	Office

Table 3.2 (cont.)

RESPONSE VARIABLES

Category	Variable	Office or field collection
Physical morphology and bedform	Extent of bars	Field
	Type of bars	Field
	Channel shape	Field
Cross-sectional dimension	Bankfull channel width	Both
	Bankfull channel depth	Both
	Baseflow stream width	Both
	Baseflow stream depth	Both
	Bank width	Both
	Bank height	Both
	Bankfull width to depth ratio	Both
	Bankfull cross-sectional area	Both
	Bankfull wetted perimeter	Both
	Baseflow cross-sectional area	Both
	Baseflow wetted perimeter	Both
Substrate	Bed compaction	Field
	Sediment angularity	Field
	Bed stability rating	Field
	Sediment matrix	Field
	Substrate composition	Field
Planform channel features	Planform channel pattern	Office
	Extent of bedform features	Field
Floodplain characteristics	Floodplain width	Field
	Floodplain features	Field
Bank characteristics	Bank shape	Field
	Bank slope	Field
	Bank material	Field
	Bedrock outcrops	Field
	Artificial bank protection measures	Field
	Factors affecting bank stability	Field
Instream vegetation and organic matter	Large woody debris	Field
	Macrophyte cover	Field
	Macrophyte species composition	Field
Physical condition indicators and habitat assessment	USEPA epifaunal substrate / available cover habitat score (high and low gradient streams)	Field
	USEPA embeddedness habitat score (high gradient streams) or pool substrate characterisation habitat score (low gradient streams)	Field
	USEPA velocity / depth regime habitat score (high gradient streams) or pool variability habitat score (low gradient streams)	Field

Table 3.2 (cont.)

Category	**Variable**	**Office or field collection**
	USEPA sediment deposition habitat score (high and low gradient streams)	Field
	USEPA channel flow status habitat score (high and low gradient streams)	Field
	USEPA channel alteration habitat score (high and low gradient streams)	Field
	USEPA frequency of riffles (or bends) habitat score (high gradient streams) or channel sinuosity habitat score (high and low gradient streams)	Field
	USEPA bank stability habitat score (high and low gradient streams)	Field
	USEPA bank vegetative protection habitat score (high and low gradient streams)	Field
	USEPA riparian vegetative zone width habitat score (high and low gradient streams)	Field
	USEPA total habitat score (high and low gradient streams)	Field
	Channel modifications	Field
	Artificial features	Field
	Physical barriers to local fish passage	Field
Riparian vegetation	Shading of channel	Field
	Extent of trailing bank vegetation	Field
	Riparian zone composition	Field
	Native and exotic riparian vegetation	Field
	Regeneration of native woody vegetation	Field
	Riparian zone width	Field
	Longitudinal extent of riparian vegetation	Field
	Overall vegetation disturbance rating	Field
Site observations	Local impacts on streams	Field
	Turbidity (visual assessment)	Field
	Water level at the time of sampling	Field
	Sediment oils	Field
	Water oils	Field
	Sediment odours	Field
	Water odours	Field
	Basic water chemistry and nutrients	Field
	Filamentous algae cover	Field
	Periphyton cover	Field
	Moss cover	Field
	Detritus cover	Field

3.3 CONTROL AND RESPONSE VARIABLES

The variables included in the protocol are divided into control and response types and have very different functions in the construction of a predictive model.

Control variables – are large-scale environmental factors that control the expression of local-scale habitat features. **Control variables are used as predictor variables in a predictive model** and are analogous to the physical, chemical and habitat information collected in AUSRIVAS (see Section 1.3.2). Control variables are generally measured in the office (see Table 3.2 for exceptions). Also, control variables are usually large scale variables that are measured within the catchment area upstream of a site, or within a stream segment that is 1000 times the bankfull channel width. Exceptions are alkalinity, valley shape, local landuse, latitude and longitude, which are measured locally at the sampling site (Table 3.2).

Response variables – are local-scale environmental features. **Response variables are used to form groups with similar physical features** and are analogous to the macroinvertebrate information collected in AUSRIVAS (see Section 1.3.2). Response variables are all collected in the field and thus, are measured on a local scale. The exception is planform channel pattern, which should be verified using maps and aerial photographs.

3.4 FIELD DATA COLLECTION

3.4.1 General overview

Field data collection occurs in a similar manner as AUSRIVAS. Upon arrival at a sampling site, determine the bankfull channel width and calculate the length of the sampling site. Locate the sampling site so as to be 'representative' of the major bedform types present in the area. Then, follow the instructions given in Part 5 for the measurement of each variable. At larger sites, sampling may need to be conducted and recorded in sections, then combined. If this occurs, combination of data from different sections should be done while still at the sampling site, and overall observations of the site are still fresh in the memory!

Sampling should only be conducted under baseflow or low flow conditions. It is important not to sample under high flow conditions, because visibility of channel features will be reduced and the watermark will be obscured at cross-sections. In addition, health and safety issues should be considered at all times, but are of particular concern under high flow conditions.

Variables measured in the field have been selected to maximise information about stream character, but are also designed to minimise the amount of sampling equipment required (see Appendix 2). This facilitates ease of movement along the entire length of the sampling site **and it is vitally important that the whole length of the sampling site is included in the assessment**. Many local variables are assessed over the area of the sampling site (see Part 5) and thus, it is important to observe the overall status of each of these variables within the entire sampling site. This will involve walking greater distances than is generally encountered with AUSRIVAS sampling.

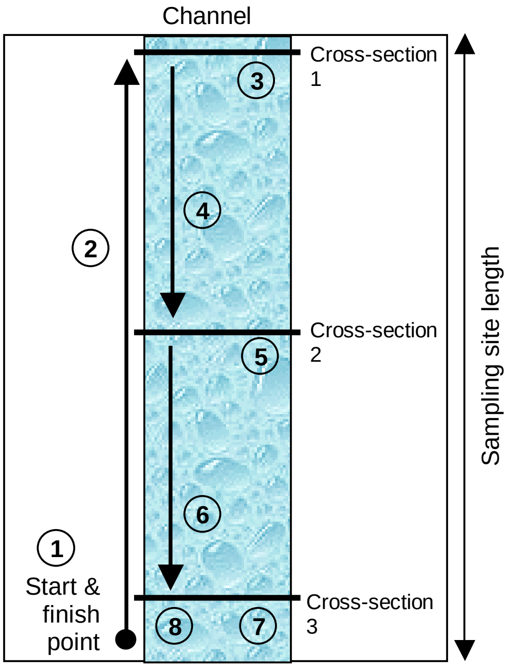
It is critical that all local scale variables are collected at every sampling site. In the physical assessment protocol, the physical, chemical and habitat variables are not used in the same way as in AUSRIVAS. The local scale variables are used to form groups of sites with similar features. Subsequently, the features present at a test site are compared against those present at a reference site and form the basis for derivation of O/E scores (see Section 1.3.2). **Failure to measure a local physical, chemical or habitat variable at any reference site is analogous to losing taxa out of a macroinvertebrate kicknet sample collected for AUSRIVAS**, and will ultimately detract from the robustness of physical predictive models.

3.4.2 Instructions for the measurement of field variables

Standardised and detailed instructions on the measurement and interpretation of each **field-based** variable are given in Part 5. It is important that sampling teams familiarise themselves with these methods prior to the commencement of field work (see

Appendix 1). This manual should also be available in the field for reference and cross checking if necessary.

The suggested sequence of work at a typical sampling site is given in Figure 3.1. This sequence of work can be adjusted to suit the needs of different sampling teams, although any sequence of work must ensure that all parts of the stream are observed and that all variables are measured. The sequence of work may also need to be adjusted for large rivers that require boat or canoe access.



Sampling sequence

① Take water quality and GPS readings at the starting point

② Walk to one end of the sampling site. Closely observe the channel along the way.

③ Assess variables such as local impacts, local landuse, valley shape etc. Perform cross-section 1 in an appropriate bedform type.

④ Travel back towards the starting point, closely observing the channel along the way. Stop at a point that is about mid-way along the sampling site.

⑤ Assess additional variables from previous observations of the channel. Perform cross-section 2 in an appropriate bedform type.

⑥ Travel the remainder of the way back to the starting point, again closely observing the channel along the way.

⑦ Assess remaining variables. Perform cross-section 3 in an appropriate bedform type.

⑧ Check that all variables have been recorded.

Figure 3.1 Suggested sequence of work at a wadeable sampling site with three cross-sections.

3.4.3 Sampling times

The physical assessment protocol is a rapid, semi-quantitative assessment method (see Section 1.3.1.4). When functional predictive models are fully implemented, this method will provide an assessment of physical stream condition that can be 'turned out' approximately 3-5 days after test site sampling. This turn out rate can be achieved because the majority of data collection occurs in the field. Laboratory processing of samples is not required, and is limited to the collection of office based predictor variables.

Further, the rapid aspect of the method is also applicable to field data collection, where sampling times have been substantially reduced in comparison to traditional geomorphological survey techniques. The approximate time required at different types of sampling sites is given in Table 3.3. However, sampling times may vary considerably depending on factors such as experience of the sampling team, site access, flow and weather conditions, ease of movement along the river, depth of the river, substrate type and periphyton cover, location of cross-sections and number of cross-sections. Thus, these times should be used as a guide only.

Table 3.3 Approximate sampling times for different types of sampling sites. These figures are derived on the basis of field testing of the protocol, but should be used as a guide only.

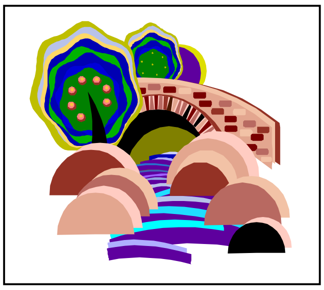
Type of sampling site	**Approximate sampling time**
Small-medium sized wadeable stream with three cross-sections, none of which are in deep pools	1 hour
Small-medium sized wadeable stream with three cross-sections, one of which is in a deep pool	1 hour 20 minutes
Large wadeable river with three cross-sections, two of which are in deep pools, or which are difficult to access	2 hours 30 minutes
Large non-wadeable river with two cross-sections, which require access with a watercraft	3 – 4 hours

3.5 OFFICE DATA COLLECTION

3.5.1 Instructions for the measurement of office variables

Standardised and detailed instructions on the measurement and interpretation of each **office-based** variable are given in Part 5. Many of the office-based variables, such as landuse and catchment characteristics can be measured using a GIS, while others will need to be measured directly off topographic maps. While not as critical as the collection of local scale variables, it is important to make an effort to measure all of the large-scale variables (i.e. those generally collected in the office). These variables are used as predictor variables and as such, have been included to cover the range of hierarchical links that may exist between local-scale and large-scale factors.

It should also be noted that for each office-based variable measured within a catchment (see Part 5), the term catchment always refers to the catchment area upstream of a site. This definition of a catchment standardises on the premise that regardless of catchment size, it is the large scale physical and geomorphological processes that occur upstream of a site, rather than downstream of a site, that determine the local scale features that will be found there.



4 FIELD DATA SHEETS

4.1 OVERVIEW

Field data sheets for the protocol are modelled on the data sheets used in the River Habitat Audit Procedure (Anderson, 1993a; Anderson, 1999). Most variables are measured visually in the field and thus, drawings and descriptions have been included on the data sheets to aid interpretation. Some general points about the data sheets and about field data collection are as follows:

- Be sure to record the general site information on the first page of the data sheet.
- Be sure to record the site number and date on **each** page of the data sheet. This is important if individual pages become separated accidentally.
- Left and right banks are defined facing in a downstream direction.
- The USEPA habitat assessment data sheets are slightly different for high and low gradient streams. Ensure that the correct sheet is filled out at a high or a low gradient sampling site. Instructions on determination of high and low gradient sampling sites are included with the description of the USEPA habitat assessment variables in Part 5.
- Many of the categorical variables can be recorded using one category only, while others can be recorded as more than one category. Instructions for each variable are provided with the data sheets and on the instruction sheets for each variable (Part 5).
- For variables that require a percent composition assessment, record non-occurring elements as zero. For example, if the substratum does not contain sand, record this component as 0% rather than as a blank space.
- Take several (minimum of three) photographs of each sampling site, from different aspects. Also photograph any unusual or difficult to interpret features of the site. Make a note of the photographs on the data sheet. These photographs will be useful during model construction and also for interpreting the relative condition of test sites.

4.2 THE FIELD DATA SHEETS

The field data sheets are provided in the following pages. The data sheets have been drawn in Microsoft Word and thus, are easy to manipulate if minor changes are required by individual States or Territories. The data sheets include all the response variables. Three cross-section sheets are provided although the number used will depend on the heterogeneity of the site (see Part 5). Likewise, the field data sheets contain the USEPA habitat assessments for both low gradient and high gradient streams, but only one is filled in at each site.

An example of a completed data sheet is also provided.

Data sheets for the collection of office variables have not been drawn up, because much of the office based data are likely to be obtained electronically.

Date ____________________ Site No. ____________________ Time ____________________ Recorder's Name ____________________

River Name ____________________________________ Location ____

Weather ______________________ Rain in last week? Y [ ] N [ ]

Photograph numbers and details ________________________

____

____

____

Latitude: deg ☐☐ min ☐☐ sec ☐☐ Longitude: deg ☐☐☐ min ☐☐ sec ☐☐

GPS Name and Datum ______________________________________

PLANFORM SKETCH OF SITE

Including bedform types, location of cross-sections, access points, landmarks and natural or artificial channel or floodplain features.
Left bank is facing downstream.

LENGTH OF SAMPLING SITE

Bankfull width __________ (m)

x 10

Length of sampling site __________ (m)

Notes

____

____

____

____

____

____

____

BEFORE LEAVING THE
SITE, CHECK DATA
SHEETS TO ENSURE
THAT ALL VARIABLES
HAVE BEEN RECORDED

☐ **Y**

Acknowledgments - The content and layout of these data sheets are derived from the sheets used in the River Habitat Audit Procedure (Anderson, 1993a), AUSRIVAS, the Index of Stream Condition (Ladson and White, 1999 and DNRE Victoria) and the River Habitat Survey (Raven *et al.*, 1998).

BASIC WATER CHEMISTRY

		Units
Temperature	________	°c
Conductivity	________	_____
Dissolved Oxygen	________	mg l^{-1}
Dissolved Oxygen Sat.	________	%
pH	________	
Turbidity	________	_____
Total phosphorus ☐ Water sample taken?	________	_____
Total nitrogen ☐	________	_____
ALKALINITY		
Amount of water	________	ml
Amount of H_2SO_4	________	ml
Alkalinity	________	mg l^{-1}

Floodplain width _____ _____ _____ Average _____ (m)

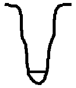
Floodplain features

Choose one or more features when present

- ☐ Sampling site has no distinct floodplain
- ☐ Oxbows / billabongs
  Body of water occupying a former river meander, isolated by a shift in the stream channel
- ☐ Remnant channels
  Formed during a previous hydrological regime. May be infilled with sediment
- ☐ Flood channels
  A channel that distributes water onto the floodplain and off the floodplain during floods
- ☐ Scroll systems
  Short, crescentic strips or patches formed along the inner bank of a stream meander
- ☐ Splays
  Small alluvial fan formed where an overloaded stream breaks through a levee and deposits material on the floodplain
- ☐ Floodplain scours
  Scour holes formed by the concentrated clearing and digging action of flowing water
- ☐ No floodplain features present
  Floodplain present at the sampling site but does not contain any of the above features

Valley shape

Choose one category only

 ☐	Steep valley
 ☐	Shallow valley
 ☐	Broad valley
 ☐	Gorge
 ☐	Symmetrical floodplain
 ☐	Asymmetrical floodplain

Local impacts on streams

Choose one or more categories and describe the detail of each

- ☐ Sand or gravel mining
- ☐ Other mining
- ☐ Road
- ☐ Bridge / culvert / wharf
- ☐ Ford / ramp
- ☐ Discharge pipe
- ☐ Forestry activities
- ☐ Sugar mill
- ☐ Irrigation run-off or pipe outlet
- ☐ Sewage effluent
- ☐ Channel straightening
- ☐ River improvement works
- ☐ Water extraction
- ☐ Dredging
- ☐ Grazing
- ☐ Litter
- ☐ Recreation
- ☐ Other

Description ______________________________
____
____

Local landuse

Choose one category for each bank

Left	**Right**	
☐	☐	Native forest
☐	☐	Native grassland (not grazed)
☐	☐	Grazing (native or non-native pasture)
☐	☐	Exotic grassland (lawns etc., no grazing)
☐	☐	Forestry Native [ ] [ ] Pine [ ] [ ]
☐	☐	Cropped Rainfed [ ] [ ] Irrigated [ ] [ ]
☐	☐	Urban residential
☐	☐	Commercial
☐	☐	Industrial or intensive agricultural
☐	☐	Recreation
☐	☐	Other ____________________

Riparian zone composition

Assess for whole sampling site

	% Cover	Vegetation Description
Trees (>10m in height)	________________	____________________________
Trees (<10m in height)	________________	____________________________
Shrubs	________________	____________________________
Grasses / ferns / sedges	________________	____________________________

May total more than 100%

Shading of channel

☐ < 5% ☐ 6 – 25% ☐ 26 – 50% ☐ 51 – 75% ☐ > 76%

Extent of trailing bank vegetation

☐ nil ☐ moderate

☐ slight ☐ extensive

Native and exotic riparian vegetation

% Native __________

% Exotic __________

Total 100%

Longitudinal extent of riparian vegetation

Choose one category for each bank. Do not include ground layer except where site is in native grassland.

		Left bank	Right bank
None		☐	☐
Isolated / scattered		☐	☐
Regularly spaced		☐	☐
Occasional clumps		☐	☐
Semi-continuous		☐	☐
Continuous		☐	☐

Regeneration of native woody vegetation

Is the sampling site in undisturbed forest?

Y [ ] N [ ]

If no, record regeneration category

☐ Abundant (>5% cover) and healthy

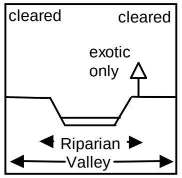
☐ Present

☐ Very limited (<1% cover)

Overall vegetation disturbance rating

Choose one category only. Sites with valley vegetation cleared on BOTH sides, but with riparian vegetation in good condition should be scored in the high disturbance category. Words within the drawings summarise the detailed text about the state of the riparian and valley vegetation for each category.

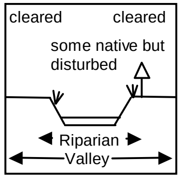
Extreme disturbance ☐



Riparian vegetation – absent or severely reduced. Vegetation is extremely disturbed (ie. dominated by exotic species with native species rare or completely absent)

Valley vegetation – agriculture and/or cleared land BOTH sides. Plants present are virtually all exotic species (willows, pines etc.)

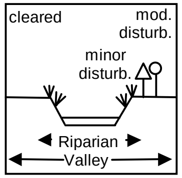
Very high disturbance ☐



Riparian vegetation – some native vegetation present, but it is severely modified BOTH sides by grazing or the intrusion of exotic species. Native species severely reduced in number and cover.

Valley vegetation – agriculture and/or cleared land BOTH sides. Plants present are virtually all exotic species (willows, pines etc.)

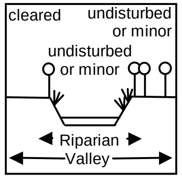
High disturbance ☐



Riparian vegetation – moderately disturbed by stock or through the intrusion of exotic species, although some native species remain

Valley vegetation – agriculture and/or cleared land ONE side, native vegetation on the other side clearly disturbed or with a high percentage of introduced species present

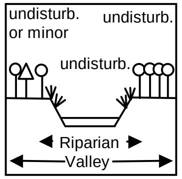
Moderate disturbance ☐



Riparian vegetation – native vegetation on BOTH sides with canopy intact or with native species widespread and common in the riparian zone. The intrusion of exotic species is minor and of moderate

Valley vegetation – agriculture and/or cleared land on ONE side, native vegetation on the other in reasonably undisturbed state

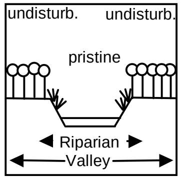
Low disturbance ☐



Riparian vegetation – native vegetation present on BOTH sides of the river and in relatively good condition with few exotic species present. Any disturbance present is relatively minor.

Valley vegetation – native vegetation present on BOTH sides of the river, with a virtually intact canopy and few exotic species

Very low disturbance ☐

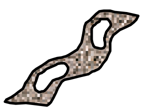
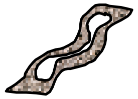
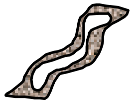
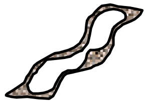
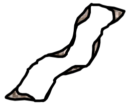
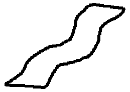


Riparian vegetation – native vegetation present on BOTH sides of the river and in an undisturbed state. Exotic species are absent or rare. Representative of natural vegetation in excellent condition

Valley vegetation – native vegetation present on BOTH sides of the river with an intact canopy. Exotic species are absent or rare. Representative of natural vegetation in excellent condition

Physical barriers to local fish passage

Choose one category for each flow condition

		Base flow	Low flow	High flow
	No passage	☐	☐	☐
	Very restricted passage	☐	☐	☐
	Moderately restricted passage	☐	☐	☐
	Partly restricted passage	☐	☐	☐
	Good passage	☐	☐	☐
	Unrestricted passage	☐	☐	☐

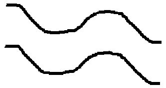
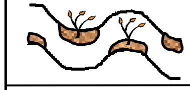
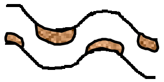
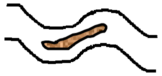
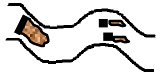
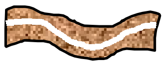
Type and height of barrier(s) ______________________

____

____

Type of bars

Choose one or more categories

	Bars absent	☐
	Side/point bars VEGETATED	☐
	Side/point bars UNVEGETATED	☐
	Mid-channel bars VEGETATED	☐
	Mid-channel bars UNVEGETATED	☐
	Bars around obstructions	☐
	Braided channel	☐
	Infilled channel	☐
	High flow deposits	☐

Extent of bars

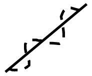
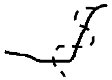
% of streambed forming a bar of any type ______ %

Dominant sediment particle size on bars

Boulder/cobble [ ] Pebble [ ] Gravel [ ]
Sand [ ] Silt/clay [ ] or __________mm

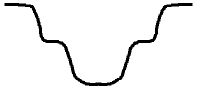
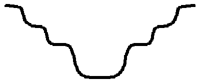
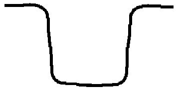
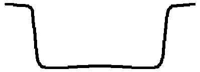
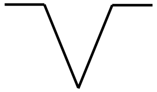
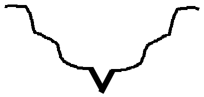
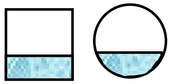
Channel modifications

Choose one or more categories

	No modifications	☐		Reinforced	☐
	Desnagged	☐		Revegetated	☐
	Dams and diversions	☐		Infilled	☐
	Resectioned	☐		Berms or embankments	☐
	Straightened	☐	Signs of work still	Recently channelised	☐
	Realigned	☐	Works old and revegetated	Channelised in the past	☐

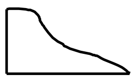
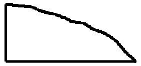
Channel shape

Choose one category only

 U shaped ☐	 Flat U shaped ☐	 Deepened U shape ☐	 Widened or infilled ☐	 Two stage ☐	 Multi stage ☐
 Box ☐	 Wide box ☐	 V shaped ☐	 Trapezoid ☐	 Concrete V ☐	 Pipe or culvert ☐

Bank shape

Choose one category for each bank

		Left bank	Right bank
	Concave	☐	☐
	Convex	☐	☐
	Stepped	☐	☐
	Wide lower bench	☐	☐
	Undercut	☐	☐

Factors affecting bank stability

Choose one or more categories

- ☐ None
- ☐ Mining
- ☐ Runoff
- ☐ Stock access
- ☐ Human access
- ☐ Ford, culvert or bridge
- ☐ Feral animals
- ☐ Other
- ☐ Cleared vegetation
- ☐ Irrigation draw-down
- ☐ Reservoir releases
- ☐ Seepage
- ☐ Flow and waves
- ☐ Drainpipes

Description ____________________

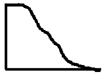
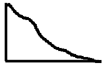
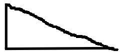
____

____

____

Bank slope

Choose one category for each bank

		Left bank	Right bank
	Vertical 80 - 90°	☐	☐
	Steep 60 - 80°	☐	☐
	Moderate 30 - 60°	☐	☐
	Low 10 - 30°	☐	☐
	Flat <10°	☐	☐

Bedrock outcrops

Assess % of each bank covered by bedrock outcrops

% bedrock outcrops Left bank ________

Right Bank ________

Artificial bank protection measures

Choose one or more categories

- ☐ None
- ☐ Fence structures
- ☐ Levee banks
- ☐ Rock or wall layer
- ☐ Rip rap
- ☐ Fenced human access
- ☐ Other ______________________________
- ☐ Fenced stock watering points
- ☐ Vegetation plantings
- ☐ Logs strapped to bank
- ☐ Concrete channel lining

____

____

Sediment oils

☐ absent ☐ light ☐ moderate ☐ profuse

Water oils

☐ none ☐ flecks ☐ globs ☐ sheen ☐ slick

Sediment odours

☐ normal/none ☐ sewage ☐ petroleum ☐ chemical

☐ anaerobic ☐ other ______________________________

Water odours

☐ normal/none ☐ sewage ☐ petroleum ☐ chemical

☐ other ______________________________

Turbidity (visual assessment)

☐ Clear ☐ Slight ☐ Turbid ☐ Opaque

↓ ↓ ↓

Is water clarity reduced by:

☐ Suspended material (e.g mud, clay, organics) ☐ Dissolved material (e.g plant leachates)

Water level at the time of sampling

☐ Dry ☐ No flow ☐ Low ☐ Baseflow or near baseflow

☐ High ☐ Flood (don't sample)

Artificial features at the sampling site

Choose one or more categories

☐ Major ☐ Minor weir ☐ Ford ☐ Bridge ☐ Culvert ☐ Other

Description ______________________________

____

____

Large woody debris

Overall % cover of logs and branches greater than 10cm in diameter

__________% Notes on visibility ____________________

____

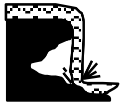
____

Extent of bedform features

Total % composition for all features must equal 100%

Height >1m
Gradient >60°

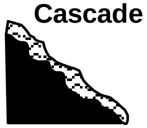
Waterfall



_____ **% of site**
_____ Est. Av. Length (m)
_____ Est. Av. Height (m)
_____ Est. Av. Gradient (°)

Step Height <1m
Gradient 5-60°
Strong currents

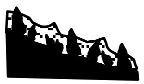
Cascade



_____ **% of site**
_____ Est. Av. Length (m)
_____ Est. Av. Height (m)
_____ Est. Av. Gradient (°)

Gradient 3-5°
Strong currents
Rocks break surface

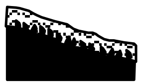
Rapid



_____ **% of site**
_____ Est. Av. Length (m)
_____ Est. Av. Depth (m)
_____ Est. Av. Width (m)

Gradient 1-3°
Moderate currents
Surface unbroken but unsmooth

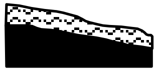
Riffle



_____ **% of site**
_____ Est. Av. Length (m)
_____ Est. Av. Depth (m)
_____ Est. Av. Width (m)

Gradient 1-3°
Small currents
Surface unbroken and smooth

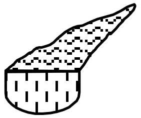
Glide



_____ **% of site**
_____ Est. Av. Length (m)
_____ Est. Av. Depth (m)
_____ Est. Av. Width (m)

Gradient 1-3°
Small but distinct & uniform current
Surface unbroken

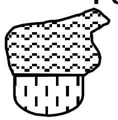
Run



_____ **% of site**
_____ Est. Av. Length (m)
_____ Est. Av. Depth (m)
_____ Est. Av. Width (m)

Area where stream widens or deepens and current declines

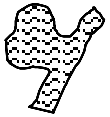
Pool



_____ **% of site**
_____ Est. Av. Length (m)
_____ Est. Av. Depth (m)
_____ Est. Av. Width (m)

A reasonable sized (>20% of channel width) cut-off section away from

Backwater



_____ **% of site**
_____ Est. Av. Length (m)
_____ Est. Av. Depth (m)
_____ Est. Av. Width (m)

Note: An additional response variable planform channel pattern is measured in the office

Macrophyte cover

Assess % cover of the sampling site by each category.

Overall % cover of macrophytes ______

% cover of emergent macrophytes ______
% cover of floating macrophytes ______
% cover of submerged macrophytes ______

Total should equal overall % cover of macrophytes

Macrophyte composition

Use a macrophyte field guide (i.e. Sainty and Jacobs, 1994) to aid identification.
Listed macrophytes can be changed to reflect the common taxa present in each State or Territory.
N denotes a native taxa and **I** denotes an introduced taxa.

Emergent macrophytes

	Present	% cover
Brachiaria (Para Grass) I	☐	______
Crassula (Crassula) N	☐	______
Cyperus (Sedge) I/N	☐	______
Eleocharis (Spikerush) N	☐	______
Juncus (Rush) I/N	☐	______
Paspalum (Water Couch) N	☐	______
Phragmites (Common Reed) N	☐	______
Ranunculus (Buttercup) I	☐	______
Scirpus (Clubrush) N	☐	______
Triglochin (Water Ribbon) N	☐	______
Typha (Cumbungi) N	☐	______
Other _________________	☐	______
Other _________________	☐	______
Other _________________	☐	______

Submerged macrophytes

	Present	% cover
Ceratophyllum (Hornwort) N	☐	______
Chara (Stonewart) N	☐	______
Elodea (Canadian Pondweed) I	☐	______
Myriophyllum (Water Milfoil) I/N	☐	______
Nitella (Stonewart) N	☐	______
Potamogeton (Pondweed) N	☐	______
Triglochin (Water Ribbon) N	☐	______
Vallisneria (Ribbonweed) N	☐	______
Other _________________	☐	______
Other _________________	☐	______
Other _________________	☐	______

Floating macrophytes

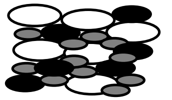
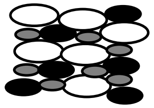
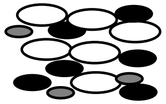
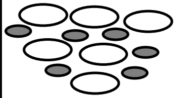
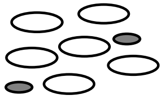
	Present	%
Azolla (Azolla) N	☐	______
Callitriche (Starwart) I	☐	______
Other _________________	☐	______
Other _________________	☐	______
Other _________________	☐	______

Overall % cover of native macrophyte taxa _______
Overall % cover of native macrophyte taxa _______

Total should equal overall % cover of macrophytes from above

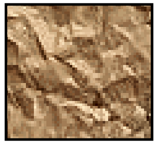
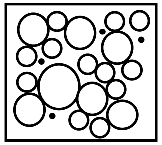
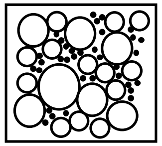
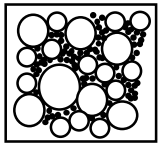
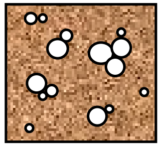
Bed compaction

Choose one category only

	Tightly packed, armoured Array of sediment sizes, overlapping, tightly packed and very hard to dislodge	☐
	Packed, unarmoured Array of sediment sizes, overlapping, tightly packed but can be dislodged with moderate	☐
	Moderate compaction Array of sediment sizes, little overlapping, some packing but can be dislodged with moderate	☐
	Low compaction (1) Limited range of sediment sizes, little overlapping, some packing and structure but can be dislodged very easily	☐
	Low compaction (2) Loose array of fine sediments, no overlapping, no packing and structure and can be dislodged very easily	☐

Sediment matrix

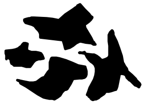
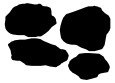
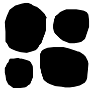
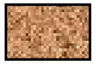
Choose one category only

	Bedrock	☐
	Open framework 0-5% fine sediment, high availability of interstitial spaces	☐
	Matrix filled contact framework 5-32% fine sediment, moderate availability of interstitial spaces	☐
	Framework dilated 32-60% fine sediment, low availability of interstitial spaces	☐
	Matrix dominated >60% fine sediment, interstitial spaces virtually absent	☐

Sediment angularity

Choose one category only

Assess cobble, pebble and gravel fractions only

	Very angular	☐
	Angular	☐
	Sub-angular	☐
	Rounded	☐
	Well rounded	☐
	Cobble, pebble and gravel fractions not present	☐

In the USEPA Habitat Assessment on the following pages, be sure to use the correct form for high or low gradient streams ▶

Bed stability rating

Choose one category only

Unstable - eroding ← **Stable** → **Unstable - depositing**

Severe erosion	**Moderate erosion**	**Bed stable**	**Moderate deposition**	**Severe deposition**
Streambed scoured of fine sediments. Signs of channel deepening. Bare, severely eroded banks. Erosion heads. Steep streambed caused by erosion. ☐	Little fine sediment present. Signs of channel deepening. Eroded banks. Streambed deep and narrow. Steep streambed comprised of unconsolidated (loosely arranged and unpacked) material ☐	A range of sediment sizes present in the streambed. Channel is in a 'relatively natural' state (not deepened or infilled). Bed and bar sediments are roughly the same size. Banks stable. Streambed comprised of consolidated (tightly arranged and packed) material. ☐	Moderate build-up of fine sediments at obstructions and bars. Streambed flat and uniform. Channel wide and shallow. ☐	Extensive build up of fine sediments to form a flat bed. Channel blocked, but wide and shallow. Bars large and covering most of the bed or banks. Streambed comprised of unconsolidated (loosely arranged and unpacked) material. ☐

USEPA Habitat Assessment
Circle a score for each parameter

HIGH GRADIENT STREAMS

Page 1 of 2

Habitat parameter	**Condition category**			
	Excellent	**Good**	**Fair**	**Poor**
1. Epifaunal substrate / available cover	Greater than 70% of substrate favourable for epifaunal colonisation and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonisation potential (i.e. logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonisation potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonisation (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble and boulder particles are more than 75% surrounded by fine sediment.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity / depth regime	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). Slow is <0.3m/s, deep is >0.5m).	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/depth regime (usually slow-deep).
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions and bends; moderate deposition in pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel flow status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Channel alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e. dredging (greater than 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Continued over

Site No. _____________ Date _____________

USEPA Habitat Assessment
Circle a score for each parameter

HIGH GRADIENT STREAMS

Page 2 of 2

<table>
<tr><th rowspan="2">Habitat parameter</th><th colspan="20">Condition category</th></tr>
<tr><th colspan="5">Excellent</th><th colspan="5">Good</th><th colspan="5">Fair</th><th colspan="5">Poor</th></tr>
<tr><td>7.
Frequency of riffles (or bends)</td><td colspan="5">Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.</td><td colspan="5">Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.</td><td colspan="5">Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.</td><td colspan="5">Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.</td></tr>
<tr><td>SCORE</td><td>20</td><td>19</td><td>18</td><td>17</td><td>16</td><td>15</td><td>14</td><td>13</td><td>12</td><td>11</td><td>10</td><td>9</td><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td>8.
Bank stability
(score each bank)</td><td colspan="5">Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.</td><td colspan="5">Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.</td><td colspan="5">Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.</td><td colspan="5">Unstable; many eroded areas; 'raw' areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.</td></tr>
<tr><td>SCORE</td><td colspan="3">Left bank</td><td>10</td><td>9</td><td colspan="2">8</td><td>7</td><td colspan="2">6</td><td colspan="2">5</td><td>4</td><td colspan="2">3</td><td colspan="2">2</td><td>1</td><td colspan="2">0</td></tr>
<tr><td>SCORE</td><td colspan="3">Right bank</td><td>10</td><td>9</td><td colspan="2">8</td><td>7</td><td colspan="2">6</td><td colspan="2">5</td><td>4</td><td colspan="2">3</td><td colspan="2">2</td><td>1</td><td colspan="2">0</td></tr>
<tr><td>9.
Vegetative protection
(score each bank)</td><td colspan="5">More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understorey shrubs, or non woody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.</td><td colspan="5">70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one half of the potential plant stubble height remaining.</td><td colspan="5">50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.</td><td colspan="5">Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimetres or less in average stubble height.</td></tr>
<tr><td>SCORE</td><td colspan="3">Left bank</td><td>10</td><td>9</td><td colspan="2">8</td><td>7</td><td colspan="2">6</td><td colspan="2">5</td><td>4</td><td colspan="2">3</td><td colspan="2">2</td><td>1</td><td colspan="2">0</td></tr>
<tr><td>SCORE</td><td colspan="3">Right bank</td><td>10</td><td>9</td><td colspan="2">8</td><td>7</td><td colspan="2">6</td><td colspan="2">5</td><td>4</td><td colspan="2">3</td><td colspan="2">2</td><td>1</td><td colspan="2">0</td></tr>
<tr><td>10.
Riparian zone score
(score each bank)</td><td colspan="5">Width of riparian zone >18 metres; human activities (i.e. roads, lawns, crops etc.) have not impacted the riparian zone.</td><td colspan="5">Width of riparian zone 12-18 metres; human activities have impacted the riparian zone only minimally.</td><td colspan="5">Width of riparian zone 6-12 metres; human activities have impacted the riparian zone a great deal.</td><td colspan="5">Width of riparian zone <6 metres; little or no riparian vegetation is present because of human activities.</td></tr>
<tr><td>SCORE</td><td colspan="3">Left bank</td><td>10</td><td>9</td><td colspan="2">8</td><td>7</td><td colspan="2">6</td><td colspan="2">5</td><td>4</td><td colspan="2">3</td><td colspan="2">2</td><td>1</td><td colspan="2">0</td></tr>
<tr><td>SCORE</td><td colspan="3">Right bank</td><td>10</td><td>9</td><td colspan="2">8</td><td>7</td><td colspan="2">6</td><td colspan="2">5</td><td>4</td><td colspan="2">3</td><td colspan="2">2</td><td>1</td><td colspan="2">0</td></tr>
</table>

TOTAL HIGH GRADIENT HABITAT SCORE ☐

Site No. _____________ Date _____________

USEPA Habitat Assessment
Circle a score for each parameter

LOW GRADIENT STREAMS

Page 1 of 2

Habitat parameter	Condition category																				
	Excellent					Good					Fair					Poor					
1. Epifaunal substrate / available cover	Greater than 50% of substrate favourable for epifaunal colonisation and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonisation potential (i.e. logs/snags that are not new fall and not transient).					30-50% mix of stable habitat; well-suited for full colonisation potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonisation (may rate at high end of scale).					10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.					Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.					
SCORE	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
2. Pool substrate characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.					Mixture of soft sand, mud or clay; mud may be dominant; some root mats and submerged vegetation present.					All mud or clay or sand bottom; little or no root mat; no submerged vegetation.					Hard-pan clay or bedrock; no root mat or vegetation.					
SCORE	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
3. Pool variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.					Majority of pools large-deep; very few shallow.					Shallow pools much more prevalent than deep pools.					Majority of pools small-shallow or pools absent.					
SCORE	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
4. Sediment deposition	Little or no enlargement of islands or point bars and less than 20% of the bottom affected by sediment deposition.					Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.					Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions and bends; moderate deposition in pools prevalent.					Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.					
SCORE	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
5. Channel flow status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.					Water fills >75% of the available channel; or <25% of channel substrate is exposed.					Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.					Very little water in channel and mostly present as standing pools.					
SCORE	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
6. Channel alteration	Channelization or dredging absent or minimal; stream with normal pattern.					Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e. dredging (greater than 20 yr) may be present, but recent channelization is not present.					Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.					Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.					
SCORE	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Continued over

USEPA Habitat Assessment
Circle a score for each parameter

LOW GRADIENT STREAMS

Page 2 of 2

Habitat parameter	**Condition category**			
	Excellent	**Good**	**Fair**	**Poor**
7. **Channel sinuosity**	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note – channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas).	The bends in the stream increase the stream length 2 to 3 times longer than if it was in a straight line.	The bends in the stream increase the stream 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**
8. **Bank stability** **(score each bank)**	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; 'raw' areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE	Left bank **10 9**	**8 7 6**	**5 4 3**	**2 1 0**
SCORE	Right bank **10 9**	**8 7 6**	**5 4 3**	**2 1 0**
9. **Vegetative protection** **(score each bank)**	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understorey shrubs, or non woody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimetres or less in average stubble height.
SCORE	Left bank **10 9**	**8 7 6**	**5 4 3**	**2 1 0**
SCORE	Right bank **10 9**	**8 7 6**	**5 4 3**	**2 1 0**
10. **Riparian zone score** **(score each bank)**	Width of riparian zone >18 metres; human activities (i.e. roads, lawns, crops etc.) have not impacted the riparian zone.	Width of riparian zone 12-18 metres; human activities have impacted the riparian zone only minimally.	Width of riparian zone 6-12 metres; human activities have impacted the riparian zone a great deal.	Width of riparian zone <6 metres; little or no riparian vegetation is present because of human activities.
SCORE	Left bank **10 9**	**8 7 6**	**5 4 3**	**2 1 0**
SCORE	Right bank **10 9**	**8 7 6**	**5 4 3**	**2 1 0**

TOTAL LOW GRADIENT HABITAT SCORE ☐

Site No. ____________ Date ____________

Channel cross-sections and variables to be measured in the area around a cross section

Detailed instructions on the measurement of channel cross-sections are provided in the protocol manual. Be familiar with these before proceeding.

Two cross-sections are required at homogeneous sampling sites (generally lowland streams) and three cross-sections at heterogeneous sampling sites (generally upland streams).

Where the water level at the time of sampling is at or near the water mark level, stream width at the water surface will be equal to stream width at the water mark. In this case, vertical distance between the water surface and the water mark should be entered as 0.

Cross-section sketch

The channel sketch should show in cross-section the shape of the channel and include the location of the water surface, watermark and bankfull points. Also show other features such as bars, rocky outcrops and snags encountered at the cross section.

Cross-section number _____ of _____

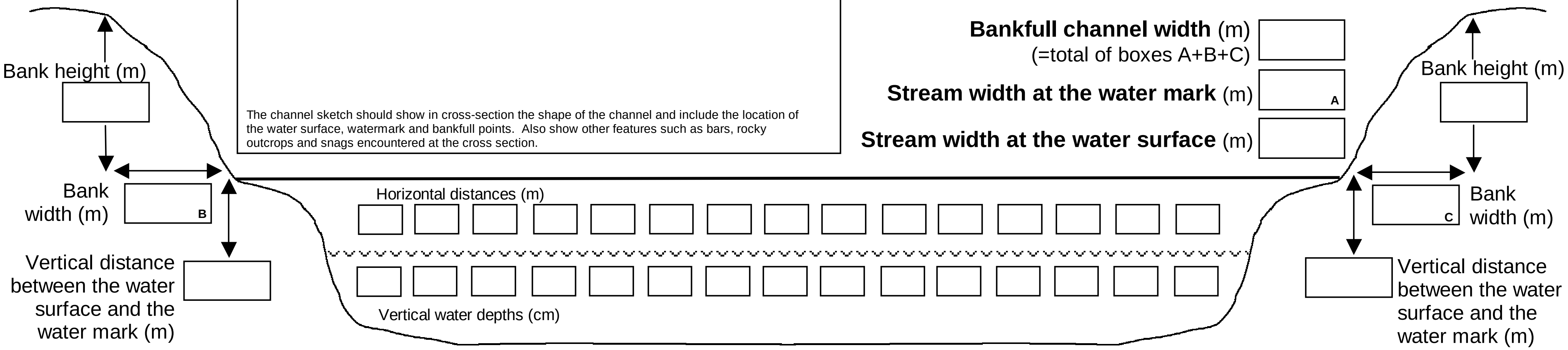
Type of bedform at the cross-section

☐ Riffle ☐ Run ☐ Pool ☐ Cascade ☐ Other __________

Bankfull channel width (m) (=total of boxes A+B+C) ☐

Stream width at the water mark (m) ☐ A

Stream width at the water surface (m) ☐



Bank height (m) ☐

Bank width (m) ☐ B

Vertical distance between the water surface and the water mark (m) ☐

Horizontal distances (m) ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Vertical water depths (cm) ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Bank height (m) ☐

Bank width (m) ☐ C

Vertical distance between the water surface and the water mark (m) ☐

Notes on cross-section measurement

____

____

Riparian zone width

Left bank _____ (m) Right bank _____ (m)

Bank material Assess % composition for each bank

	Left bank	**Right bank**
Bedrock	_____	_____
Boulder (>256mm)	_____	_____
Cobble (64-256mm)	_____	_____
Pebble (16-64mm)	_____	_____
Gravel (2-16mm)	_____	_____
Sand (0.06-2mm)	_____	_____
Fines (silt and clay, <0.06mm)	_____	_____

Total 100% each

Substrate composition

Assess % composition in the area of bed 5m either side of the cross-section.

Bedrock	_______
Boulder (>256mm)	_______
Cobble (64-256mm)	_______
Pebble (16-64mm)	_______
Gravel (2-16mm)	_______
Sand (0.06-2mm)	_______
Fines (silt and clay <0.06mm)	_______

Total 100%

Assess in the area 5m either side of the cross section

Filamentous algae cover

☐ <10% ☐ 10–35% ☐ 35-65% ☐ 65-90% ☐ >90%

Periphyton cover

☐ <10% ☐ 10–35% ☐ 35-65% ☐ 65-90% ☐ >90%

Moss cover

☐ <10% ☐ 10–35% ☐ 35-65% ☐ 65-90% ☐ >90%

Detritus cover

☐ <10% ☐ 10–35% ☐ 35-65% ☐ 65-90% ☐ >90%

Channel cross-sections and variables to be measured in the area around a cross section

Detailed instructions on the measurement of channel cross-sections are provided in the protocol manual. Be familiar with these before proceeding.

Two cross-sections are required at homogeneous sampling sites (generally lowland streams) and three cross-sections at heterogeneous sampling sites (generally upland streams).

Where the water level at the time of sampling is at or near the water mark level, stream width at the water surface will be equal to stream width at the water mark. In this case, vertical distance between the water surface and the water mark should be entered as 0.

Cross-section sketch

The channel sketch should show in cross-section the shape of the channel and include the location of the water surface, watermark and bankfull points. Also show other features such as bars, rocky outcrops and snags encountered at the cross section.

Cross-section number _____ of _____

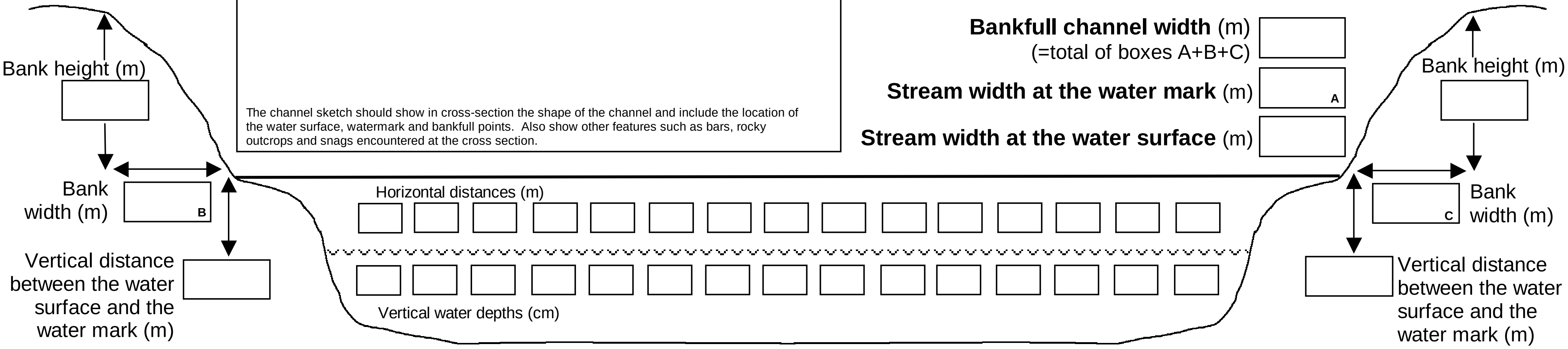
Type of bedform at the cross-section

☐ Riffle ☐ Run ☐ Pool ☐ Cascade ☐ Other ___________

Bankfull channel width (m) ☐
(=total of boxes A+B+C)

Stream width at the water mark (m) ☐ A

Stream width at the water surface (m) ☐



Notes on cross-section measurement

____

____

Riparian zone width

Left bank _____ (m) Right bank _____ (m)

Bank material

Assess % composition for each bank

	Left bank	Right bank
Bedrock	______	______
Boulder (>256mm)	______	______
Cobble (64-256mm)	______	______
Pebble (16-64mm)	______	______
Gravel (2-16mm)	______	______
Sand (0.06-2mm)	______	______
Fines (silt and clay, <0.06mm)	______	______

Total 100% each

Substrate composition

Assess % composition in the area of bed 5m either side of the cross-section.

Bedrock	________
Boulder (>256mm)	________
Cobble (64-256mm)	________
Pebble (16-64mm)	________
Gravel (2-16mm)	________
Sand (0.06-2mm)	________
Fines (silt and clay <0.06mm)	________

Total 100%

Assess in the area 5m either side of the cross section

Filamentous algae cover

☐ <10% ☐ 10–35% ☐ 35-65% ☐ 65-90% ☐ >90%

Periphyton cover

☐ <10% ☐ 10–35% ☐ 35-65% ☐ 65-90% ☐ >90%

Moss cover

☐ <10% ☐ 10–35% ☐ 35-65% ☐ 65-90% ☐ >90%

Detritus cover

☐ <10% ☐ 10–35% ☐ 35-65% ☐ 65-90% ☐ >90%

Site No. ______________ **Date** ______________

Channel cross-sections and variables to be measured in the area around a cross section

Detailed instructions on the measurement of channel cross-sections are provided in the protocol manual. Be familiar with these before proceeding.

Two cross-sections are required at homogeneous sampling sites (generally lowland streams) and three cross-sections at heterogeneous sampling sites (generally upland streams).

Where the water level at the time of sampling is at or near the water mark level, stream width at the water surface will be equal to stream width at the water mark. In this case, vertical distance between the water surface and the water mark should be entered as 0.

Cross-section sketch

The channel sketch should show in cross-section the shape of the channel and include the location of the water surface, watermark and bankfull points. Also show other features such as bars, rocky outcrops and snags encountered at the cross section.

Cross-section number _____ of _____

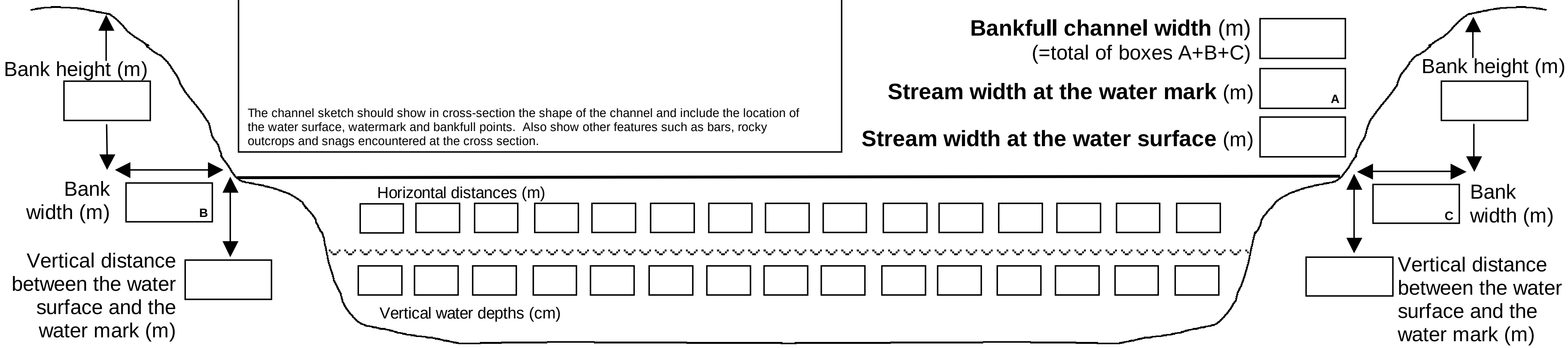
Type of bedform at the cross-section

☐ Riffle ☐ Run ☐ Pool ☐ Cascade ☐ Other ____________

Bankfull channel width (m) (=total of boxes A+B+C) ☐

Stream width at the water mark (m) ☐ A

Stream width at the water surface (m) ☐



Notes on cross-section measurement

____

____

Riparian zone width

Left bank _____ (m) Right bank _____ (m)

Bank material Assess % composition for each bank

	Left bank	Right bank
Bedrock	______	______
Boulder (>256mm)	______	______
Cobble (64-256mm)	______	______
Pebble (16-64mm)	______	______
Gravel (2-16mm)	______	______
Sand (0.06-2mm)	______	______
Fines (silt and clay, <0.06mm)	______	______

Total 100% each

Substrate composition

Assess % composition in the area of bed 5m either side of the cross-section.

Bedrock	________
Boulder (>256mm)	________
Cobble (64-256mm)	________
Pebble (16-64mm)	________
Gravel (2-16mm)	________
Sand (0.06-2mm)	________
Fines (silt and clay <0.06mm)	________

Total 100%

Assess in the area 5m either side of the cross section

Filamentous algae cover

☐ <10% ☐ 10–35% ☐ 35-65% ☐ 65-90% ☐ >90%

Periphyton cover

☐ <10% ☐ 10–35% ☐ 35-65% ☐ 65-90% ☐ >90%

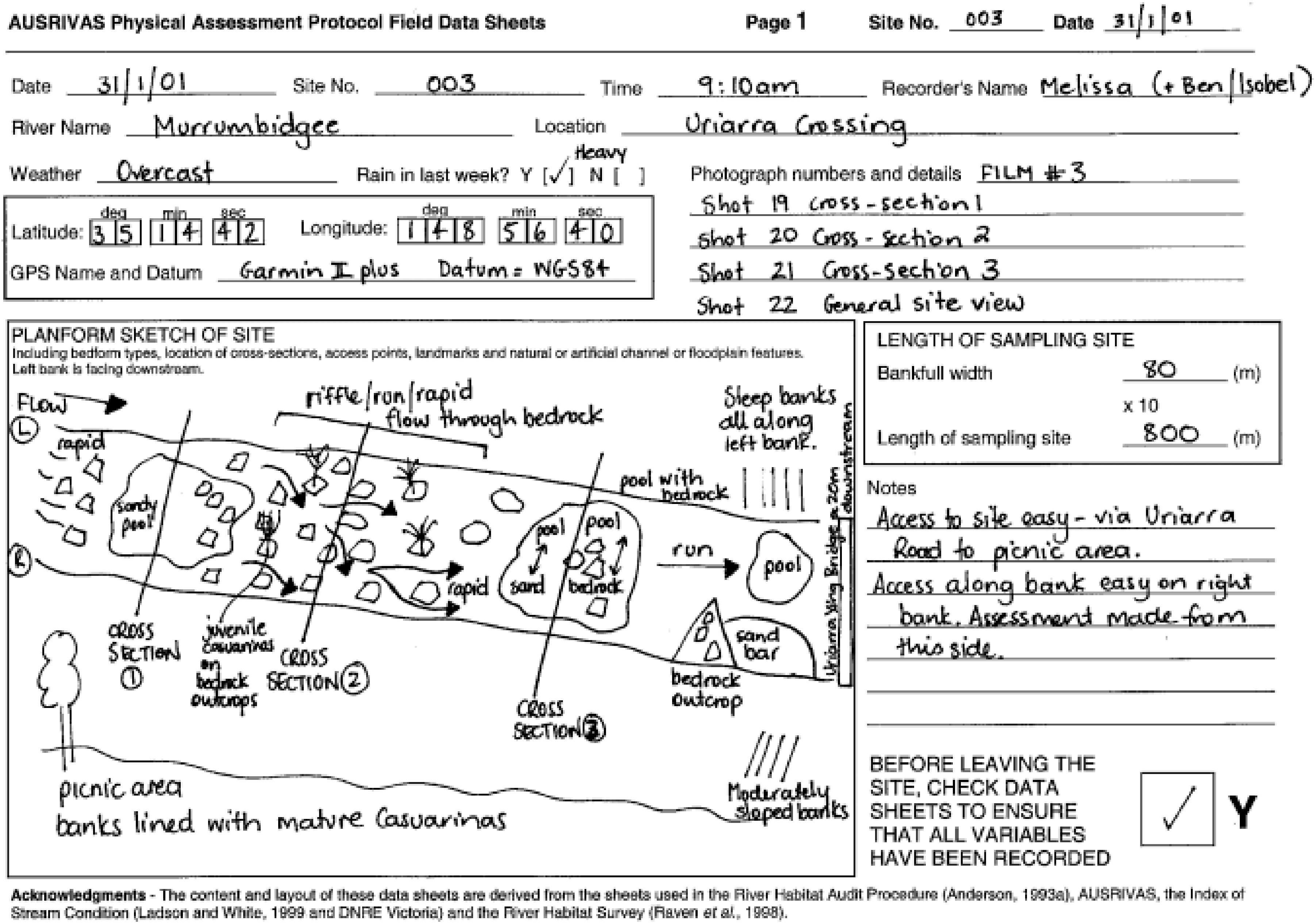
Moss cover

☐ <10% ☐ 10–35% ☐ 35-65% ☐ 65-90% ☐ >90%

Detritus cover

☐ <10% ☐ 10–35% ☐ 35-65% ☐ 65-90% ☐ >90%

Example of a completed field data sheet



AUSRIVAS Physical Assessment Protocol Field Data Sheets **Page 1** **Site No.** 003 **Date** 31/1/01

Date 31/1/01 Site No. 003 Time 9:10am Recorder's Name Melissa (+ Ben/Isobel)

River Name Murrumbidgee Location Uriarra Crossing

Weather Overcast Rain in last week? Y [✓] Heavy N [ ]

Photograph numbers and details FILM #3

Shot 19 cross-section 1

Shot 20 Cross-section 2

Shot 21 Cross-section 3

Shot 22 General site view

Latitude: deg 35 min 14 sec 42 Longitude: deg 148 min 56 sec 40

GPS Name and Datum Garmin II plus Datum = WGS84

PLANFORM SKETCH OF SITE

Including bedform types, location of cross-sections, access points, landmarks and natural or artificial channel or floodplain features.
Left bank is facing downstream.

LENGTH OF SAMPLING SITE

Bankfull width 80 (m)

x 10

Length of sampling site 800 (m)

Notes

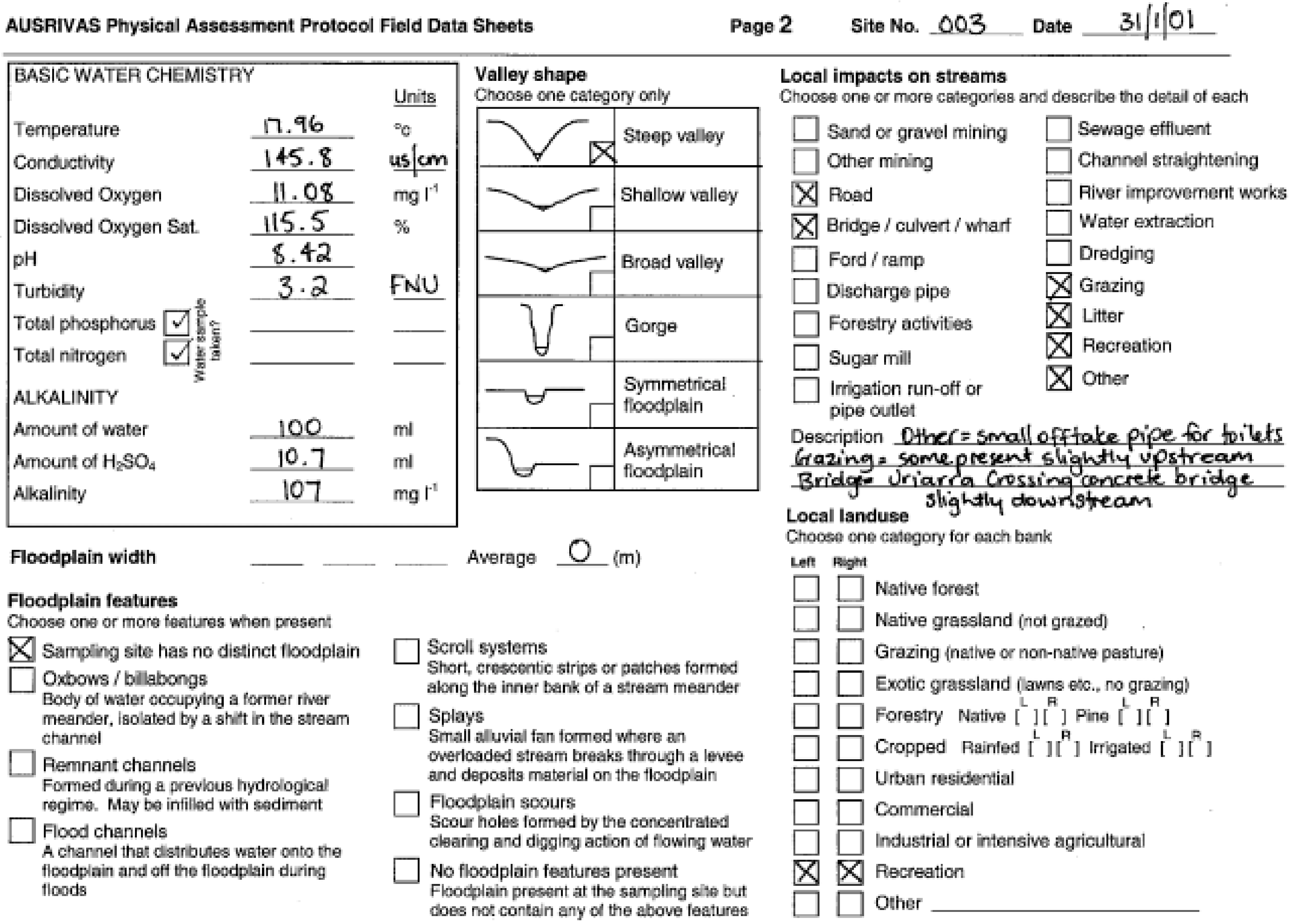
Access to site easy - via Uriarra Road to picnic area.

Access along bank easy on right bank. Assessment made from this side.

BEFORE LEAVING THE SITE, CHECK DATA SHEETS TO ENSURE THAT ALL VARIABLES HAVE BEEN RECORDED ☑ Y

Acknowledgments - The content and layout of these data sheets are derived from the sheets used in the River Habitat Audit Procedure (Anderson, 1993a), AUSRIVAS, the Index of Stream Condition (Ladson and White, 1999 and DNRE Victoria) and the River Habitat Survey (Raven *et al.*, 1998).

Example of a completed field data sheet (cont.)



AUSRIVAS Physical Assessment Protocol Field Data Sheets **Page 2** **Site No.** 003 **Date** 31/1/01

BASIC WATER CHEMISTRY

	Water sample taken?		Units
Temperature		17.96	°c
Conductivity		145.8	us/cm
Dissolved Oxygen		11.08	$mg\ l^{-1}$
Dissolved Oxygen Sat.		115.5	%
pH		8.42	
Turbidity		3.2	FNU
Total phosphorus	☑		
Total nitrogen	☑		
ALKALINITY			
Amount of water		100	ml
Amount of H_2SO_4		10.7	ml
Alkalinity		107	$mg\ l^{-1}$

Valley shape
Choose one category only

☒ Steep valley
☐ Shallow valley
☐ Broad valley
☐ Gorge
☐ Symmetrical floodplain
☐ Asymmetrical floodplain

Floodplain width ______ ______ ______ Average 0 (m)

Floodplain features
Choose one or more features when present

☒ Sampling site has no distinct floodplain

☐ Oxbows / billabongs
Body of water occupying a former river meander, isolated by a shift in the stream channel

☐ Remnant channels
Formed during a previous hydrological regime. May be infilled with sediment

☐ Flood channels
A channel that distributes water onto the floodplain and off the floodplain during floods

☐ Scroll systems
Short, crescentic strips or patches formed along the inner bank of a stream meander

☐ Splays
Small alluvial fan formed where an overloaded stream breaks through a levee and deposits material on the floodplain

☐ Floodplain scours
Scour holes formed by the concentrated clearing and digging action of flowing water

☐ No floodplain features present
Floodplain present at the sampling site but does not contain any of the above features

Local impacts on streams
Choose one or more categories and describe the detail of each

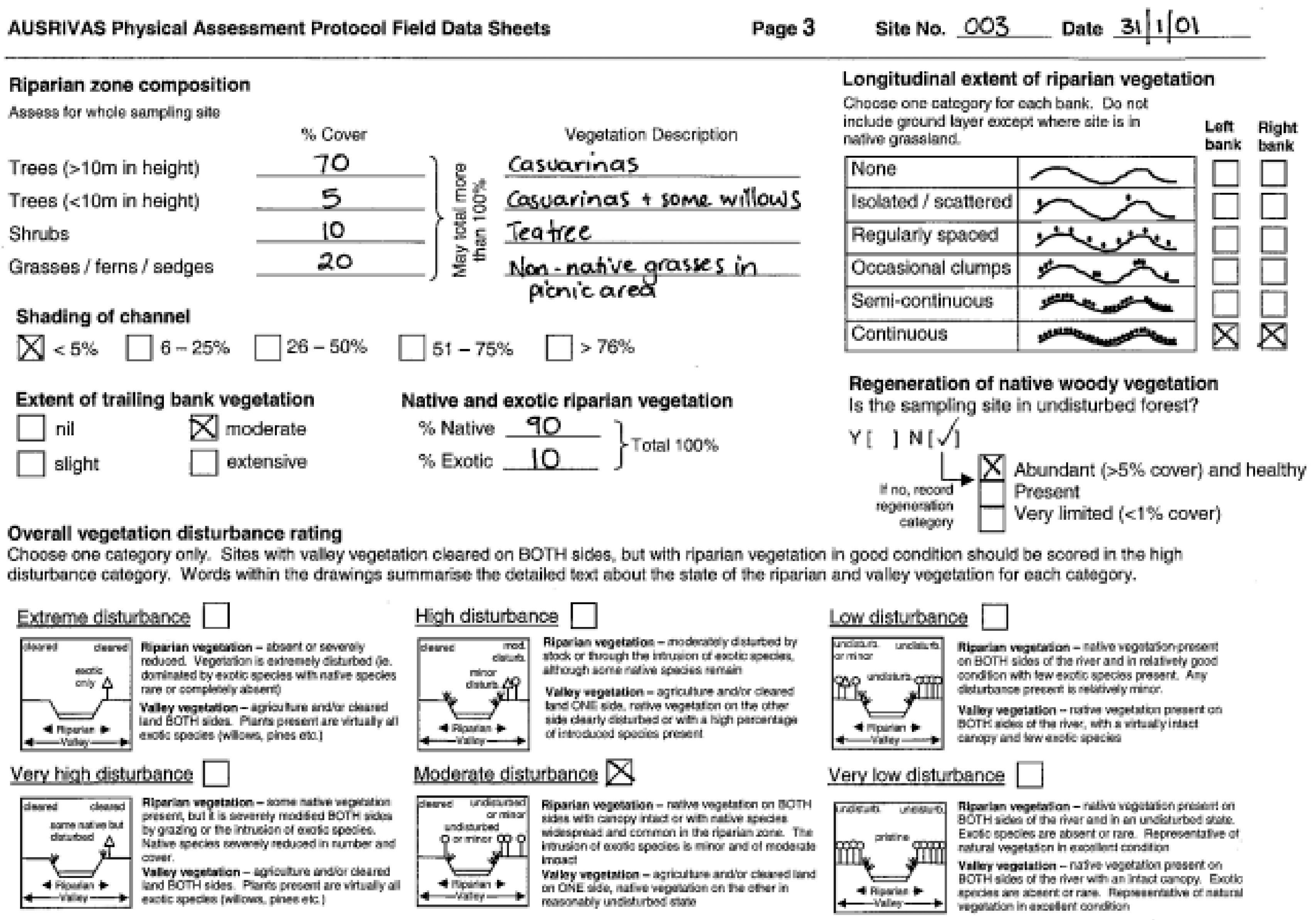
☐ Sand or gravel mining
☐ Other mining
☒ Road
☒ Bridge / culvert / wharf
☐ Ford / ramp
☐ Discharge pipe
☐ Forestry activities
☐ Sugar mill
☐ Irrigation run-off or pipe outlet
☐ Sewage effluent
☐ Channel straightening
☐ River improvement works
☐ Water extraction
☐ Dredging
☒ Grazing
☒ Litter
☒ Recreation
☒ Other

Description Other = small offtake pipe for toilets
Grazing = some present slightly upstream
Bridge = Uriarra Crossing concrete bridge slightly downstream

Local landuse
Choose one category for each bank

Left	Right	
☐	☐	Native forest
☐	☐	Native grassland (not grazed)
☐	☐	Grazing (native or non-native pasture)
☐	☐	Exotic grassland (lawns etc., no grazing)
☐	☐	Forestry Native L [ ] R [ ] Pine L [ ] R [ ]
☐	☐	Cropped Rainfed L [ ] R [ ] Irrigated L [ ] R [ ]
☐	☐	Urban residential
☐	☐	Commercial
☐	☐	Industrial or intensive agricultural
☒	☒	Recreation
☐	☐	Other ______

Example of a completed field data sheet (cont.)



AUSRIVAS Physical Assessment Protocol Field Data Sheets **Page 3** **Site No.** 003 **Date** 31/1/01

Riparian zone composition

Assess for whole sampling site

	% Cover	Vegetation Description
Trees (>10m in height)	70	Casuarinas
Trees (<10m in height)	5	Casuarinas + some willows
Shrubs	10	Teatree
Grasses / ferns / sedges	20	Non-native grasses in picnic area

May total more than 100%

Shading of channel

☒ < 5% ☐ 6 – 25% ☐ 26 – 50% ☐ 51 – 75% ☐ > 76%

Extent of trailing bank vegetation

☐ nil ☒ moderate

☐ slight ☐ extensive

Native and exotic riparian vegetation

% Native 90

% Exotic 10

Total 100%

Longitudinal extent of riparian vegetation

Choose one category for each bank. Do not include ground layer except where site is in native grassland.

	Left bank	Right bank
None	☐	☐
Isolated / scattered	☐	☐
Regularly spaced	☐	☐
Occasional clumps	☐	☐
Semi-continuous	☐	☐
Continuous	☒	☒

Regeneration of native woody vegetation

Is the sampling site in undisturbed forest?

Y [ ] N [✓]

If no, record regeneration category

☒ Abundant (>5% cover) and healthy

☐ Present

☐ Very limited (<1% cover)

Overall vegetation disturbance rating

Choose one category only. Sites with valley vegetation cleared on BOTH sides, but with riparian vegetation in good condition should be scored in the high disturbance category. Words within the drawings summarise the detailed text about the state of the riparian and valley vegetation for each category.

Extreme disturbance ☐

Riparian vegetation – absent or severely reduced. Vegetation is extremely disturbed (ie. dominated by exotic species with native species rare or completely absent)

Valley vegetation – agriculture and/or cleared land BOTH sides. Plants present are virtually all exotic species (willows, pines etc.)

Very high disturbance ☐

Riparian vegetation – some native vegetation present, but it is severely modified BOTH sides by grazing or the intrusion of exotic species. Native species severely reduced in number and cover.

Valley vegetation – agriculture and/or cleared land BOTH sides. Plants present are virtually all exotic species (willows, pines etc.)

High disturbance ☐

Riparian vegetation – moderately disturbed by stock or through the intrusion of exotic species, although some native species remain

Valley vegetation – agriculture and/or cleared land ONE side, native vegetation on the other side clearly disturbed or with a high percentage of introduced species present

Moderate disturbance ☒

Riparian vegetation – native vegetation on BOTH sides with canopy intact or with native species widespread and common in the riparian zone. The intrusion of exotic species is minor and of moderate impact

Valley vegetation – agriculture and/or cleared land on ONE side, native vegetation on the other in reasonably undisturbed state

Low disturbance ☐

Riparian vegetation – native vegetation present on BOTH sides of the river and in relatively good condition with few exotic species present. Any disturbance present is relatively minor.

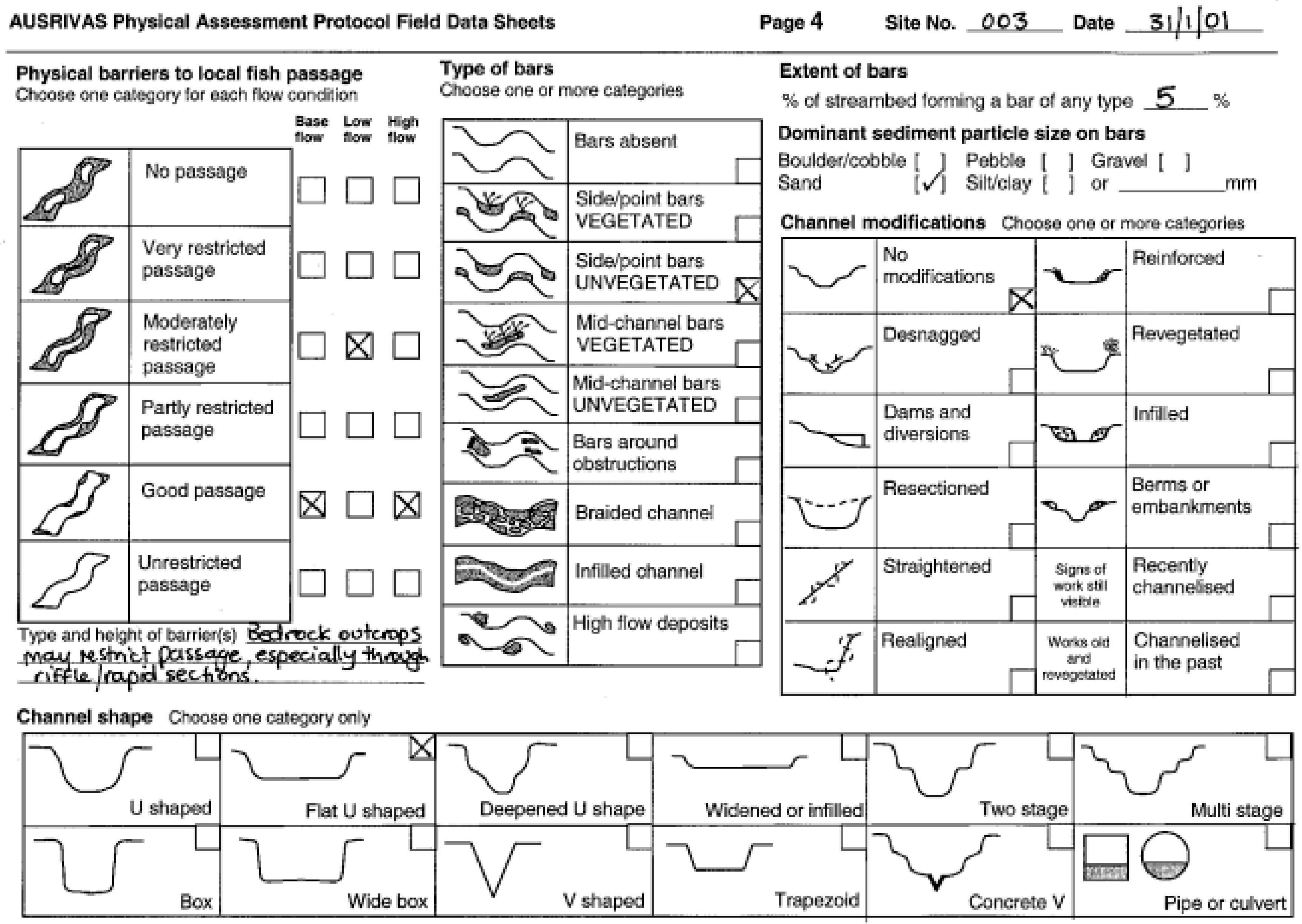
Valley vegetation – native vegetation present on BOTH sides of the river, with a virtually intact canopy and few exotic species

Very low disturbance ☐

Riparian vegetation – native vegetation present on BOTH sides of the river and in an undisturbed state. Exotic species are absent or rare. Representative of natural vegetation in excellent condition

Valley vegetation – native vegetation present on BOTH sides of the river with an intact canopy. Exotic species are absent or rare. Representative of natural vegetation in excellent condition

Example of a completed field data sheet (cont.)



AUSRIVAS Physical Assessment Protocol Field Data Sheets **Page** 4 **Site No.** 003 **Date** 31/1/01

Physical barriers to local fish passage
Choose one category for each flow condition

		Base flow	Low flow	High flow
	No passage	☐	☐	☐
	Very restricted passage	☐	☐	☐
	Moderately restricted passage	☐	☒	☐
	Partly restricted passage	☐	☐	☐
	Good passage	☒	☐	☒
	Unrestricted passage	☐	☐	☐

Type and height of barrier(s) Bedrock outcrops may restrict passage, especially through riffle/rapid sections.

Type of bars
Choose one or more categories

	Bars absent	☐
	Side/point bars VEGETATED	☐
	Side/point bars UNVEGETATED	☒
	Mid-channel bars VEGETATED	☐
	Mid-channel bars UNVEGETATED	☐
	Bars around obstructions	☐
	Braided channel	☐
	Infilled channel	☐
	High flow deposits	☐

Extent of bars
% of streambed forming a bar of any type 5 %

Dominant sediment particle size on bars
Boulder/cobble [ ] Pebble [ ] Gravel [ ]
Sand [✓] Silt/clay [ ] or ________mm

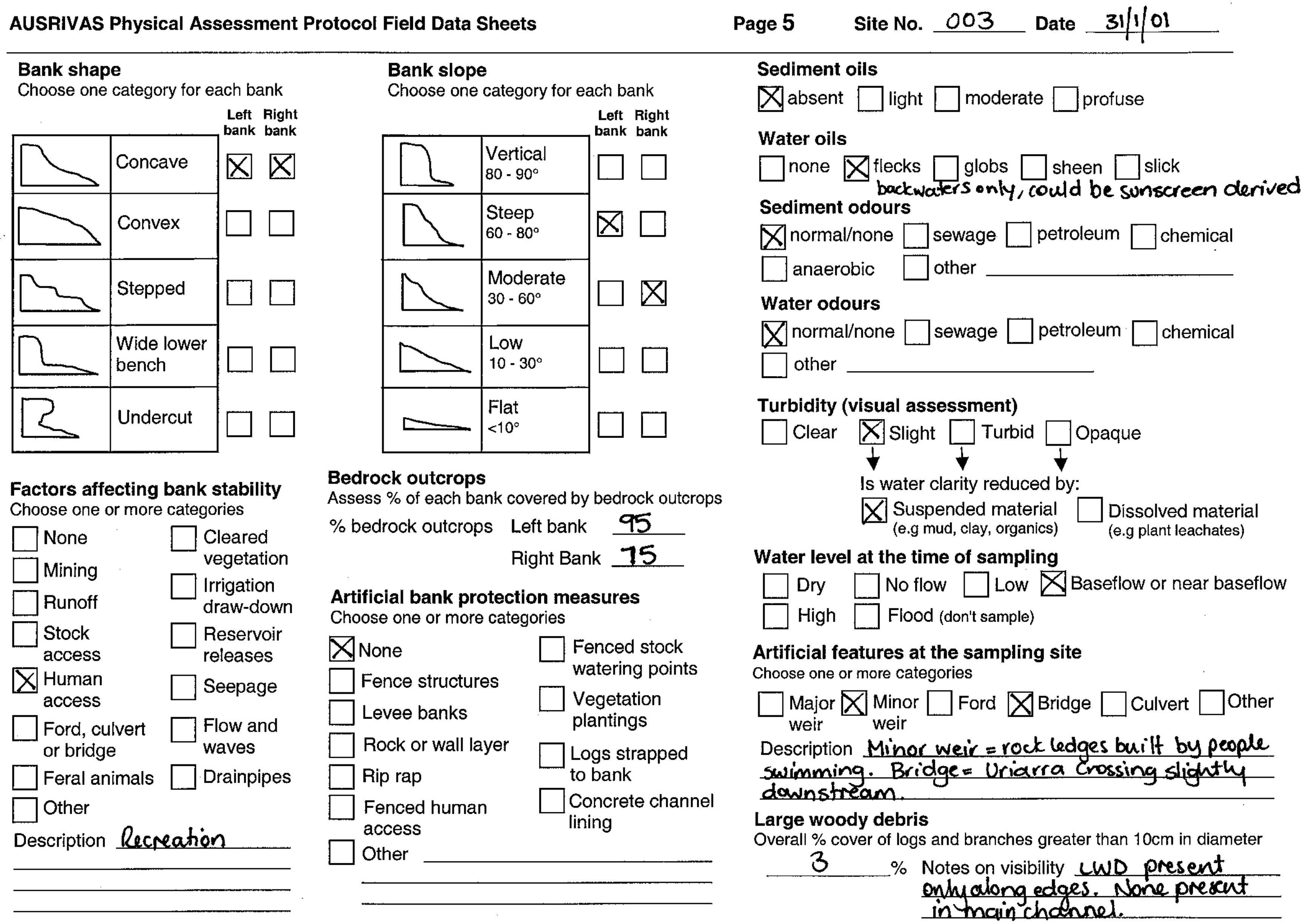
Channel modifications Choose one or more categories

	No modifications	☒		Reinforced	☐
	Desnagged	☐		Revegetated	☐
	Dams and diversions	☐		Infilled	☐
	Resectioned	☐		Berms or embankments	☐
	Straightened	☐	Signs of work still visible	Recently channelised	☐
	Realigned	☐	Works old and revegetated	Channelised in the past	☐

Channel shape Choose one category only

U shaped ☐	Flat U shaped ☒	Deepened U shape ☐	Widened or infilled ☐	Two stage ☐	Multi stage ☐
Box ☐	Wide box ☐	V shaped ☐	Trapezoid ☐	Concrete V ☐	Pipe or culvert ☐

Example of a completed field data sheet (cont.)



AUSRIVAS Physical Assessment Protocol Field Data Sheets **Page 5** **Site No.** 003 **Date** 31/1/01

Bank shape
Choose one category for each bank

		Left bank	Right bank
	Concave	☒	☒
	Convex	☐	☐
	Stepped	☐	☐
	Wide lower bench	☐	☐
	Undercut	☐	☐

Bank slope
Choose one category for each bank

		Left bank	Right bank
	Vertical 80 - 90°	☐	☐
	Steep 60 - 80°	☒	☐
	Moderate 30 - 60°	☐	☒
	Low 10 - 30°	☐	☐
	Flat <10°	☐	☐

Factors affecting bank stability
Choose one or more categories

- ☐ None
- ☐ Mining
- ☐ Runoff
- ☐ Stock access
- ☒ Human access
- ☐ Ford, culvert or bridge
- ☐ Feral animals
- ☐ Other
- ☐ Cleared vegetation
- ☐ Irrigation draw-down
- ☐ Reservoir releases
- ☐ Seepage
- ☐ Flow and waves
- ☐ Drainpipes

Description Recreation

Bedrock outcrops
Assess % of each bank covered by bedrock outcrops

% bedrock outcrops Left bank 95
Right Bank 15

Artificial bank protection measures
Choose one or more categories

- ☒ None
- ☐ Fence structures
- ☐ Levee banks
- ☐ Rock or wall layer
- ☐ Rip rap
- ☐ Fenced human access
- ☐ Other
- ☐ Fenced stock watering points
- ☐ Vegetation plantings
- ☐ Logs strapped to bank
- ☐ Concrete channel lining

Sediment oils
☒ absent ☐ light ☐ moderate ☐ profuse

Water oils
☐ none ☒ flecks ☐ globs ☐ sheen ☐ slick
backwaters only, could be sunscreen derived

Sediment odours
☒ normal/none ☐ sewage ☐ petroleum ☐ chemical
☐ anaerobic ☐ other

Water odours
☒ normal/none ☐ sewage ☐ petroleum ☐ chemical
☐ other

Turbidity (visual assessment)
☐ Clear ☒ Slight ☐ Turbid ☐ Opaque

Is water clarity reduced by:
☒ Suspended material (e.g mud, clay, organics) ☐ Dissolved material (e.g plant leachates)

Water level at the time of sampling
☐ Dry ☐ No flow ☐ Low ☒ Baseflow or near baseflow
☐ High ☐ Flood (don't sample)

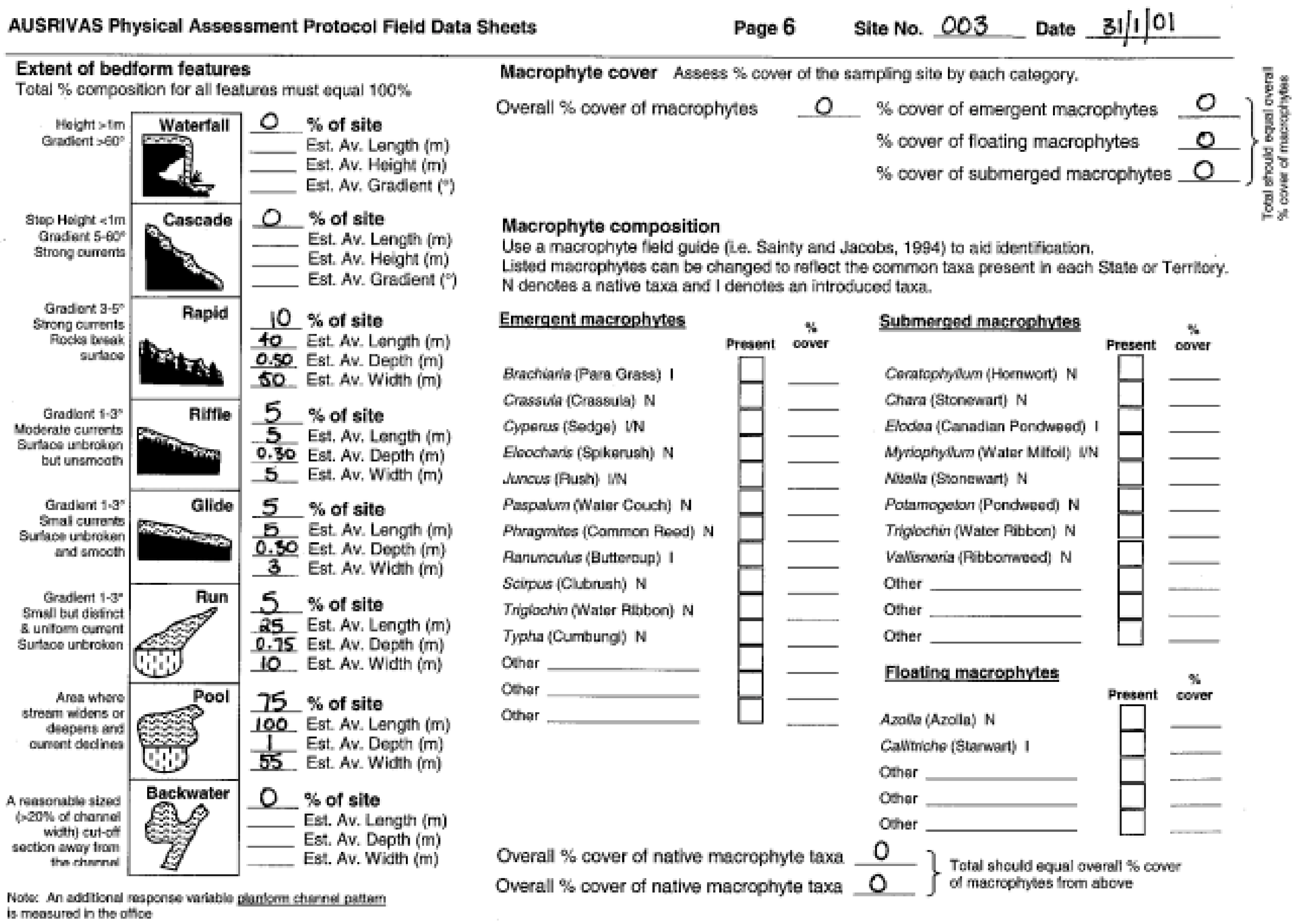
Artificial features at the sampling site
Choose one or more categories

☐ Major weir ☒ Minor weir ☐ Ford ☒ Bridge ☐ Culvert ☐ Other

Description Minor weir = rock ledges built by people swimming. Bridge = Uriarra Crossing slightly downstream.

Large woody debris
Overall % cover of logs and branches greater than 10cm in diameter
3 % Notes on visibility LWD present only along edges. None present in main channel.

Example of a completed field data sheet (cont.)



AUSRIVAS Physical Assessment Protocol Field Data Sheets **Page 6** **Site No.** 003 **Date** 31/1/01

Extent of bedform features
Total % composition for all features must equal 100%

Height >1m Gradient >60°	**Waterfall**	0	**% of site**
			Est. Av. Length (m)
			Est. Av. Height (m)
			Est. Av. Gradient (°)
Step Height <1m Gradient 5-60° Strong currents	**Cascade**	0	**% of site**
			Est. Av. Length (m)
			Est. Av. Height (m)
			Est. Av. Gradient (°)
Gradient 3-5° Strong currents Rocks break surface	**Rapid**	10	**% of site**
		40	Est. Av. Length (m)
		0.50	Est. Av. Depth (m)
		50	Est. Av. Width (m)
Gradient 1-3° Moderate currents Surface unbroken but unsmooth	**Riffle**	5	**% of site**
		5	Est. Av. Length (m)
		0.30	Est. Av. Depth (m)
		5	Est. Av. Width (m)
Gradient 1-3° Small currents Surface unbroken and smooth	**Glide**	5	**% of site**
		5	Est. Av. Length (m)
		0.30	Est. Av. Depth (m)
		3	Est. Av. Width (m)
Gradient 1-3° Small but distinct & uniform current Surface unbroken	**Run**	5	**% of site**
		25	Est. Av. Length (m)
		0.75	Est. Av. Depth (m)
		10	Est. Av. Width (m)
Area where stream widens or deepens and current declines	**Pool**	75	**% of site**
		100	Est. Av. Length (m)
		1	Est. Av. Depth (m)
		55	Est. Av. Width (m)
A reasonable sized (>20% of channel width) cut-off section away from the channel	**Backwater**	0	**% of site**
			Est. Av. Length (m)
			Est. Av. Depth (m)
			Est. Av. Width (m)

Note: An additional response variable planform channel pattern is measured in the office

Macrophyte cover Assess % cover of the sampling site by each category.

Overall % cover of macrophytes 0

% cover of emergent macrophytes 0
% cover of floating macrophytes 0
% cover of submerged macrophytes 0

Total should equal overall % cover of macrophytes

Macrophyte composition
Use a macrophyte field guide (i.e. Sainty and Jacobs, 1994) to aid identification.
Listed macrophytes can be changed to reflect the common taxa present in each State or Territory.
N denotes a native taxa and I denotes an introduced taxa.

Emergent macrophytes

	Present	% cover
Brachiaria (Para Grass) I	☐	
Crassula (Crassula) N	☐	
Cyperus (Sedge) I/N	☐	
Eleocharis (Spikerush) N	☐	
Juncus (Rush) I/N	☐	
Paspalum (Water Couch) N	☐	
Phragmites (Common Reed) N	☐	
Ranunculus (Buttercup) I	☐	
Scirpus (Clubrush) N	☐	
Triglochin (Water Ribbon) N	☐	
Typha (Cumbungi) N	☐	
Other	☐	
Other	☐	
Other	☐	

Submerged macrophytes

	Present	% cover
Ceratophyllum (Hornwort) N	☐	
Chara (Stonewart) N	☐	
Elodea (Canadian Pondweed) I	☐	
Myriophyllum (Water Milfoil) I/N	☐	
Nitella (Stonewart) N	☐	
Potamogeton (Pondweed) N	☐	
Triglochin (Water Ribbon) N	☐	
Vallisneria (Ribbonweed) N	☐	
Other	☐	
Other	☐	
Other	☐	

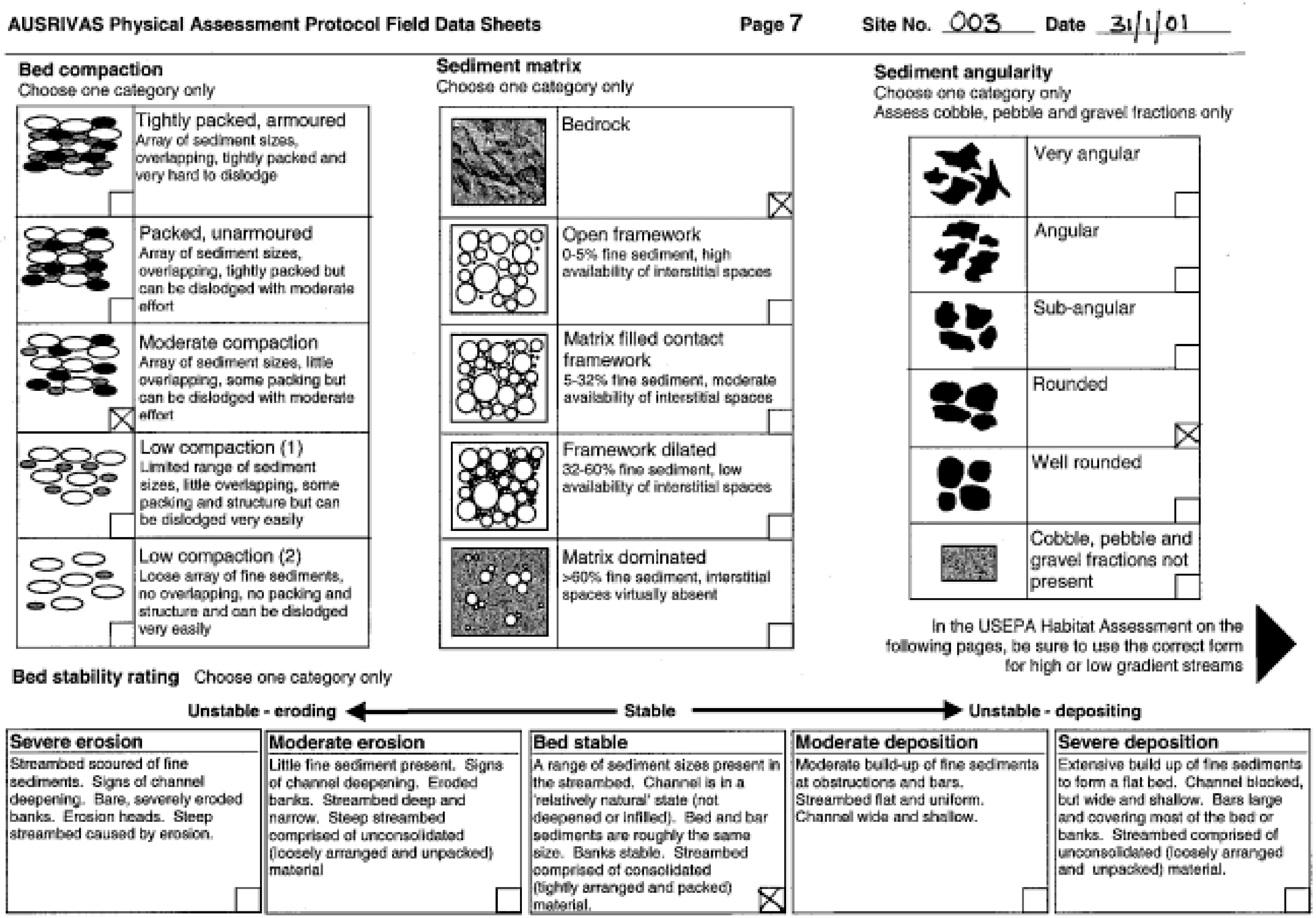
Floating macrophytes

	Present	% cover
Azolla (Azolla) N	☐	
Callitriche (Starwart) I	☐	
Other	☐	
Other	☐	
Other	☐	

Overall % cover of native macrophyte taxa 0
Overall % cover of native macrophyte taxa 0

Total should equal overall % cover of macrophytes from above

Example of a completed field data sheet (cont.)



AUSRIVAS Physical Assessment Protocol Field Data Sheets **Page 7** **Site No.** 003 **Date** 31/1/01

Bed compaction
Choose one category only

Tightly packed, armoured Array of sediment sizes, overlapping, tightly packed and very hard to dislodge	☐
Packed, unarmoured Array of sediment sizes, overlapping, tightly packed but can be dislodged with moderate effort	☐
Moderate compaction Array of sediment sizes, little overlapping, some packing but can be dislodged with moderate effort	☒
Low compaction (1) Limited range of sediment sizes, little overlapping, some packing and structure but can be dislodged very easily	☐
Low compaction (2) Loose array of fine sediments, no overlapping, no packing and structure and can be dislodged very easily	☐

Sediment matrix
Choose one category only

Bedrock	☒
Open framework 0-5% fine sediment, high availability of interstitial spaces	☐
Matrix filled contact framework 5-32% fine sediment, moderate availability of interstitial spaces	☐
Framework dilated 32-60% fine sediment, low availability of interstitial spaces	☐
Matrix dominated >60% fine sediment, interstitial spaces virtually absent	☐

Sediment angularity
Choose one category only
Assess cobble, pebble and gravel fractions only

Very angular	☐
Angular	☐
Sub-angular	☐
Rounded	☒
Well rounded	☐
Cobble, pebble and gravel fractions not present	☐

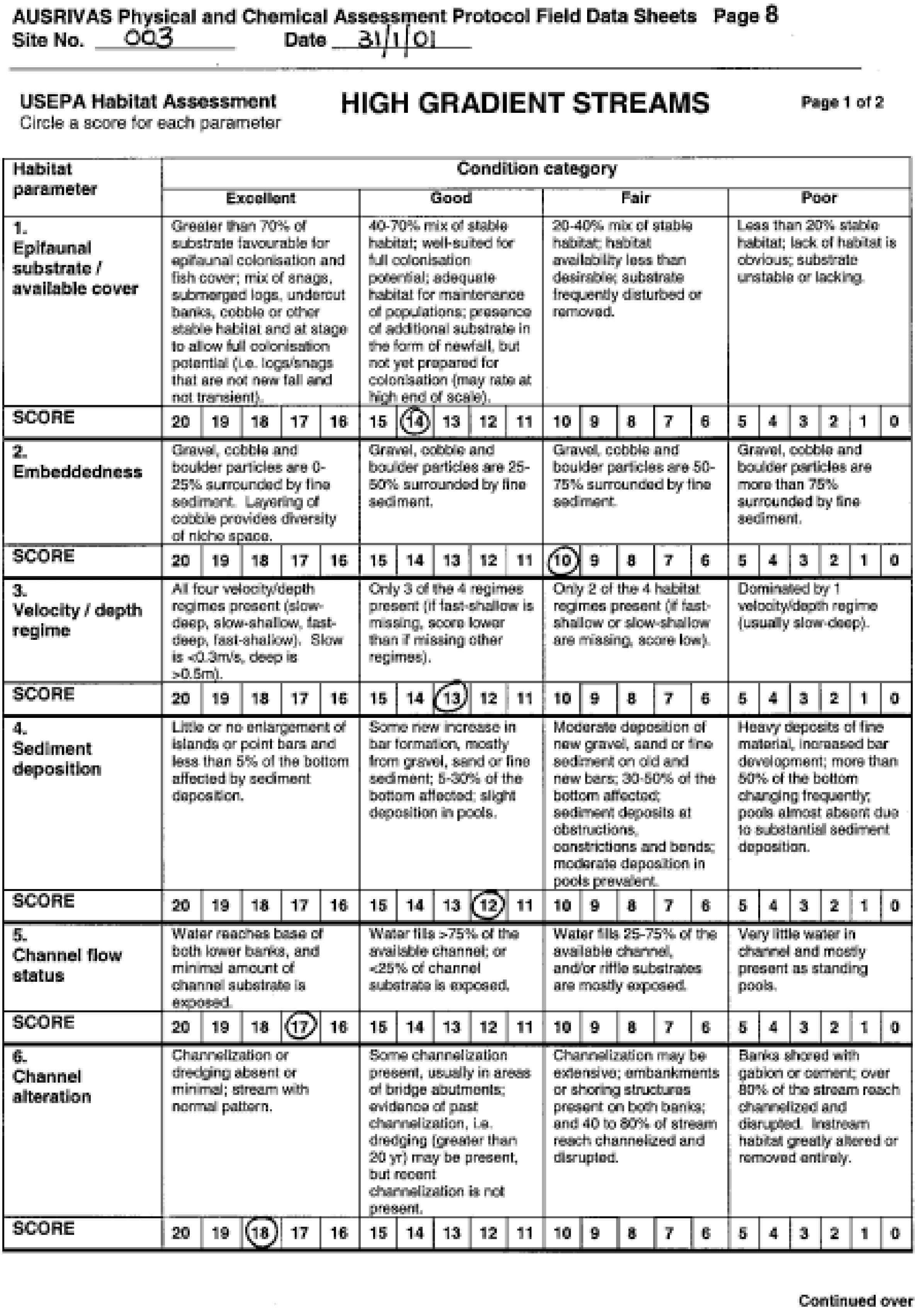
In the USEPA Habitat Assessment on the following pages, be sure to use the correct form for high or low gradient streams ▶

Bed stability rating Choose one category only

Unstable - eroding ◀—— **Stable** ——▶ **Unstable - depositing**

Severe erosion	**Moderate erosion**	**Bed stable**	**Moderate deposition**	**Severe deposition**
Streambed scoured of fine sediments. Signs of channel deepening. Bare, severely eroded banks. Erosion heads. Steep streambed caused by erosion.	Little fine sediment present. Signs of channel deepening. Eroded banks. Streambed deep and narrow. Steep streambed comprised of unconsolidated (loosely arranged and unpacked) material	A range of sediment sizes present in the streambed. Channel is in a 'relatively natural' state (not deepened or infilled). Bed and bar sediments are roughly the same size. Banks stable. Streambed comprised of consolidated (tightly arranged and packed) material.	Moderate build-up of fine sediments at obstructions and bars. Streambed flat and uniform. Channel wide and shallow.	Extensive build up of fine sediments to form a flat bed. Channel blocked, but wide and shallow. Bars large and covering most of the bed or banks. Streambed comprised of unconsolidated (loosely arranged and unpacked) material.
☐	☐	☒	☐	☐

Example of a completed field data sheet (cont.)



AUSRIVAS Physical and Chemical Assessment Protocol Field Data Sheets **Page 8**

Site No. 003 **Date** 31/1/01

USEPA Habitat Assessment
Circle a score for each parameter

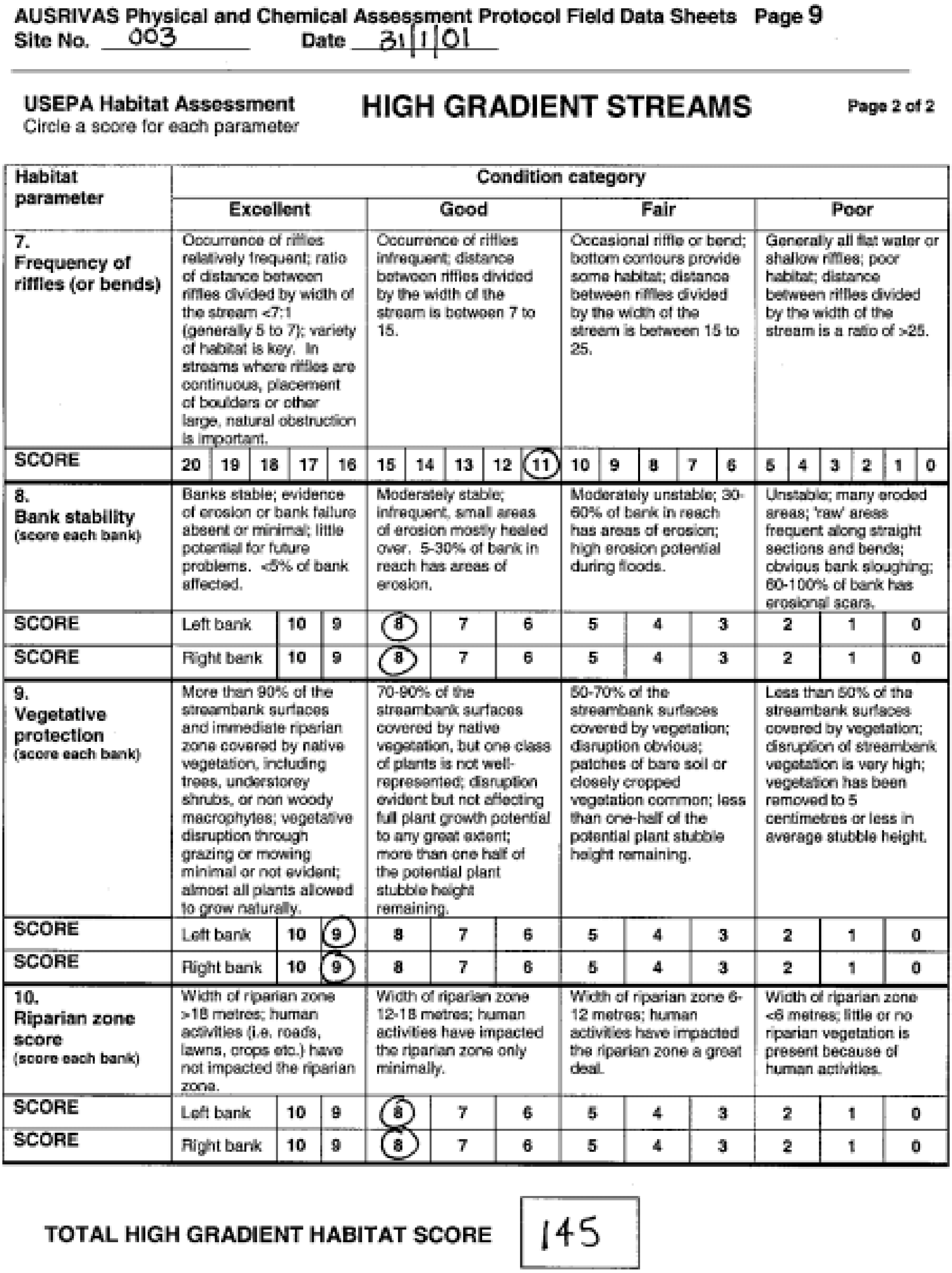
HIGH GRADIENT STREAMS

Page 1 of 2

Habitat parameter	Condition category: Excellent	Condition category: Good	Condition category: Fair	Condition category: Poor
1. Epifaunal substrate / available cover	Greater than 70% of substrate favourable for epifaunal colonisation and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonisation potential (i.e. logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonisation potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonisation (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 [✓ 14] 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble and boulder particles are more than 75% surrounded by fine sediment.
SCORE	20 19 18 17 16	15 14 13 12 11	[✓ 10] 9 8 7 6	5 4 3 2 1 0
3. Velocity / depth regime	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). Slow is <0.3m/s, deep is >0.5m).	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/depth regime (usually slow-deep).
SCORE	20 19 18 17 16	15 14 [✓ 13] 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions and bends; moderate deposition in pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 [✓ 12] 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel flow status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 [✓ 17] 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Channel alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e. dredging (greater than 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 [✓ 18] 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Continued over

Example of a completed field data sheet (cont.)



AUSRIVAS Physical and Chemical Assessment Protocol Field Data Sheets **Page** 9

Site No. 003 **Date** 31/1/01

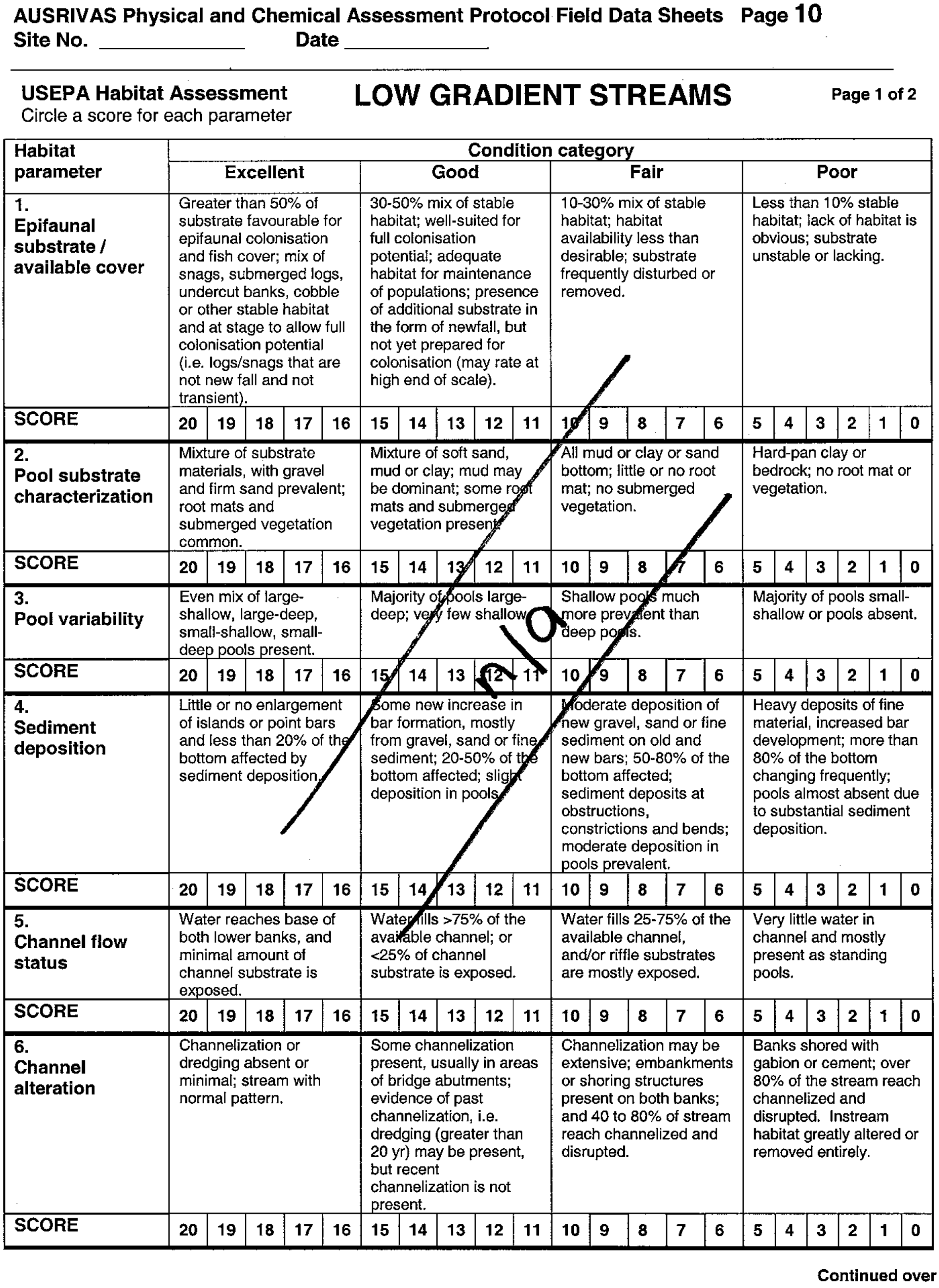
USEPA Habitat Assessment **HIGH GRADIENT STREAMS** **Page 2 of 2**

Circle a score for each parameter

Habitat parameter	Condition category			
	Excellent	Good	Fair	Poor
7. Frequency of riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
SCORE	20 19 18 17 16	15 14 13 12 [✓ 11]	10 9 8 7 6	5 4 3 2 1 0
8. Bank stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; 'raw' areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE	Left bank 10 9	[✓ 8] 7 6	5 4 3	2 1 0
SCORE	Right bank 10 9	[✓ 8] 7 6	5 4 3	2 1 0
9. Vegetative protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understorey shrubs, or non woody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimetres or less in average stubble height.
SCORE	Left bank 10 [✓ 9]	8 7 6	5 4 3	2 1 0
SCORE	Right bank 10 [✓ 9]	8 7 6	5 4 3	2 1 0
10. Riparian zone score (score each bank)	Width of riparian zone >18 metres; human activities (i.e. roads, lawns, crops etc.) have not impacted the riparian zone.	Width of riparian zone 12-18 metres; human activities have impacted the riparian zone only minimally.	Width of riparian zone 6-12 metres; human activities have impacted the riparian zone a great deal.	Width of riparian zone <6 metres; little or no riparian vegetation is present because of human activities.
SCORE	Left bank 10 9	[✓ 8] 7 6	5 4 3	2 1 0
SCORE	Right bank 10 9	[✓ 8] 7 6	5 4 3	2 1 0

TOTAL HIGH GRADIENT HABITAT SCORE 145

Example of a completed field data sheet (cont.)



AUSRIVAS Physical and Chemical Assessment Protocol Field Data Sheets **Page 10**
Site No. ______________ **Date** ______________

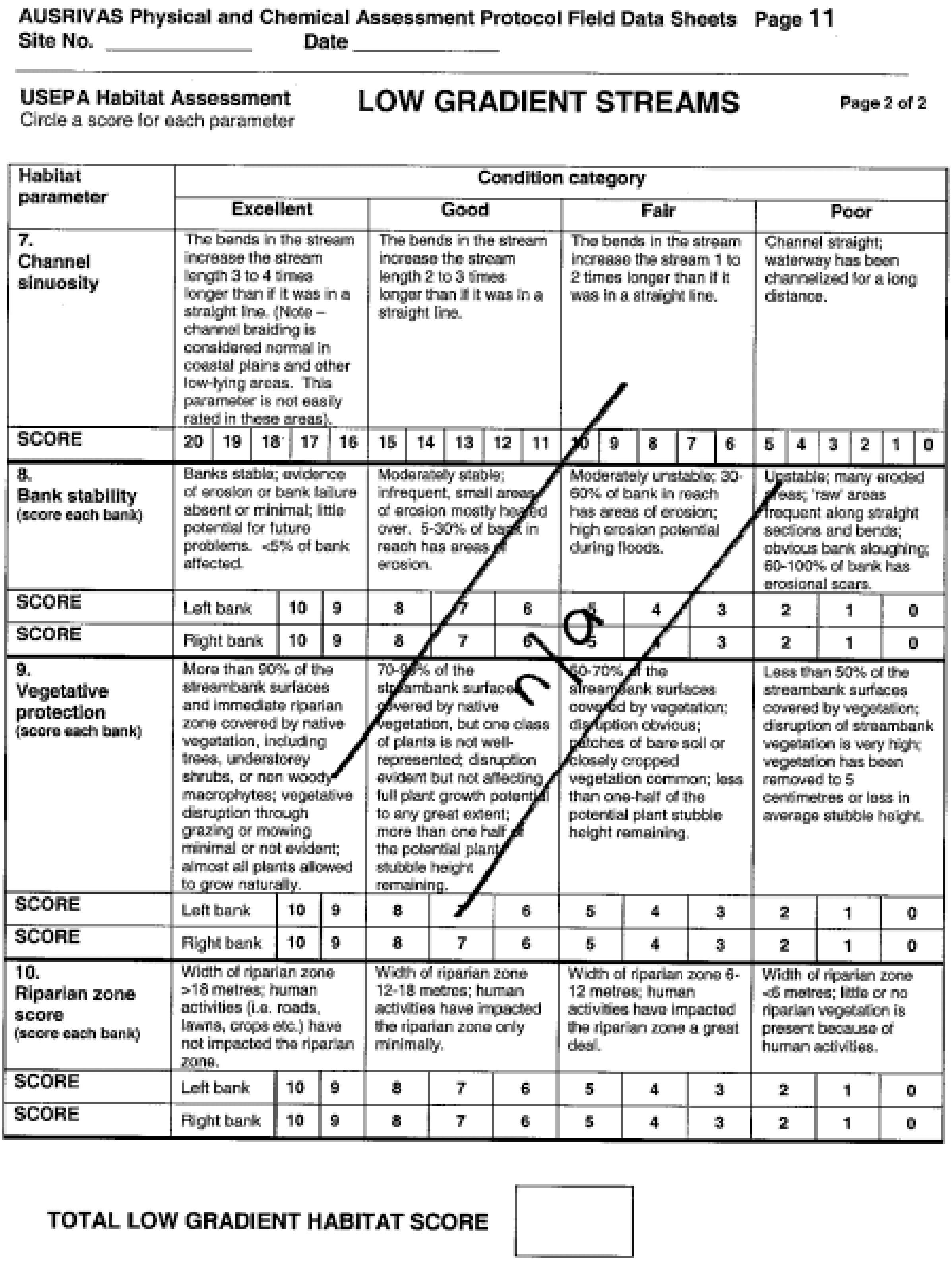
USEPA Habitat Assessment **LOW GRADIENT STREAMS** **Page 1 of 2**
Circle a score for each parameter

Habitat parameter	**Condition category**			
	Excellent	**Good**	**Fair**	**Poor**
1. Epifaunal substrate / available cover	Greater than 50% of substrate favourable for epifaunal colonisation and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonisation potential (i.e. logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonisation potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonisation (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool substrate characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment deposition	Little or no enlargement of islands or point bars and less than 20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions and bends; moderate deposition in pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel flow status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Channel alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e. dredging (greater than 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

2/10

Continued over

Example of a completed field data sheet (cont.)



AUSRIVAS Physical and Chemical Assessment Protocol Field Data Sheets **Page 11**

Site No. ____________ **Date** ____________

USEPA Habitat Assessment
Circle a score for each parameter

LOW GRADIENT STREAMS

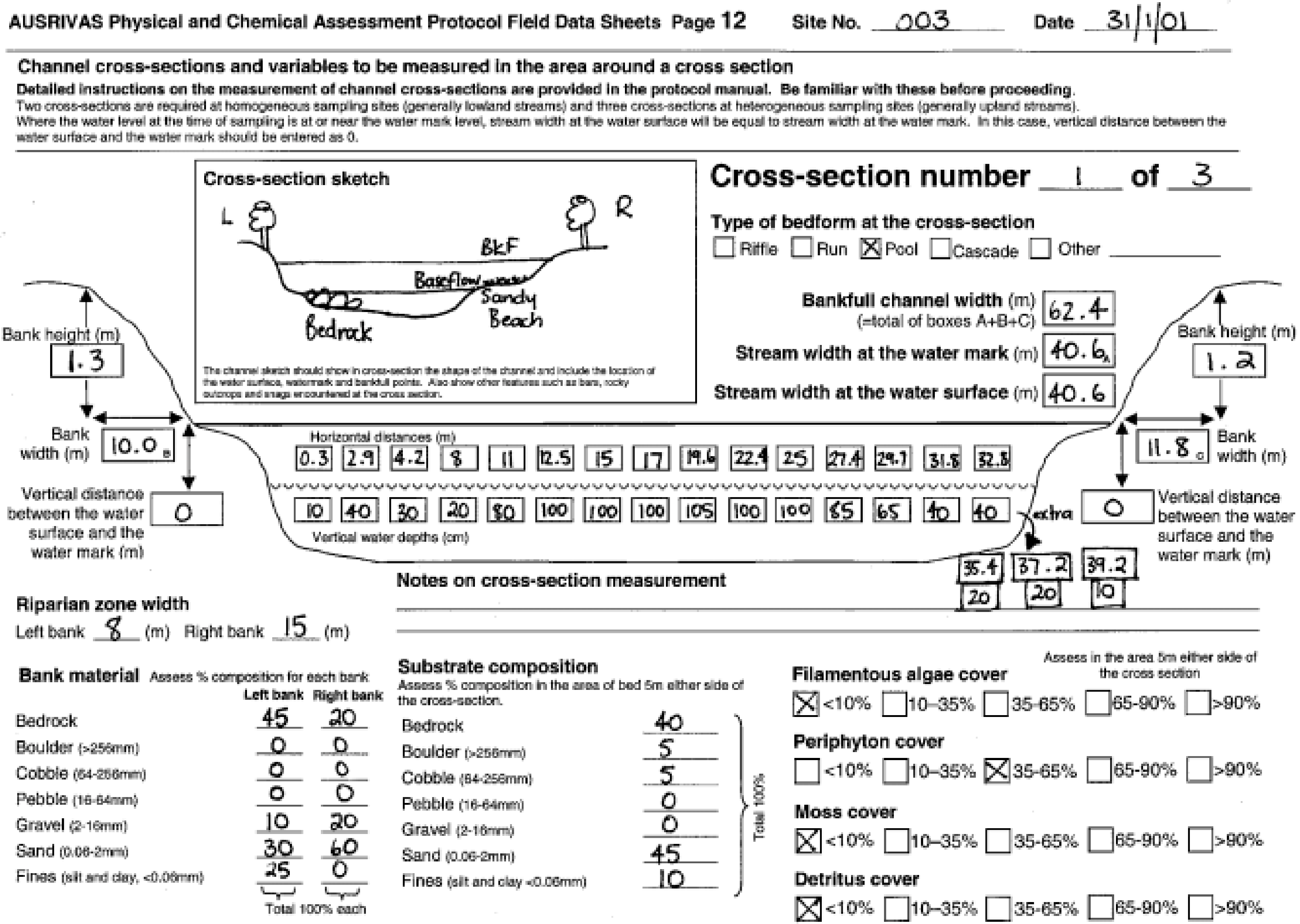
Page 2 of 2

Habitat parameter	Condition category			
	Excellent	Good	Fair	Poor
7. Channel sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note – channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas).	The bends in the stream increase the stream length 2 to 3 times longer than if it was in a straight line.	The bends in the stream increase the stream 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; 'raw' areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE	Left bank 10 9	8 7 6	5 4 3	2 1 0
SCORE	Right bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understorey shrubs, or non woody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimetres or less in average stubble height.
SCORE	Left bank 10 9	8 7 6	5 4 3	2 1 0
SCORE	Right bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian zone score (score each bank)	Width of riparian zone >18 metres; human activities (i.e. roads, lawns, crops etc.) have not impacted the riparian zone.	Width of riparian zone 12-18 metres; human activities have impacted the riparian zone only minimally.	Width of riparian zone 6-12 metres; human activities have impacted the riparian zone a great deal.	Width of riparian zone <6 metres; little or no riparian vegetation is present because of human activities.
SCORE	Left bank 10 9	8 7 6	5 4 3	2 1 0
SCORE	Right bank 10 9	8 7 6	5 4 3	2 1 0

n/a

TOTAL LOW GRADIENT HABITAT SCORE ☐

Example of a completed field data sheet (cont.)



AUSRIVAS Physical and Chemical Assessment Protocol Field Data Sheets Page 12 **Site No.** 003 **Date** 31/1/01

Channel cross-sections and variables to be measured in the area around a cross section

Detailed instructions on the measurement of channel cross-sections are provided in the protocol manual. Be familiar with these before proceeding.
Two cross-sections are required at homogeneous sampling sites (generally lowland streams) and three cross-sections at heterogeneous sampling sites (generally upland streams).
Where the water level at the time of sampling is at or near the water mark level, stream width at the water surface will be equal to stream width at the water mark. In this case, vertical distance between the water surface and the water mark should be entered as 0.

Cross-section sketch

The channel sketch should show in cross-section the shape of the channel and include the location of the water surface, watermark and bankfull points. Also show other features such as bars, rocky outcrops and snags encountered at the cross section.

Cross-section number 1 of 3

Type of bedform at the cross-section
☐ Riffle ☐ Run ☒ Pool ☐ Cascade ☐ Other ______

Bankfull channel width (m) (=total of boxes A+B+C) 62.4

Stream width at the water mark (m) 40.6

Stream width at the water surface (m) 40.6

Left bank:
Bank height (m) 1.3
Bank width (m) 10.0 A
Vertical distance between the water surface and the water mark (m) 0

Right bank:
Bank height (m) 1.2
Bank width (m) 11.8 C
Vertical distance between the water surface and the water mark (m) 0

Horizontal distances (m)	0.3	2.9	4.2	8	11	12.5	15	17	19.6	22.4	25	27.4	29.1	31.8	32.8	35.4	37.2	39.2
Vertical water depths (cm)	10	40	30	20	80	100	100	100	105	100	100	65	65	40	40	20	20	10

extra

Notes on cross-section measurement

______

Riparian zone width
Left bank 8 (m) Right bank 15 (m)

Bank material Assess % composition for each bank

	Left bank	Right bank
Bedrock	45	20
Boulder (>256mm)	0	0
Cobble (64-256mm)	0	0
Pebble (16-64mm)	0	0
Gravel (2-16mm)	10	20
Sand (0.06-2mm)	30	60
Fines (silt and clay, <0.06mm)	25	0
	Total 100% each	

Substrate composition
Assess % composition in the area of bed 5m either side of the cross-section.

Bedrock	40
Boulder (>256mm)	5
Cobble (64-256mm)	5
Pebble (16-64mm)	0
Gravel (2-16mm)	0
Sand (0.06-2mm)	45
Fines (silt and clay <0.06mm)	10

Total 100%

Assess in the area 5m either side of the cross section

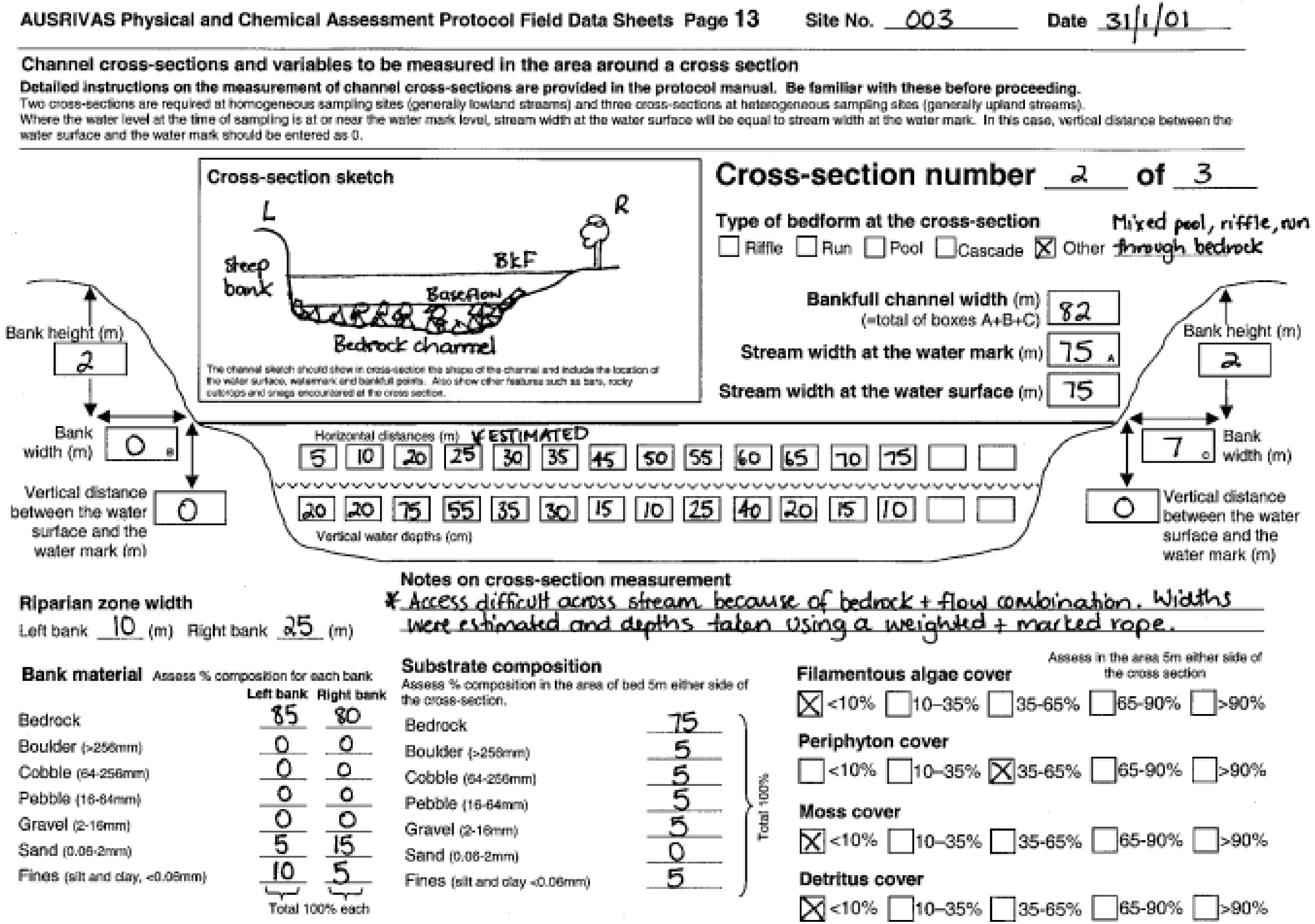
Filamentous algae cover
☒ <10% ☐ 10–35% ☐ 35-65% ☐ 65-90% ☐ >90%

Periphyton cover
☐ <10% ☐ 10–35% ☒ 35-65% ☐ 65-90% ☐ >90%

Moss cover
☒ <10% ☐ 10–35% ☐ 35-65% ☐ 65-90% ☐ >90%

Detritus cover
☒ <10% ☐ 10–35% ☐ 35-65% ☐ 65-90% ☐ >90%

Example of a completed field data sheet (cont.)



AUSRIVAS Physical and Chemical Assessment Protocol Field Data Sheets Page 13 **Site No.** 003 **Date** 31/1/01

Channel cross-sections and variables to be measured in the area around a cross section

Detailed instructions on the measurement of channel cross-sections are provided in the protocol manual. Be familiar with these before proceeding.
Two cross-sections are required at homogeneous sampling sites (generally lowland streams) and three cross-sections at heterogeneous sampling sites (generally upland streams).
Where the water level at the time of sampling is at or near the water mark level, stream width at the water surface will be equal to stream width at the water mark. In this case, vertical distance between the water surface and the water mark should be entered as 0.

Cross-section sketch

The channel sketch should show in cross-section the shape of the channel and include the location of the water surface, watermark and bankfull points. Also show other features such as bars, rocky outcrops and snags encountered at the cross section.

Cross-section number 2 of 3

Type of bedform at the cross-section
☐ Riffle ☐ Run ☐ Pool ☐ Cascade ☒ Other Mixed pool, riffle, run through bedrock

Bankfull channel width (m) (=total of boxes A+B+C) 82

Stream width at the water mark (m) 75 A

Stream width at the water surface (m) 75

Bank height (m) 2 — Bank width (m) 0 B — Vertical distance between the water surface and the water mark (m) 0

Bank height (m) 2 — Bank width (m) 7 C — Vertical distance between the water surface and the water mark (m) 0

Horizontal distances (m) *ESTIMATED

5	10	20	25	30	35	45	50	55	60	65	70	75		
20	20	75	55	35	30	15	10	25	40	20	15	10		

Vertical water depths (cm)

Notes on cross-section measurement
* Access difficult across stream because of bedrock + flow combination. Widths were estimated and depths taken using a weighted + marked rope.

Riparian zone width
Left bank 10 (m) Right bank 25 (m)

Bank material Assess % composition for each bank

	Left bank	Right bank
Bedrock	85	80
Boulder (>256mm)	0	0
Cobble (64-256mm)	0	0
Pebble (16-64mm)	0	0
Gravel (2-16mm)	0	0
Sand (0.06-2mm)	5	15
Fines (silt and clay, <0.06mm)	10	5
	Total 100% each	

Substrate composition
Assess % composition in the area of bed 5m either side of the cross-section.

Bedrock	75
Boulder (>256mm)	5
Cobble (64-256mm)	5
Pebble (16-64mm)	5
Gravel (2-16mm)	5
Sand (0.06-2mm)	0
Fines (silt and clay <0.06mm)	5

Total 100%

Assess in the area 5m either side of the cross section

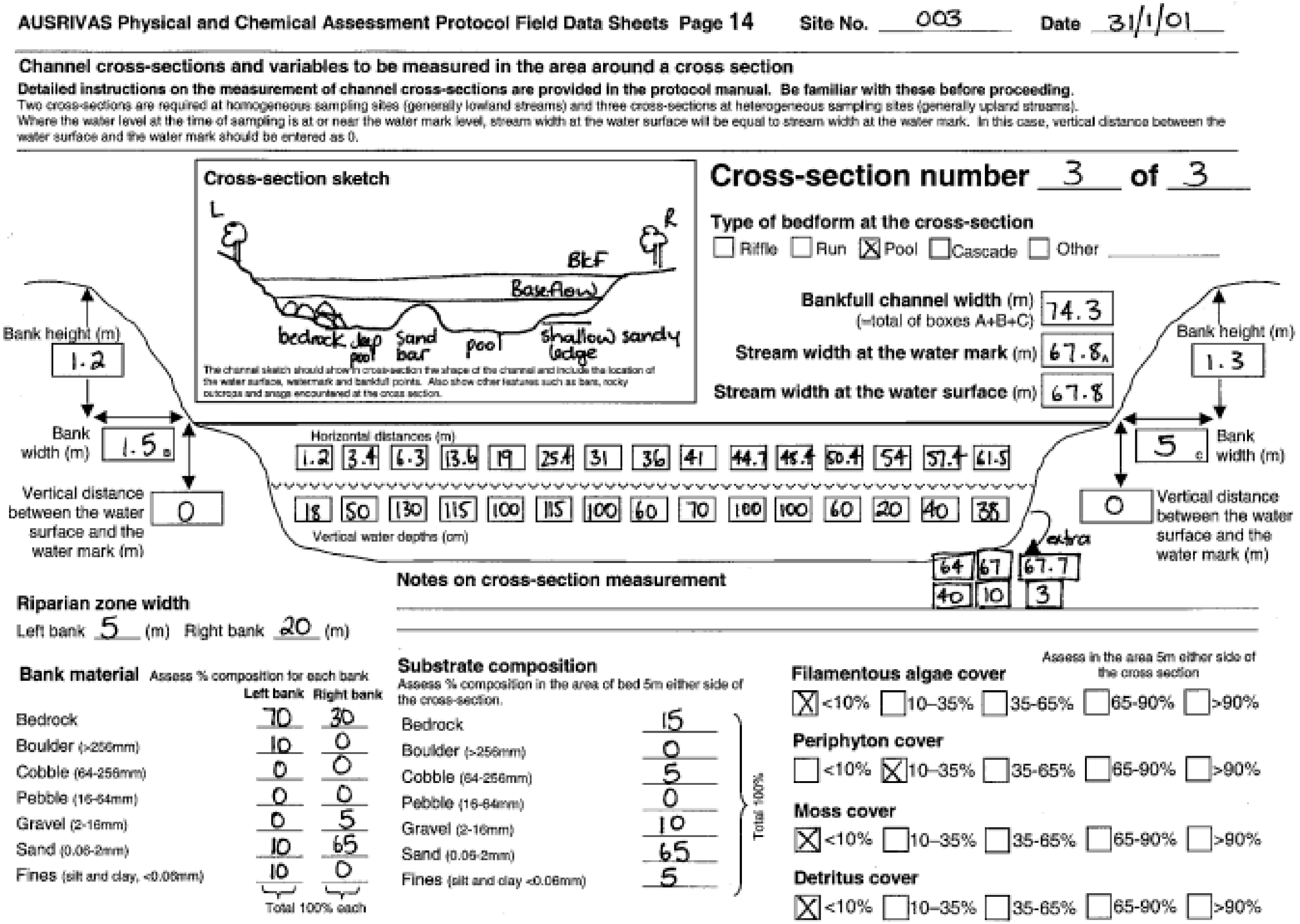
Filamentous algae cover
☒ <10% ☐ 10–35% ☐ 35-65% ☐ 65-90% ☐ >90%

Periphyton cover
☐ <10% ☐ 10–35% ☒ 35-65% ☐ 65-90% ☐ >90%

Moss cover
☒ <10% ☐ 10–35% ☐ 35-65% ☐ 65-90% ☐ >90%

Detritus cover
☒ <10% ☐ 10–35% ☐ 35-65% ☐ 65-90% ☐ >90%

Example of a completed field data sheet (cont.)



AUSRIVAS Physical and Chemical Assessment Protocol Field Data Sheets Page 14 Site No. 003 Date 31/1/01

Channel cross-sections and variables to be measured in the area around a cross section

Detailed instructions on the measurement of channel cross-sections are provided in the protocol manual. Be familiar with these before proceeding.
Two cross-sections are required at homogeneous sampling sites (generally lowland streams) and three cross-sections at heterogeneous sampling sites (generally upland streams).
Where the water level at the time of sampling is at or near the water mark level, stream width at the water surface will be equal to stream width at the water mark. In this case, vertical distance between the water surface and the water mark should be entered as 0.

Cross-section sketch

The channel sketch should show in cross-section the shape of the channel and include the location of the water surface, watermark and bankfull points. Also show other features such as bars, rocky outcrops and snags encountered at the cross section.

Cross-section number 3 **of** 3

Type of bedform at the cross-section
☐ Riffle ☐ Run ☒ Pool ☐ Cascade ☐ Other

Bankfull channel width (m) (=total of boxes A+B+C) 74.3

Stream width at the water mark (m) 67.8 A

Stream width at the water surface (m) 67.8

Bank height (m) 1.2
Bank width (m) 1.5 B
Vertical distance between the water surface and the water mark (m) 0

Bank height (m) 1.3
Bank width (m) 5 C
Vertical distance between the water surface and the water mark (m) 0

Horizontal distances (m)	1.2	3.4	6.3	13.6	19	25.4	31	36	41	44.7	48.4	50.4	54	57.4	61.5	64	67	67.7
Vertical water depths (cm)	18	50	130	115	100	115	100	60	70	100	100	60	20	40	38	40	10	3

extra

Notes on cross-section measurement

Riparian zone width
Left bank 5 (m) Right bank 20 (m)

Bank material Assess % composition for each bank

	Left bank	Right bank
Bedrock	70	30
Boulder (>256mm)	10	0
Cobble (64-256mm)	0	0
Pebble (16-64mm)	0	0
Gravel (2-16mm)	0	5
Sand (0.06-2mm)	10	65
Fines (silt and clay, <0.06mm)	10	0

Total 100% each

Substrate composition
Assess % composition in the area of bed 5m either side of the cross-section.

Bedrock	15
Boulder (>256mm)	0
Cobble (64-256mm)	5
Pebble (16-64mm)	0
Gravel (2-16mm)	10
Sand (0.06-2mm)	65
Fines (silt and clay <0.06mm)	5

Total 100%

Assess in the area 5m either side of the cross section

Filamentous algae cover
☒ <10% ☐ 10–35% ☐ 35-65% ☐ 65-90% ☐ >90%

Periphyton cover
☐ <10% ☒ 10–35% ☐ 35-65% ☐ 65-90% ☐ >90%

Moss cover
☒ <10% ☐ 10–35% ☐ 35-65% ☐ 65-90% ☐ >90%

Detritus cover
☒ <10% ☐ 10–35% ☐ 35-65% ☐ 65-90% ☐ >90%