

AUSRIVAS IN WESTERN AUSTRALIA

Manual for use of AusRivAS models for assessing river health in Western Australia.

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AusRivAS Website: <http://enterprise.canberra.edu.au/Databases/AusRivAS.nsf>

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BACKGROUND

Since European settlement anthropogenic effects on Australia's streams and rivers have been considerable. Sewage, detergents and agricultural run-off have altered nutrient balances and contributed to toxic algal blooms. Mine wastes have sometimes caused heavy metal pollution, acidification and sedimentation. Agricultural pest control has caused pesticides to enter waterways, while land clearing and deforestation have often caused sedimentation and salinisation. Other impacts include alteration of flow regimes through construction of dams, extraction of water for irrigation and thermal pollution from power plants. In addition, introduced biota have had deleterious effects on the ecological condition of rivers.

The degradation of Australia's rivers is widely recognised but, until recently, there was no coordinated effort to monitor or manage pollution and disturbance. The toxic blue-green algal blooms along 1000 km of the Darling river, New South Wales, in 1991 served to focus public and political attention on the condition of Australia's rivers, and following this, in December 1992, the Commonwealth Government announced a major new initiative to tackle the health and management of Australia's waterways. The initiative, known as the National River Health Program (NRHP) had three main aims:

- to monitor and assess the ecological condition of Australia's rivers,
- to assess the effectiveness of current management practices,
- to provide better ecological and hydrological data on which to base management decisions.

The NRHP has had two phases. The major component of the first phase, which commenced in 1993, was the Monitoring River Health Initiative (MRHI). The MRHI was a national program that used aquatic macroinvertebrates to assess the ecological condition, or health, of Australia's rivers. The primary aim of the MRHI was to develop models that predict the invertebrates likely to occur at an undisturbed site based on its geographic position and the habitat at the site. The predicted community is then compared with the actual community and the ratio of observed/expected families is used as a measure of ecological condition. The MRHI models are known as AusRivAS models (Australian River Assessment Scheme). AusRivAS is based on the British bioassessment system RIVPACS (River Invertebrate Prediction and Classification System), which also uses aquatic invertebrates and has been developed and refined during the past 15 years.

The second phase of the NRHP involved using AusRivAS models in the First National Assessment of River Health (FNARH). The FNARH commenced in 1997 and by late 1999 nearly 5000 sites throughout Australia had been biologically assessed. In Western Australia about 650 sites, throughout the State, were assessed, some several times in different seasons and years.

The rationale behind the use of macroinvertebrates as for river assessment is that they are highly sensitive to pollutants and changes in river flow and the condition of channels and floodplains. In addition, if the structure of the macroinvertebrate community is intact, it is likely that the important ecological functions of the river will be intact. Thus, bioassessment using macroinvertebrate communities provides the good measure of the ecological condition and health of a river.

From 1994-1997, the MRHI was administered by the Land and Water Resources Research and Development Corporation (LWRRDC), in collaboration with the Department of Environment, Sport and Territories (DEST). During 1998 Environment Australia (EA) took over the project with funding coming from the National Heritage Trust. While AusRivAS is an Australia-wide initiative being coordinated and funded by the Commonwealth Government, the program is being implemented by State and Territory Governments. The lead agency for the MRHI and subsequent FNARH in Western Australia has been the Department of Conservation and Land Management, with support from the Water and Rivers Commission.

Western Australian AusRivAS models are based on results of macroinvertebrate sampling at about 250 **reference** sites on rivers throughout the State. Reference sites were located, as much as possible, on undisturbed rivers, where an intact fauna and river ecology would be expected. In some regions, no such rivers occurred and least-disturbed sites were used as reference, although such reference sites were often discarded during the model-building process because of discrepancies in their fauna.

SAMPLING METHODS

The protocols described in this manual are mostly based on the methods in Davies (1994) but have been revised and modified to suit Western Australian conditions. This Western Australian protocol must be used to get valid outputs from the Western Australian AusRivAS models.

Sampling Frequency

There are two sampling windows in any one year for samples to be collected. These roughly coincide with base and recessional flows for the rivers concerned. In the north-west these times are: March - May for recessional flows and September - October for base flows. In the south-west recessional flows occur from August - October and base flows from December - February, with sampling later in the window being more appropriate at southern sites or in years of heavy rain. Sampling efficiency will usually decline markedly when streams are swollen owing to recent heavy rains and sampling should be deferred until after the spates have subsided (usually at least two weeks).

Fieldwork

A two-person team (minimum) is required for each sampling session for safety, to share sampling and picking tasks and transportation of field gear. There are two possible macroinvertebrate sampling protocols to follow. In this manual we emphasize use of live picking for 60 minutes to maximize the number of taxa collected (Davies 1994) but an **alternative** is to use a subsampler to obtain a **random** sample of 200 animals (see *Invertebrate Sample Processing* below).

Pondnets

All invertebrate sampling should be done with a standard 250 gm mesh pondnet. Recommended dimensions are 350 by 250 mm opening, 50 - 75 cm depth and with a 1 - 1.5 m handle. Net contents are less likely to reflux, in sites with high flow, from nets with longer 'tails'. The net should be checked for holes prior to a sampling trip and washed thoroughly after sampling each habitat to remove animals left from previous sampling.

Habitats

Sampling should be conducted in an area at the centre of a study reach whose length is 50m upstream and downstream of the point of entry. The predominant habitat types should be identified at each site (these may be channel, riffle, macrophytes, pool rocks, logs/sticks etc) and sampling should be restricted to the habitats for which models exist. In Western Australia, reliable models exist only for Channel, although Macrophyte models are available too. We recommend sampling Channel habitat wherever possible. Sampling of a distinct habitat type is prescribed because each habitat has a potentially distinct fauna and the performance of the predictive models will be confounded if several habitats (or the wrong habitat) are used.

Channel habitat is defined as the central part and margins of the main channel of a stream, without riffles, submerged macrophytes or pool rocks. Areas of areas of emergent sedges and shrubs along the banks should be avoided. Some sampling must occur in the central channel but, if possible, sampling should also occur along bare stream edges. Detritus and leaf packs should be sampled if they occur in the central channel and edges.

Macrophyte habitat consists of areas with submerged vegetation, usually in the central part of the channel, and fringing emergent vegetation on the stream banks. Emergent vegetation may consist of sedges or shrubs growing in the water or draped into it.

Collecting the Invertebrate Sample

Channel: wash the net. Vigorously sweep the net through the water column using short vertical lifts to disturb the substrate and catch the suspended organisms. Dig shallowly into surface sediment with forward movement of the net and then sweep through suspended substrate. If the substrate is stony and flow is fairly strong, then kick sampling may be appropriate - place apex of net on the substrate downstream of sampler. Face the net and work backwards upstream, dislodging cobbles and other substrate by kicking with your heels.

Macrophyte: wash the net. Vigorously sweep the net within the aquatic vegetation over a length of about 10 m. Aim to sample the upper, middle and lower portions of the plants. A combination of short lateral sweeps with vertical lifts will aid in dislodging and catching suspended organisms.

If net begins to fill with detritus/cobbles etc, and a pressure wave is created in front of it when sweeping, empty the net into a 20 L bucket. Continue sweeping/kick sampling until the full 10 m sample has been taken, perhaps emptying the net into the bucket several times. This improves efficiency of sampling. Alternatively, wash large pieces of debris in net and then discard after checking that no animals remain on the debris. Remember that net contents will be lost if the net snags on an obstacle in the stream that checks forward movement.

Invertebrate Sample Processing

Two methods can be used to sort macroinvertebrates: 60-minute picking or subsampling. With both methods, all sorting is at the site while animals are still alive. Current Western Australian AusRivAS models are based on 60-minute picking and models outputs based on the 60-minute pick should have more validity than those based on subsampling. However, recent testing suggests subsampling distinguishes pristine and disturbed sites more readily than 60-minute picking. Subsampling is much slower in forest sites where animal abundances are low, but faster in enriched agricultural sites.

60-minute Picking

Empty the contents of the net into a bucket of water and swirl vigorously to separate the mineral substrate from the organic component of the sample. This may need to be repeated several times, with water and organic contents being poured through a stack of four sieves with mesh apertures of 16mm, 2mm, 500 μ m and 250 μ m (the coarsest sieve should be on top). After elutriating the sample, agitate the stack of sieves in the water column to separate the contents into the four size fractions. Empty each of the four fractions into separate large white sorting trays (> 4 trays may be required). Separating the samples into the various size fractions facilitates the picking process by refining the search image of the collector.

The sample must be picked by two collectors for a total of 60 minutes (ie 30 minutes by each collector). Allocate picking effort to each tray proportional to the amount of material it contains. Typically, the larger fractions (16mm and 2mm) are picked for longer (eg 9 minutes by each collector) with less time being allocated to the smaller fractions (500 μ m and 250 μ m - 6 minutes each).

Remove animals from the trays using forceps and/or a pipette and store in a vial containing 70% alcohol (a clear 250 ml vial is ideal). The aim of the sampling process is to maximize the diversity of animals collected. Start by collecting common, abundant taxa for about the first 5 minutes. After that, the major picking effort should be directed at finding the less common, inconspicuous taxa. Avoid over-picking large or colourful taxa. Aim for a total of 200 animals (use a hand-held counter) with maximum diversity. There is no need for large numbers of any single taxon but a minimum of 30 chironomids should be picked from every sample to ensure that all the sub-families are represented in the vial. Estimate and record log abundance of each family, or order, **in the whole sample** on *Assessment Sheet 2 - Each*

Habitat (see below). The aim is to derive an estimate of the abundance of each family but some families will not be recognized until under the microscope and their abundance estimate will have to be derived from estimates of order-level abundance. The AusRivAS models use only presence/absence data but information on abundance may help with interpreting the outputs of the AusRivAS models.

Particular care should be taken to search for the groups that are commonly missed when live sorting (ie cryptic taxa): elmidae larvae, Oligochaeta, Empididae, Hydroptilidae, small molluscs (search the tray after tipping out contents at completion of picking) and Ceratopogonidae.

Do not forget to put a label in the vial, giving site, habitat, date and other important details.

Subsampling

Empty the contents of the net into a bucket of water and swirl vigorously to separate the mineral substrate from the organic component of the sample. Remove cobbles and large pieces of wood and other debris, after washing carefully to remove any animals. Either elutriate into another bucket to separate the organic and sand fractions or use sieves as for 60-minute picking. The aim of this pre-sorting is to remove all large pieces of debris that are too large to fit into a cell in the subsampler without losing animals.

After cleaning the sample, empty into a box sampler, agitate the sample and then remove the contents of one randomly selected cell into a sorting tray. (The animals can be easily removed using a hand vacuum pump and conical flask - see Fig. 1). Pick out all animals from the tray (ie all animals that were in the cell) using forceps and/or a pipette and store in a vial containing 70% alcohol. Count the number of animals with a hand-held counter. Empty contents of another randomly selected cell into the tray and pick out all animals until a total of 200 animals has been collected (this will require 3-5 cells in enriched sites and > 70 cells in some pristine sites so that a second sample may need to be collected). The purpose of this method is to obtain a random sample of animals to accurately reflect community structure. All animals in a cell must be picked out but, because the cell contains only a small amount of material in a large sorting tray, picking is relatively easy. Nevertheless care should be taken to ensure no cryptic individual animals are missed (see *60-minute Picking*).



Figure 1. Box subsampler. Sample is being sucked out of a randomly selected cell into conical flask using vacuum created with hand pump (out of sight)

Invertebrate Sample Identification and Enumeration

In the laboratory, tip the contents of the vial into a large petri dish. Place the petri dish under a dissecting microscope which is correctly adjusted for your vision and work posture (refer to manufacturer's instructions). Most identifications will be done with a dissecting microscope but occasionally a compound microscope will be required.

A dedicated tally sheet should be developed for recording the identities and numbers of all taxa in a sample. It should have fields for site code, date and the person making the identifications, as well as for listing the taxa (usually orders) recorded in the field. A sample sheet is shown in Appendix 5.

Organisms should be identified to family level with the exception of oligochaetes (worms) and acariniids (mites), which are left at order level. Chironomids (midges) are taken to subfamily. Ignore all microcrustacea (ostracods, copepods, cladocerans) but include conchostracans and anostracans. Recommended taxonomic keys are listed in Appendix 3. Select specimens and follow the appropriate keys to family level. If uncertain about the identity obtain a second opinion from a colleague/local specialist. If a family new to the region is suspected, or other significant problems arise in taxonomic identification, contact a national taxonomic specialist.

When each specimen has been confidently identified, mark one stroke in the tally column of the data sheet, place the specimen in a properly labelled vial and examine the next specimen. When all specimens have been counted, add the tally for each taxon and write the total in the appropriate column on the data sheet. Place the vial, filled with preservative, in an evaporation proof box in a suitable storage location.

Physical and Chemical Sampling

A total of 44 physical and chemical variables are recorded for each site (see Appendix 2). Many of these variables are not used in models but contain diagnostic information about site condition. If you intend omitting data for some variables, check the appropriate AusRivAS model(s) on the Website to make sure these are not predictor variables. Models cannot be run if predictor variable data are missing.

Five assessment sheets need to be filled in at each site where the AusRivAS protocols are being used. Most of the information relates to chemical and physical habitat assessment. The process is briefly described, although the sheets are largely self-explanatory and information about the definition of categories to be used is found either on the sheets or in Appendix 5. Only fields likely to cause confusion are covered below in a description of each sheet.

Water Samples

Water samples should be collected just upstream of the biological sampling area (and of the water sample collector!). Two water samples are taken. The first is a 250ml sample for the determination of colour, alkalinity, turbidity and total nutrients (the sample should be cooled if stored for more than a couple of weeks). The second is a 125ml sample for different forms of dissolved nutrients. This must be filtered through a 0.45µm filter and then frozen. Water sample bottles should be pre-washed with a nutrient-free detergent such as Extran. Label samples with site name, code, date and parameters to be measured. Temperature, conductivity, pH dissolved oxygen and flow are measured *in situ* at each site with hand-held meters.

Site Sheet

Site No - unique code used on site labels etc. Often alphanumeric (operator initials plus sequential sample number may be a useful system).

Site Name - name of site on river (should use a name that identifies the site rather than the river that it is on).

SOE - does not need to be filled in. Is for agency purposes (is the site used for SOE reporting?).

River System - the name of the AWRAC river basin to which the site belongs (maps of these basins are available from Water and Rivers Commission).

River Name - name of the particular river or stream sampled.

IBRA region - mostly for agency purposes. Regions are listed on the sheet (it is a biogeographic regionalisation scheme for the whole of Australia).

Latitude/Longitude - use degrees, minutes, seconds.

Altitude - derive from topographic map (may need to interpolate).

Slope - estimate the slope of the river section containing the site. Use topographic map and estimate using contour lines.

DFS (Distance from Source) - use map to calculate distance of the site from its headwater

Flow pattern category - see bottom of sheet for categories (refers to period of **flow**, not length of time water is present).

Discharge category - needs to be calculated by an agency (macros are available to do the calculation if catchment area, rainfall and runoff coefficients known). Categories used listed in Appendix 5.

Av. annual rainfall - use isohyet information and interpolate.

Site description - short account of main features of site and any unusual characteristics that may affect its condition or the assessment of condition.

Access Sheet

Maps used - provide the sheet numbers of maps used (eg World Aeronautical Chart 1:1,000,000 - Halls Creek).

Land tenure - whether freehold, reserve, national park etc.

Contact - list person to contact prior to visit (to request permission, as courtesy etc).

Position - the position of the contact person (eg owner, manager, ranger).

CALM region/district - CALM administrative region in which site occurs (important to know since it identifies the office you should contact if site is on CALM land).

DRA permit - is the site in a dieback-infected area that requires a permit for access (this applies to much State Forest and National Park in the south-west)? Permits are available from local CALM office.

Schematic diagram of reach - note important features that the next person can use to guide them to sample the same areas. Show the parts of the reach where samples taken.

Access sketch - this should show mileages from named roads, landmarks, and clear instructions about which tracks to take. Also show other useful features to guide a person **exactly** to the site. Most access sketches are incomplete and inadequate. Take time to prepare a proper map based on details recorded as you drive to, or from, the site.

Assessment Sheet 1 - Whole Site

Round No - agency purposes (refers to the sampling round in whole program).

Season - choice is wet or dry season as defined in section on *Sampling Frequency* (above). However, you may want to make some comments on prior rain and the type of season (very wet/drought) in the *Comments* field on this sheet.

Mean river width - width of the wetted river channel in the area sampled (average of three measurements).

Site type - principally for agency purposes but see box at bottom of sheet for categories.

Landuse - see box at bottom of sheet for categories.

Impacts - see box at bottom of sheet for categories. Two impacts can be listed but only list an impact if it is likely to be affecting the health of the river (don't fill these fields in just for the sake of it).

Water chemistry - measure pH, temperature and conductivity about 15 cm below the surface and take water samples from the same depth.

Habitats present - list the habitats present provided they cover >5% of reach.

Assessment Sheet 2 - Each Habitat

A separate sheet should be filled in for each habitat sampled (ie if both channel and macrophyte habitats are sampled, two sheets should be completed).

Sample collected by - show who collected the invertebrate sample (and who picked it in the adjacent field).

Mineral substrate - estimate visually the percentage of the riverbed covered by each category (some AusRivAS models use information derived from these measurements as predictor variables, although the measurements themselves are not used).

Habitat surface area - estimate visually the percentage areal cover of each category and its density [eg algae may cover 10% of substrate very densely (5) or sparsely (1)].

Depth - this is the average depth where the macroinvertebrate sample was collected.

Flow - both maximum and minimum flow should be measured. Maximum flow will usually be about halfway through water column in a fast-flowing area. The datasheet assumes a flow meter with a propeller has been used, which is not always the case, so some fields may be redundant. Make sure the velocity (with units of **cm/sec**) is recorded.

DO - measure about 15 cm below surface (top) and near the riverbed (bottom). Express as percentage saturation.

Taxa collected - after picking invertebrates out of the sample, record all groups collected (as best can be identified in the field) and their 'log' abundance (see categories of abundance at bottom of sheet) in the **whole sample**.

Physical Habitat Assessment Sheet 3

This sheet tries to quantify the condition of the physical habitat around the stream. There is information in each component but, at this stage, more emphasis is placed on the total score than the score for individual categories. Some guidance to assessment is given below, bearing in mind that the suggested scores are indicative and may need to be modified to cater for unusual conditions.

Degree of naturalness - your feeling about the naturalness of the site, ranging from pristine to totally altered

Catchment condition - score according to what you know (and can see on maps) of the extent clearing and type of land use

- Fully cleared for intensive agriculture/urbanisation gives low score (ca. 2)
- Part cleared for grazing etc gives moderate score (ca. 9-10)
- Part in plantation or recently logged, part uncleared gives pretty high score (ca. 15)
- All forest but some past logging gives high score (ca. 16-18)

Landuse at site - base assessment on what is occurring within 500 m either side of channel and about 1 km upstream. Score according to likely impact of the different activities with

- Intensive agriculture/housing/industry having low scores (ca. <4)
- Plantations having moderate scores (ca. 5-7)
- Old forest or uncleared bush having high scores (ca. 9-10)

Physical habitat - score physical habitat heterogeneity with mix of boulders, pebbles, sand etc scoring well and silt with low score. Lowest scores for bedrock (ie as shown on sheet)

Biological substrate - score as shown on sheet

Vegetative protection - score on condition of the riparian vegetation and intactness of all layers.

- Dense tree, shrub, sedge/grass vegetation with no weeds or disturbance gets high score (ca. 9-10)
- Good tree vegetation but no understorey gets moderate score (ca. 4-5)
- Few scattered trees gets low score (ca. 2-3)

Width of riparian vegetation - score on width and unbrokenness (ie deduct points if tracks come in)

- 500m unbroken gets high score (ca. 10)
- 50 m unbroken gets fairly high score (ca. 8)
- 10 m gets fairly moderate score (ca. 4-5)
- 5 m gets poor score (ca. 2)

Bank stability - score how much erosion has occurred and how likely the bank is to release sediment

- well vegetated sloping banks will get high scores
- upright or undercut banks with evidence of soil erosion will get low scores
- obvious tree/shrub roots holding soil in place may increase score in some bare-soil banks

Sediment deposition - assess the amount of sand/silt that has settled on stream bed

- boulder, cobble bed with minimal sand gives high score (ca. 19-20)
- some silt or sand deposits in slow flowing parts of channel gives moderate score (ca. 10-13)
- large soft sand deposits (rather than hard sand) or silt deposits give low score (ca. <4)

Impoundments etc - score on likely effect, proximity and number of these impacts

- immediately below dam that has dramatically reduced flow gives low score (ca. 0-1)
- in a section of channelised river gives lowish score (ca. 5-6)
- below pump extracting water depends on likely effect of flow, usually score ca. 10
- if impacts occur well upstream of site, assess likely cumulative impact (ca. 11-18)

QA/QC

Invertebrate Identification. The first 20 samples identified by a new operator should be re-identified by an experienced operator. Thereafter, 5 % of samples are to be checked (these samples are chosen at random and without prior warning). If errors are found, there should be further re-identification of any family pairs where consistent errors are likely to have occurred (ie if QC has shown that an operator confuses families A and B, all recent identifications of A and B are checked again).

Invertebrate Identification. It is much easier to prevent errors than find and correct them. Whenever an operator is unsure of the identification of an animal, he/she should ask another operator for assistance and they should do the identification together. If the family has not been recorded previously, the specimen may need to be sent to a taxonomic specialist for confirmation.

Data Entry. All biological, habitat and chemical data entered for each site should be printed out from the database and checked against original datasheets as the site is processed.

Habitat and Chemical Data. The database should be scanned for erroneous habitat and chemical values (as a result of meter errors, recording errors etc) using logical checks. This process can be automated and done regularly or done manually prior to analysis. Extreme values (detected as outliers when checking data distributions) should be validated.

Live-picking. Live-picking is prone to error and taxa that are likely to be overlooked are listed in the *60-minute Picking* section. All samples should be picked by two operators, with at least one being experienced, to minimise picking bias across operators. At the conclusion of picking, operators should compare the list of taxa each has picked. Unusual taxa should be shown to each other and, if one operator is missing taxa, the other should point them out when encountered in subsequent samples.

Sample residues. It may be necessary to preserve residues (after like-picking or subsampling) for external quality control or for an internal check of picking efficiency and error. Ascertain requirements prior to fieldwork.

HOW AUSRIVAS MODELS WORK

The AusRivAS models predict macroinvertebrate communities that would be expected to occur at test sites in the absence of impact. These predictions are derived from the 250 or so **reference sites**, which are assumed to have an undisturbed invertebrate fauna, sampled throughout Western Australia. Various environmental variables (the **predictor variables**) are used in each model to determine the group of reference sites to which a test site is most similar in terms of river size, landscape setting etc. If the test site is unimpacted, it should support very similar invertebrate families to those at the appropriate group of reference sites.

The model compares the invertebrate families predicted occur at the test site (really the list of families occurring at the equivalent reference sites) with those actually collected at the site. This gives an *O/E* score, which is a measure of the ecological condition of the site. If $O/E = 1$, the test site contains the same families as undisturbed sites with the same stream characteristics and is assumed to be in good condition. If $O/E < 1$, some families have probably been lost and the site is assumed to be degraded to some extent.

The first step in running a model is to enter the appropriate biological and habitat data from the test site under investigation. The model then performs preliminary analyses to determine whether that the test site falls within the experience of that model (ie whether the site is in the right region, was sampled at the right time, and can be matched with the reference sites in the model dataset). If the test site passes the validation procedure, the probability of the test site belonging to each reference site group is calculated using the predictor variables.

The method for calculating the expectation that a family will occur at a test site (ie its *E* value) is given in Table 2.

Table 2. Calculation of the probability of a family X occurring at a test site. Combined probability that taxon X will occur at Site Y = 76.5 %.

Reference Site Group	Probability that test site belongs to each Group	Frequency of family X in each Group	Contribution to probability that Family X will occur at the test site
A	0.50	0.90	0.450
B	0.30	0.70	0.210
C	0.15	0.60	0.090
D	0.05	0.30	0.015
Probability that Family X will occur at the test site			0.765

AusRivAS models only consider families with probability of ≥ 0.5 of occurring at a test site when calculating the overall *O/E* score of a site. If families with < 0.5 probability of occurrence are used, the list of predicted taxa is larger but the sum of the probabilities of those predicted (ie *E*) remains similar because families with low probabilities of occurrence contribute little to the list of expected taxa. However, there is a greater chance of stochastic fluctuations in the number of observed families (ie *O*) because of random events, introducing more error into assessments.

USING AUSRIVAS VIA THE INTERNET

The AusRivAS predictive models are run in a Windows 32 bit application and presented in a spreadsheet format. AusRivAS requires a minimum of 16Mb RAM. Data can easily be imported from ASCII files or entered manually if the user prefers. Output from the AusRivAS models can be viewed on screen or exported for inclusion in reporting documentation. Outputs range from simple single number indexes suitable for school and community groups through to more comprehensive information for detailed ecological assessments.

Gaining Access

AusRivAS models can be downloaded from the Internet and opened for perusal by anyone with Internet access. However, an authorised access code is required to run the models. **To receive an access code an application must be lodged with Dr Stuart Halse, Department of Conservation and Land Management.** Codes are then issued by the University of Canberra. To download AusRivAS to your computer click on the "Download AusRivAS" link found on the AusRivAS homepage (<http://AusRivAS.canberm.edu.au/AusRivAS/>). A box listing downloading options will appear. Click on the 'save to disk' option and then indicate which directory you wish to save the compressed file to. Decompress the file (eg. AusRivAS1p.zip) into an empty directory. This will create an install directory in which will be the AusRivAS setup program (i.e. setup.exe). Run the setup program and the Install Shield will run you through the installation procedure. If you follow all the default settings during installation an AusRivAS icon will be placed in the Start button - Programs menu.

Getting Started

To open AusRivAS click on the AusRivAS icon. The AusRivAS program will open as a series of labelled overlying sheets with a toolbar across the top of the page and a status indicator at the base. The first two sheets are for the entry of the invertebrate and habitat data from your test sites. The remaining sheets will contain various outputs from the model once it has been run. The toolbar includes some standard Windows menu items along with a few new ones for importing and exporting text format data.

Choosing a model

Choice of model is determined by the season in which data were collected and the habitat sampled (we recommend Channel). Note that models cannot be run with missing habitat data (ie if the appropriate physical variables have not been measured). The habitat variables required by AusRivAS models can be located in the 'view' menu in the AusRivAS package. From June 2001, six models will be available. They are:

Habitat	Data type	Season	Date of commission
Channel	Presence/Absence	Spring, Summer, Combined season	2001
Macrophyte	Presence/Absence	Spring, Summer, Combined season	1997

Entering Data

AusRivAS requires the use of specific codes for the invertebrate taxa and habitat variables. These codes can be available through the website. AusRivAS will open on the invertebrate data sheet. To import your invertebrate data file, click on the file menu and select import or hit the import button on the toolbar. A box listing possible file formats and attributes will appear. Tick the option boxes that describe the text file you wish to import and click OK. A directory box will open allowing you to select the file to be imported. Click open, and your data will appear on the invertebrate sheet with taxa listed across the top and site codes listed down the side. AusRivAS will highlight any cells with missing data, taxa that have incorrect codes and taxa that are not covered by the models. If these errors appear they can be rectified easily by

either entering the correct values directly into the invertebrate sheet or by deleting, any columns containing invalid taxa. To delete a column click in the header box of that column and the column will be highlighted. Next click on the edit menu and select remove column, the selected column will be deleted. Data can also be entered directly onto the invertebrate sheet. To enter the invertebrate names and site codes double click on the desired header box. A cursor will appear allowing the headers to be entered. To enter the data simply click on the desired cell. If at a later date you wish to modify an entry, a single click will allow replacement of an entry while a double click will allow the entry to be modified. Once the invertebrate data has been entered click on the tab at the bottom of the screen for the physical/chemical sheet. A blank sheet will open for entering the physical and chemical variables required to run the model. To import the file containing your physical and chemical data follow the same procedure used for the invertebrate data. As for the invertebrate data, incorrect variable spelling, variables not recognised by the model and missing data will be highlighted.

When your data entry is complete click on the 'run model' menu. A box requesting your user access code will appear. Enter your access code and click 'next'. Select the State or Territory your test sites were sampled in and click 'next'. Now select the season or seasons your test sites were sampled in and click 'next'. Finally, select the habitat your test sites were collected from and click 'finish'. AusRivAS is now running.

AusRivAS is running

The first step AusRivAS will perform is validating your data. Typical errors will be missing data, incorrect invertebrate codes, misspelled habitat variable names, missing invertebrate taxa and missing predictor variables. If AusRivAS detects any errors in the variable names or in the data, the program will stop and the list of detected errors will appear. Once the errors have been corrected the model can be resumed. If your data are free of errors AusRivAS will then check if the test data are within the experience of the model you have chosen. That is, are there suitable reference sites with which your test sites can be compared? If the wrong model for the season of sampling was chosen or the model has no suitable reference site with which to compare the test data AusRivAS will stop and a box listing the problems will appear. If your data pass the validation checks AusRivAS will proceed to the predictive calculations.

There are three steps involved in deriving the predictive calculations. First, the probability of group membership for your test sites will be calculated. Second, the individual taxon probabilities of occurrence at each test site will be calculated. Third, these results are then used to produce the *O/E* scores. The outputs from the above steps are presented on separate sheets that are opened by clicking the name tab at the bottom of each sheet.

AusRivAS OUTPUTS

Group Probabilities Sheet

The first AusRivAS output sheet, labelled group probabilities, lists the probability of your test site belonging to each of the reference site classification groups. This output is used to determine the group of reference sites to which your test site is most similar in physical and chemical character.

Family Probabilities Sheet

This sheet lists the probability of each family used by the model being found at a tested site. Families that were actually collected at the test site are flagged (>). This output can be used to determine what taxa you would expect to find at the test site and whether they were actually collected. A family with a 0.12 probability of occurrence that was not collected would be no cause for concern because it would rarely be found, even if the site were equivalent to reference. However, if a family with 0.95 probability of occurrence were not collected, it is reasonable to assume that some impact may have caused its absence. Biological information about that taxon may then provide a clue to the type of impact the test site could be experiencing and provide a focus for further investigation.

Predicted/Collected Sheet

The *O/E* ratio sheet provides an assessment of biological condition of a test site. The number of families expected at a test site are compared to the number collected giving an *O/E Family* ratio. In addition to family numbers, this sheet compares the *O/E SIGNAL* (Stream Invertebrate Grade Number - Average Level) scores at each test site. SIGNAL is a system that grades invertebrate families on their sensitivity to pollution. Highly sensitive families score a 10 while highly tolerant families score 1 but, at this stage,

caution should be used when interpreting *O/E SIGNAL* in Western Australia. Many families are tolerant in the west and the current *SIGNAL* index, which was based largely on eastern Australian data and undisturbed sites, needs further modification to improve its usefulness.

Note that the *O* (observed) portion of these *O/E* ratios refers only to families that were predicted to occur in the sample and were recorded. Families that were recorded in the sample, but were not predicted, are not included in the *O/E* indices. Such 'unexpected families' may provide additional diagnostic information for interpretation by expert biologists but there is no simple method of incorporating them into an index. Unexpected families occurring in a sample are listed in on the 'unused taxa' sheet output of AusRivAS.

Both *O/E* indices have a minimum value of 0 if none of the families expected in a sample were found. Values <1 indicate either that some of the expected families were not collected (*O/E Families*) or that the suite of families collected was, on average, more tolerant of pollution than expected (*O/E SIGNAL*). In either case, impairment of the invertebrate community could reasonably be inferred. However, in practice a value less than 1 could result from chance variations in the families captured, or inevitable statistical uncertainty in the model predictions. Therefore, impairment is inferred only if values are sufficiently < 1 for chance factors to be unlikely.

A value > 1 indicates that more families were found than were expected (*O/E Families*) or that those found were, on average, more sensitive than expected (*O/E SIGNAL*). There are three potential explanations for index values >1. First, chance factors may result in more families being collected than expected. Differences between operators in invertebrate sampling efficiency fall into this category. Second, the site may have unusual microhabitat or other ecological features that permit the coexistence of more families than expected. Third, the site may be disturbed by human activities in such a way as to allow additional families to establish. An example of such a disturbance is a mild increase in nutrient levels, which can sometimes result in invertebrate communities that are more abundant or diverse than those that would occur naturally.

The two *O/E* ratios (*Families* and *SIGNAL*) can be used in combination to provide a measure of biological impairment at the test site. To simplify interpretation and to aid management decisions, both *O/E* indices can be divided into bands representing different levels of biological condition (Table 5). The width of the bands is based on 10th percentile *O/E* scores of reference sites used to create the model. The Band for each site is listed in the last column on the *O/E Ratios* sheet.

Table 3. Division of the indices into bands or categories for reporting. The label column gives a general interpretation of the meaning of each band, the *O/E* columns give the meaning for *Family* and *SIGNAL* indices.

Band	Label	<i>O/E Families</i>	<i>O/E SIGNAL</i>
X	Richer than reference	More families found than expected. Potential biodiversity 'hot-spot'	Greater <i>SIGNAL</i> value than expected reference. Differential loss of pollution-tolerant taxa (potential impact unrelated to water quality)
A	Equivalent to reference	Index value within range of central 80% of reference sites	Index value within range of central 80% of reference sites
B	Below reference	Fewer families than expected. Potential impact either on water quality or habitat quality	Lower <i>SIGNAL</i> value than expected. Differential loss of pollution-sensitive families
C	Well below reference	Many fewer families than expected Loss of families due to substantial impacts on water and or habitat quality	Potential impact on water quality Much lower <i>SIGNAL</i> value than expected Most expected families that are sensitive to pollution have been lost
D	Impoverished	Few of the expected families remain. Severe impact	Substantial impact on water quality Very low <i>SIGNAL</i> value. Only hardy, pollution-tolerant families remain

Extracting AusRivAS Outputs

Each of the AusRivAS output sheets can be exported separately as a text file by selecting the desired sheet and using the 'export' function in the file menu or the export button on the toolbar. A box will appear listing format options for the exported text file. Select the desired option and click 'OK'. A box

enabling you to name the text file and save it to a specified directory will then appear. Name the file, select a directory and click 'save' to complete exporting.

Appendix 1

FURTHER READING

Chessman B.C. (1995) Rapid assessment of rivers using macroinvertebrates- a procedure based on habitat specific sampling, family level identification and a biotic index. *Australian Journal of Ecology*, **20**, 122-129.

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Appendix 2

Environmental variables measured at each site.

Site variables

Latitude

Longitude

Altitude (m Australian Height Datum)

Slope (m km⁻¹)

Distance from source (km)

Discharge category (I - 6)

Flow pattern (I - 4)

Mean river width (m)

S

Water chemistry variables

PH

Temperature (°C)

Conductivity (µS cm⁻¹)

Dissolved oxygen (% saturation)**

Colour (TCU)

Alkalinity (mg L⁻¹ CaCO₃)

Turbidity (NTU)

Nitrogen ammonia fraction (mg L⁻¹)

Nitrogen nitrate&nitrite fraction (mg L⁻¹)

Total nitrogen (mg L⁻¹)

Soluble reactive phosphorus (mg L⁻¹)

Total phosphorus (mg L⁻¹)

Habitat variables*

Substrate characteristics*

Bedrock (% bedrock)

Boulders (% boulders > 256 mm)

Cobbles (% cobbles 64-256 mm)

Pebbles (% pebbles 16-64 mm)

Gravel (% gravel 4-16 mm)

Sand (% 1-4 mm)

Silt (% <1 mm)

Clay (%)

Habitat characteristics*

Habitat area (% area of the habitat within 10m reach)

Mineral substrate (% cover within habitat)

Emergent macrophyte (% cover within habitat)

Emergent macrophyte density (1-5; 1=sparse, 5=dense)

Submerged macrophyte (% cover within habitat)

Submerged macrophyte density (1-5; 1=sparse, 5=dense)

Floating macrophyte (% cover within habitat)

Floating macrophyte density (1-5; 1=sparse, 5=dense)

Algae (% cover within habitat)

Algae density (1-5; 1=sparse, 5=dense)

Detritus (% cover within habitat)

Detritus density (1-5; 1=sparse, 5=dense)

Riparian vegetation (% cover within habitat)

Maximum Flow (cm s⁻¹)

Minimum Flow (cm s⁻¹)

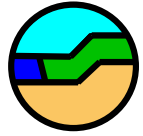
Mean depth (1-5; 1 < 25cm; 2 < 50cm; 3 < 100cm; 4 < 200cm-, 5 > 200cm)

*Habitat variables were measured for each habitat.

**Two dissolved oxygen measurements were taken for each habitat, at the top and bottom of the water column.

Appendix 3
SITE SHEET

Department of Conservation and Land Management
CALM**Science** Division
Monitoring River Health in Western Australia



Site Details

Site No. _____ Site name _____ SOE (Y/N) _____

River System _____ River Name _____ IBRA Region _____

Latitude _____ ° _____ ' _____ " S Longitude _____ ° _____ ' _____ " E

Altitude _____ (m) Slope _____ (m/km) DFS _____ (km)

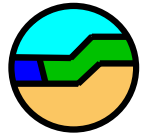
Flow pattern cat. _____ Discharge cat. _____ Av. ann. rainfall _____ (mm)

Site description (riparian vegetation, stream condition, catchment condition, surrounding landuse, etc.):

Photo taken by _____ Film No. _____ Frame No. _____ Entered into database by _____

IBRA Region:	IBRA Region:	IBRA Region:	Flow:
(AW) Avon Wheatbelt	(GAS) Gascoyne	(NK) North Kimberley	1=Permanent
(CAR) Carnarvon	(GD) Gibson Desert	(NUL) Nullabor	2=Semi-permanent
(CK) Central Kimberley	(GS) Geraldton Sandplains	(OVP) Ord-Victoria Plains	3=Seasonal
(COO) Coolgardie	(GSD) Great Sandy Desert	(PIL) Pilbara	4=Episodic
(CR) Central Ranges	(GVD) Great Victoria Desert	(SWA) Swan Coastal Plain	
(DL) Dampierland	(HAM) Hampton	(TAN) Tanami	
(ESP) Esperance Plains	(JF) Jarrah Forest	(VB) Victoria Bonaparte	
	(LSD) Little Sandy Desert	(WAR) Warren	
	(MAL) Mallee	(YAL) Yalgoo	
	(MUR) Murchison		

Department of Conservation and Land Management
Monitoring River Health in Western Australia
ACCESS SHEET



Access Details

Site No. _____ Site name _____

Latitude _____ ° _____ ' _____ " S Longitude _____ ° _____ ' _____ " E

WAC (1:1,000,000) _____ 1:250,000 Topo _____

1:100,000 Topo _____ 1:50,000 Topo _____

Land tenure _____ Access by _____

Air / Ground / Boat

Contact _____ Position _____ Phone _____

Postal address _____

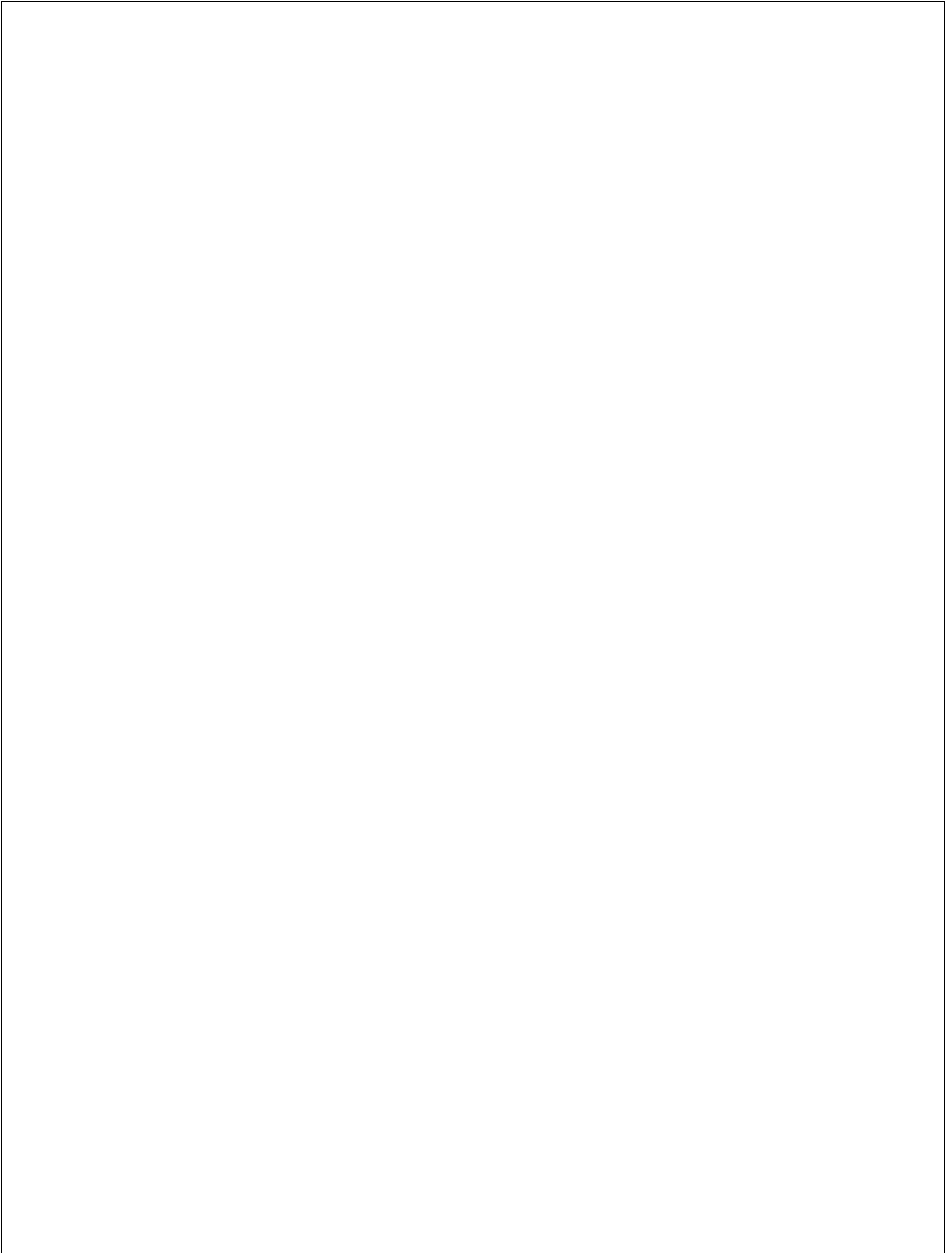
CALM Region _____ CALM District _____ DRA Permit (Y/N) _____

Notes _____

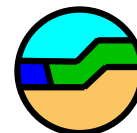
Schematic diagram of 100 m reach:

Draw access sketch on other side

Access Sketch



**Department of Conservation and Land Management
Monitoring River Health in Western Australia
ASSESSMENT SHEET 1 - WHOLE SITE**



Water Chemistry

Site No. _____ Site name _____ Date _____

Round No. _____ Season _____ Mean River Width _____ (m)
Wet / Dry

Site type _____ Landuse _____ Impact 1 _____ Impact 2 _____

NB only assign an impact category if there is physical evidence of disturbance at the site at the time of sampling

Water Chemistry		Units
pH		[H ⁺]
Temperature		(°C)
Conductivity		(µS/cm)

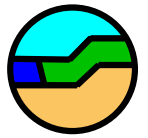
Water Samples	Check (√)	Bottle No.
125 ml water sample, filtered and frozen		
250 ml water sample, unfiltered		

Habitats within 100 m reach	%
Channel	
Macrophytes	
Riffle	
Pool Rocks	
Total	

Comments _____

Site Types:	Landuse:	Impacts:	Impacts:
REF1 = highest quality	(AG) Agriculture	(AB) Abstraction	(OR) Organic load
REF2 = minimally disturbed	(AR) Aboriginal Reserve	(CM) Channel modification	(PE) Pesticides
REF3 = best available	(CO) Conservation	(CR) Cropping	(RO) Roading
TEST = not reference	(FO) State Forest	(DW) De-watering	(RE) Recreation pressure
	(IN) Industrial	(ER) Erosion	(RI) Riparian veg cleared
	(MI) Mining	(FI) Fire	(RR) River regulation
	(PA) Pastoralism	(HC) Hydrocarbons	(SA) Secondary salinization
	(RV) Remnant Vegetation	(HM) Heavy metals	(SE) Sedimentation
	(TO) Tourism	(IM) Impoundment	(ST) Stock
	(UR) Urban	(MI) Mining	(WE) Weeds
	(VC) VCL	(NI) No Impact	
	(WC) Water catchment	(NU) Nutrients	

**Department of Conservation and Land Management
Monitoring River Health in Western Australia
ASSESSMENT SHEET 2 - EACH HABITAT**



Habitat Details

Site No. _____ Site name _____ Date _____

Habitat _____ % of 100 m reach _____

Sample collected by _____ 60 minute live pick by _____ & _____

Mineral Substrate	%	Breakdown of habitat surface area	%	Density (1 = sparse; 5=dense)
Bedrock		Mineral substrate		
Boulders (>256 mm)		Emergent Macrophyte		1 2 3 4 5
Cobbles (64 – 256 mm)		Submerged Macrophyte		1 2 3 4 5
Pebbles (16 – 64 mm)		Floating Macrophyte		1 2 3 4 5
Gravel (4 – 16 mm)		Algal Cover		1 2 3 4 5
Sand (1 – 4 mm)		Detritus		1 2 3 4 5
Silt (< 1mm)		Riparian veg draped in water		
Clay		Other		
Total		Total		

Depth 1 (< 25 cm) 2 (< 50 cm) 3 (< 100 cm) 4 (< 200 cm) 5 (> 200 cm)

Flow **Meter used** _____ **Max flow =** _____ revs/30s = _____ revs/sec = _____ cm/s

Yes

No **Fan used** _____ x _____ **Min flow =** _____ revs/30s = _____ revs/sec = _____ cm/s

Dissolved Oxygen: **Top** of water column = _____ % saturation

Bottom of water column = _____ % saturation

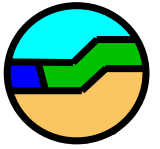
Taxon	Log abundance	Estimate of total no.	Taxon	Log abundance	Estimate of total no.
Nematoda			Hemiptera Corixidae		
Platyhelminthes			Notonectidae		
Oligochaeta			Gerridae		
Hirudinea					
Bivalvia					
Gastropoda			Coleoptera Dytiscidae		
Acarina			Hydrophilidae		
Diptera Chironomidae					
Ceratopogonidae					
Culicidae			Odonata Epiproctophora		
Empididae			Zygoptera		
Ephydriidae			Trichoptera Leptoceridae		
Simuliidae			Ecnomidae		
Stratiomyidae					
Tabanidae					
			Amphipoda Ceinidae		
			Perthiidae		
Plecoptera Gripopterygidae			Isopoda		
Ephemeroptera Baetidae			Decapoda Atyidae		
Caenidae			Palaemonidae		
Leptophlebiidae			Parastacidae		

Abundance 1 = (A≤10) 2 = (11≤A≤100) 3 = (101≤A≤1000) 4 = (A>1000+)

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

Site No. _____ Site name _____ Date _____

PHYSICAL HABITAT ASSESSMENT SHEET 3



HABITAT PARAMETER	OPTIMAL CONDITION	SUB-OPTIMAL CONDITION	MARGINAL CONDITION	POOR CONDITION
Degree of naturalness	Pristine	Minimally disturbed	Moderately disturbed	Heavily disturbed
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Catchment condition	Pristine	Minimally disturbed	Moderately disturbed	Heavily disturbed
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Landuse at site	Near pristine	Minimally disturbed	Moderately disturbed	Heavily disturbed
	Left bank 10 9	8 7 6	5 4 3	2 1 0
	Right bank 10 9	8 7 6	5 4 3	2 1 0

Physical substrate characterisation	Optimal mix of substrate types: Many interstitial spaces	Sub-optimal mix of substrate types	Minimal substrate diversity	Lack of substrate types and spaces: Bedrock only
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Biological substrate characterisation	Optimal: decaying twigs, leaf litter, epiphytes etc	Sub-optimal: some leaf litter, epiphytes etc	Minimal leaf litter, epiphytes etc	Complete absence of detritus and epiphytes
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Vegetative protection	Pristine	Minimally disturbed	Moderately disturbed	Heavily disturbed
	Left bank 10 9	8 7 6	5 4 3	2 1 0
	Right bank 10 9	8 7 6	5 4 3	2 1 0

Width of riparian vegetation	Pristine	Minimally disturbed	Moderately disturbed	Heavily disturbed
	Left bank 10 9	8 7 6	5 4 3	2 1 0
	Right bank 10 9	8 7 6	5 4 3	2 1 0

Bank stability				
	Left bank 10 9	8 7 6	5 4 3	2 1 0
	Right bank 10 9	8 7 6	5 4 3	2 1 0

Sediment deposition	Optimal condition	Sub-optimal condition	Marginal condition	Poor condition
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Impoundments, abstraction or channelisation	Optimal condition	Sub-optimal condition	Marginal condition	Poor condition
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

TOTAL _____

MRHI MACROINVERTEBRATE IDENTIFICATION SHEET

Site No. _____ Collection Date _____ Sampling round _____	HABITAT <input type="checkbox"/> Channel <input type="checkbox"/> Macrophyte <input type="checkbox"/> Pool Rocks <input type="checkbox"/> Riffle <input type="checkbox"/> Organics <input type="checkbox"/> Logs	COMMENTS
Picked by _____ Identified by _____ Date identified _____	Entered into database on _____ Entered into database by _____ Checked on _____ by _____	

* **Abundance categories:** 1 = 1 to 10 animals; 2 = 11 to 100 animals; 3 = >101 animals.

Order/Family (Field data)	Abundance estimate of Order *	Family code	Family or Sub-family	Abundance of Family *	Number identified	Life stage	Genus/species (if identified further)	Voucher or Slide No.
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								

VARIABLES USED IN WA MRHI/FNARH DATABASE

DISTURBANCE CATEGORIES (Site Type)

REF1	Least disturbed
REF2	Minimally disturbed
REF3	Best available
TEST	Test site

FLOW CATEGORIES

1	Perennial	Water flowing year round, all years
2	Almost perennial	Water flowing year round, most years
3	Seasonal	Subject to predictable seasonal flow
4	Episodic	Prone to major flood events following which there is no flow

DISCHARGE CATEGORIES (Mega-litres per annum)

1	10	-	100	ML/a
2	100	-	1000	ML/a
3	1000	-	10000	ML/a
4	10000	-	100000	ML/a
5	100000 -		1000000	ML/a
6	1000000-		10000000	ML/a

DENSITY OF HABITAT VARIABLES

0	Absent
1	Very low
2	Low
3	Moderate
4	High
5	Very high

MEAN DEPTH (applies to area sampled not entire reach)

1	<25cm
2	<50cm
3	<100cm
4	<200cm
5	>200cm