Natural Heritage Trust
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Quality Control and Assurance Programs

for the NRHP in NSW

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Quality control and assurance (QA/QC) procedures in NSW

Quality control and assurance programs for the NRHP were undertaken both at the national level and within each State and Territory Program. During MRHI QA/QC programs were initiated at the national level to address issues of sorting and macroinvertebrate identification. A second national QA/QC program was also recently implemented to deal with sorting issues for the AWARH phase. The individual states and territories assumed responsibility for QA/QC for identifications during AWARH. The purpose of this document is to outline the QA/QC programs undertaken out at the state/territory level for NSW.

A QA/QC program was implemented in NSW to ensure quality assured data were used in all aspects of model development and model testing. Quality control procedures were undertaken for field measurements, macroinvertebrate identification, data handling and storage and the screening of poor quality environmental and biological data. These were undertaken to ensure an acceptable standard of data quality was achieved throughout the program addressing issues of lineage, positional accuracy, attribute accuracy, logical consistency and completeness.

Data collected from reference and test sites throughout the MRHI (Monitoring River Health Program, 1994-1996) and the AWARH (Australian Wide Assessment of River Health, 1997-2000) phases were included in the QA/QC program. A rigorous screening procedure, however, could not be undertaken on the biological data from all test sites. This was due to a number of confounding factors including lack of replication during the AWARH sampling stage and the difficulty of determining what should be expected from a test site with good quality data particularly when only a single sample is available for consideration.

Another issue that was not adequately addressed in the current QA/QC plan was that of errors in site assessments resulting from over-sampling and excessive sorting effort. The QA/QC procedures adopted for this program focused primarily on the detection and elimination of errors resulting from poor performance in macroinvertebrate collection and sorting. They were not designed to detect the

products of over-sampling or over-sorting. These, however, may also cause erroneous results in site assessments particularly at disturbed sites.

QA/QC procedures

Field measurements

Water quality meters were calibrated prior to each sampling event and checked daily during sampling. Alkalinity was measured both in the field and in the laboratory from frozen water samples. Values were compared and suspect data flagged and excluded from analyses. Field measurements such as stream width and riffle depth were regularly confirmed using a measuring tape and more subjective measurements such as disturbance rankings were regularly compared between team leaders to ensure consistency between sampling teams.

Site attributes such as site code, name, position and elevation were checked using topographic maps and/or GPS on each sampling occasion. Positional accuracy was reconfirmed in the office using GIS.

Data handling and storage

All data collected during the NRHP for NSW were entered and stored in an Oracle® database. To ensure completeness of records in the database, all samples collected in the field were entered into a field master form within the database. This was done immediately following all sampling trips and included information such as site code, date and the habitats from which biological samples were collected. A complete record of all samples collected was therefore readily available.

To help minimise errors associated with data entry, electronic data entry forms were set up to mimic the layout of the field and laboratory datasheets. Range checks were also in-built to highlight unusual or incorrect values for given variables (such as a pH value >10). All entered data was then checked. During the MRHI phase this entailed the double entry of all field and biological data into a QA/QC table followed by electronic comparison and subsequent checking of inconsistent results. In 1997 this procedure was replaced by a separate visual check of inconsistent data between hardcopy records and database records by another operator. Errors were then rectified and changes noted on the original datasheet. To provide a measure of

accuracy in data entry, a second checking procedure was undertaken on the field data from 25 randomly selected samples in each season. All errors were recorded and these data were analysed to provide an assessment data entry accuracy.

Macroinvertebrate identification

A QA/QC program was undertaken on a subset of all AWARH samples collected in NSW to ensure an acceptable standard of macroinvertebrate identification was achieved. Procedures for macroinvertebrate identification and quantification followed the guidelines used for the national QA/QC program presented in Hawking and O'Connor (1997a).

In NSW, all taxa were identified to family level with the exception of Nemertea, Nematoda, Oligochaeta, Polychaeta, Ostracoda and Acarina to a higher level and Chironomidae to the lower level of subfamily. Taxonomic keys used for identification included those listed by Hawking (2000). Where uncertainties arose, such as for damaged, immature or unknown specimens, the decision tree presented in Hawking and O'Connor (1997a) was followed to establish whether a specimen could be correctly identified or not. A voucher collection was also set up and validated by taxonomic specialists (as listed in Hawking and O'Connor, 1997a) for reference during identifications. Pupae, exuviae, empty mollusc shells and terrestrial taxa were not included in the identifications.

Five percent of samples were selected from each season on a stratified/random basis ensuring all identifiers were considered and a range of habitats and biogeographic regions represented. Selected samples were then re-identified by an experienced staff member according to the guidelines presented in Hawking and O'Connor (1997a). Error rates including Percentage of New Taxa and the Bray Curtis Dissimilarity Index were then calculated for each of these samples as specified in Hawking and O'Connor (1997b). In addition, Sorrenson's index (Bennison et al*.,* 1989) was also calculated to provide an alternative estimate of dissimilarity between original and QA/QC samples. This index was considered more appropriate than Bray Curtis for reflecting errors that may affect AUSRIVAS results, which are based on presence/absence data, as it uses total taxa numbers and not relative abundance. In accordance with the MRHI QA/QC program (Hawking and O'Connor, 1997c) < 10%

error was deemed acceptable and therefore samples with a 'new taxa' percentage of 10% or greater and/or a Sorrenson's index of less than 0.91 failed the QA/QC test.

All identification errors were compiled and appropriate follow-up action implemented to rectify mistakes and improve identification performance. Follow-up action was also undertaken to address identification problems highlighted in the national QA/QC program conducted on samples collected during the MRHI phase (Hawking and O'Connor, 1997c).

Biological data screening

To ensure that only quality-assured samples were included in model development and performance testing, a formal procedure was undertaken to screen all biological data collected at reference sites. A set of criteria was developed and biological samples that failed to pass the quality control and assurance procedure were flagged in the database and excluded from use in all modeling procedures. Biological samples were assigned a 'fail' for quality control and assurance if they contained:

- An unusually low number of taxa for the site (as compared to other samples collected at the site for the same habitat and season) and/or,
- Unusually low O/E results and a different fauna composition than expected for the site in the relevant season and habitat (as compared to other samples collected at the site) and/or,
- A lower than expected number of cryptic taxa (as compared to other samples collected at the site and similar sites for the same habitat and season).

And satisfied one or more of the following criteria:

- Sorted by an untrained or inexperienced operator,
- Collected by an untrained or inexperienced operator,
- Collected from a marginal habitat e.g. small bedrock riffle or a fast flowing edge,
- Collected from an unusual site e.g. acid stream,
- Sorted under low or artificial light conditions e.g. dusk or motel room,
- Sampled with limited access to available habitats e.g. steep, slippery banks, deep pools or very fast flowing riffles,

- Sampled under extreme circumstances e.g. heavy rain,
- Sampled under extreme flow conditions i.e. during or immediately following a flood or drought,
- Collected outside the acceptable date range for a given season.

This screening procedure was also applied to some test site data where replicate samples were available for comparison. The quality of test data, however, is a lot harder to assess than reference data. Whereas data collected in other years/seasons from the same site and in the same year from similar sites could be used as a benchmark for assessing reference site data, such benchmarks are not available for test sites because it is neither possible nor appropriate to attempt to anticipate results from test sites. Even when replicates were available from a disturbed test site it was often not safe to assume that there should be consistency in the results over time because in most cases the degree of disturbance would change greatly over time. Consequently the screening procedure for the test site data was probably less reliable and depended on the results of the reference data screening procedure to identify possible problems such as consistently poor sorters, flood or drought extremity, difficult sampling conditions etc.

Environmental data screening

Map/GIS derived data

All predictor variables derived by topographic maps or GIS including elevation, distance from source, latitude, longitude, slope and mean annual rainfall, were checked and screened for unexpected results.

Field data

A rigorous screening procedure was undertaken to ensure only reliable field recordings were used in all aspects of model development, testing and site assessment. This followed the finding of a recent internal study, conducted to assess temporal variation in AUSRIVAS outputs, that one of the major factors affecting group probabilities and hence O/E values between samples from the same reference site was variation in environmental data. This was particularly evident for substrate variables such as clay and silt where large differences were evident between different sampling occasions. As a consequence, potential predictor variables

including substrate composition, mode stream width, mode riffle depth and field alkalinity readings were screened for all reference and test samples. Records that were inconsistent with other samples and/or inconsistent with the checkers knowledge of the site were recorded as unreliable and eliminated from any analysis.

For modeling purposes substitute values were then derived for all deleted and previously missing environmental records. The mean value of all quality assured records for the site was used for this purpose. If no quality assured values were available for a site an estimate was derived from values recorded at similar sites in combination with the samplers knowledge of the site.

For alkalinity, field records were also compared to values derived in the laboratory from frozen water samples. If consistent with laboratory-derived values field records were used preferentially for modelling purposes. If reliable field data were not available for a sample the lab value was used followed by the mean value of all quality assured field records.

Results

Data entry

Results from the QA/QC program indicate the methods used by the EPA for data entry and checking have been successful in achieving a very low error rate. In total less than 5% error was obtained for all data records and these mostly included missing data for observations such as general comments and land use. Very few incorrect entries were found and of these none involved data used in model development. The incorrect recording of a mode riffle depth as 0.4 m instead of 0.45 m at one test site sampled in 1995 was the only error that may have affected AUSRIVAS outputs (although this is very unlikely).

Macroinvertebrate identification

Available results from the QA/QC program suggest that overall errors in macroinvertebrate identification were very low. Around 70% of the samples cross-identified for both the EPA and DLWC contained no errors at all and very few failed the QA/QC criteria (see Appendix 1). Even if the QA/QC criterion was further reduced

to 5% as suggested by Hawking and O'Connor (1997c) the failure rate for NSW would be very low.

Only two samples identified by EPA staff failed the QA/QC criteria. A higher number failed from DLWC, however, new and inexperienced staff were responsible for identifying all failed samples. Subsequently all samples originally identified by these and other new staff members have been re-identified and further training undertaken to improve identification performance. Experienced staff, however, carried out the majority of sample identifications at DLWC and made very few errors. Results for the latest sampling seasons are presently not available although errors are expected to be very low for both EPA and DLWC samples due to the continual use of experienced staff and the increased effort in training and cross-checking of new staff at DLWC. Errors for EPA, spring 99 samples are expected to be particularly low as the same operator who identified the autumn 99 samples was used where very few errors were found.

The most common error made by EPA and experienced DLWC staff was missed taxa. In most cases a missed taxon was represented by a single, tiny individual and often involved rare taxa, mostly excluded from the AUSRIVAS models in NSW such as Empididae and Ostracoda. Actual misidentifications were rare. Of these misidentification errors a few had no possible consequences for affecting AUSRIVAS results, for example, the identification of a rarely collected Chironomidae subfamily, Aphroteniinae as Podonominae (another rare taxon not included in the NSW models). Errors involving the misidentification of common taxa were very rare and appeared to be isolated mistakes. This was re-confirmed by spot-checking additional samples processed by the original identifier. Two exceptions, however, included the misidentification of Libellulidae as Cordulidae and Corbiculidae as Sphaeriidae. During spot-checking confusion between these families was also evident in at least one other sample and by different identifiers. Errors involving the misidentification of Corbiculidae and Sphaeriidae were particular evident for small juveniles.

To address the problem associated with the misidentification of Libellulidae as Cordulidae all subsequent samples were double-checked by the Odonata specialist, Gunther Theischinger. Apparently this error involved the confusion of one genus of Corduliidae with Libellulidae. Samples likely to contain such a mistake were also re-

checked and training was provided to familiarise other identifiers with the specific characteristics of each taxon. In the case of the Corbiculidae/Sphaeriidae problem it was decided, together with a DLWC representative, to combine the families for modelling purposes. The potential for further identification errors and the ecological characteristics of the two families were considered during the decision process.

Follow up action was also undertaken to address the errors identified in the national QA/QC program conducted on MRHI data by Hawkings and O'Connor (1997c). This included the re-identification of all samples identified by staff at Charles Sturt University (CSU), the identification of all Chironomids to sub-family (not completed prior to the external QA/QC review for spring 94 and autumn 95) and spot-checking samples with the potential for similar mistakes for all other misidentifications.

Biological data screening

A rigorous QA/QC procedure was undertaken on all reference samples collected for MRHI/AWARH from 1994 to 1998. On average 13.6% of all reference samples failed to met the QA/QC criteria with a similar proportion of failed samples for each model (Table 1). A modified less rigorous screening procedure was undertaken on test samples collected for MRHI/AWARH from this same period. Overall 4.1% of all test sites were identified as poor quality data although the percentage for each model varied considerably from 0.9% to 8.3% (Table 1). These figures, however, probably under-estimate the true percentage of test samples that would have failed a QA/QC test if a more rigorous procedure was possible.

The results of the reference data screening gives some indication of the number of test samples expected to contain poor quality data if similar QA/QC criteria were applied. These results suggest that a fair number of undetected test samples contain poor quality data and therefore have unreliable site assessments.

Table 1. Numbers of reference and test sites from 1994-1998 that failed to meet the QA/QC criteria.

MODEL	**Total No. Samples**	**Samples QA/QC PASS**	**Samples QA/QC FAIL**	**Reference samples FAIL**	**% Reference samples FAIL**	**Test samples FAIL**	**% Test samples FAIL**
SPRING EDGE	1065	996	69	64	12.4%	5	0.9%
SPRING RIFFLE	511	458	53	38	11.6%	15	8.2%
AUTUMN EDGE	1109	1005	103	79	14.0%	24	4.4%
AUTUMN RIFFLE	564	491	73	56	16.4%	17	8.3%
TOTAL	**3311**	**3013**	**298**	**237**	**13.6%**	**61**	**4.1%**

The most common reason for biological samples not satisfying the QA/QC criteria was the use of untrained and/or inexperienced sorters (Table 2). A high number of these, however, were collected in the first year of the program or by CSU, an organisation only involved in the program for the first two sampling seasons. Sorting under low or artificial light conditions was also thought responsible for producing poor quality data for a few samples.

Another major factor that influenced the quality of biological samples included exceptional flow conditions, particular for Autumn Edge data. Both high flow/flood conditions and low flow/drought conditions were found to significantly reduce the number and richness of macroinvertebrate samples in some situations. Collecting samples from a marginal or unsuitable habitat also proved to be a problem in some cases, especially for riffles. Examples of a marginal or unsuitable riffle included an entirely bedrock riffle, a very sandy riffle and a very shallow riffle with less than 10 m of suitable habitat. Unusual circumstances were also responsible for reducing the suitability of a habitat for sampling. Examples included the smothering of available edge habitat by thick snow and the reduction of safe sampling areas in the riffle due to a very fast midstream flow.

The difficulty of collecting a good sample for some of the large western rivers was also considered when assessing the quality of samples collected from these rivers. As a consequence, samples containing a very low number of taxa (i.e. less than 8) from relatively undisturbed sites were considered to be of poor quality. This was particularly a problem for the Autumn Edge where a relatively high number of samples failed as they contained a very low number of taxa. A few samples collected

from the western flowing rivers also failed, as they were collected out of the acceptable date range for any of the models.

Table 2. Number of biological samples that failed the QA/QC test under the given criteria.

MODEL	FLOW	SAMPLING	HABITAT	SITE	SEASON
SPRING EDGE	19 8 high/ recent flood 11 low/ drought	37 35 untrained/ inexperienced sorter (19 from 1994) 2 sorted indoors	4 1 unsuitable edge 3 unusual conditions i.e. heavy snow, recent fire	5 1 unusual site 4 western site, very low number of taxa collected	4 4 sampled late into summer
SPRING RIFFLE	8 3 high/ recent flood 5 low/ drought	33 30 untrained/ inexperienced sorter (21 from 1994) 1 sorted low light/rain 2 untrained collector	7 7 marginal/ unsuitable riffle	2 2 western site, very low number of taxa collected	3 3 sampled late into summer
AUTUMN EDGE	31 12 high/ recent flood 19 low/ drought	46 45 untrained/ inexperienced (9 from CSU) 1 sorted low light	6 2 unsuitable edge 4 unusual conditions i.e. heavy snow	20 20 western site, very low number of taxa collected	
AUTUMN RIFFLE	7 3 high/ recent flood 4 low/ drought	44 40 untrained/ inexperienced (4 from CSU)	22 19 marginal/ unsuitable riffle 3 difficult sampling		
TOTAL	**65**	**160**	**39**	**27**	**7**

In some situations reference samples with a relatively low number of taxa or poorer than expected AUSRIVAS outputs were excluded as potential model samples even though they met the QA/QC criteria. In these cases probable reasons for suspecting poor quality data did exist but could not be assured. Numbers of such samples for each model are given in Table 3 together with possible reasons why they were poorer than expected. These also included samples with less than 10 taxa as this was considered a prerequisite for samples used in model development (Turak and Waddell, 2001a). As shown in Table 3, potential sampling problems were the main factor thought to affect the quality of this data.

Table 3. Number of samples that met the QA/QC criteria but were excluded from model development and possible reasons that may have affected quality of the data.

MODEL	NUMBER OF SAMPLES	FLOW	SAMPLING	HABITAT/ SITE	<10 TAXA
SPRING EDGE	54	8	37 (25 from 1994)	2	7
SPRING RIFFLE	12	1	8 (3 from 1994)	3	
AUTUMN EDGE	59	14	32	5	8
AUTUMN RIFFLE	3		3		
TOTAL	**128**	**23**	**80**	**10**	**15**

Environmental data screening

Results of the environmental screening procedures indicated the overall errors in environmental data recording were very low. The number of records that required substitute values due to missing or inconsistent values was very low for all variables tested. Alkalinity had the highest number of records requiring substitute values at about 10% of all samples. This figure, however, was strongly influenced by a large number of missing values for samples collected in northern NSW where alkalinity was not recorded. The proportion of samples requiring substitute values for other variables was much lower. These included about 2% of stream width measurements, 3% of riffle depth measurements and about 6% of substrate estimates.

For all environmental variables the most common error in data recording was missing values. Errors resulting from inconsistent records were much lower. These did, however, uncover a few problems associated with the collection of subjective field data using many different operators. In particular, some estimates of substrate proportions were found to vary quite considerable between different samples from the same site. This was particularly evident between the finer substrates such as silt and clay. A few discrepancies were also found between samples for variables such as mode stream width, mode riffle depth and alkalinity. Inconsistencies in field alkalinity were checked against laboratory measurements and appear to have resulted from incorrect use of the field measuring kit by inexperienced operators. Large inconsistencies in mode stream width were most common for channelled rivers and highlighted the need for clearer definitions in the training manuals to ensure data is collected in a consistent manner.

Implications for data and models

One of the main objectives of the AWARH phase in NSW was to develop new AUSRIVAS models that were free of poor quality data (Turak and Waddell, 2000a). The QA/QC procedures outlined above were essential for achieving this objective and the satisfactory results obtained ensured only quality assured data were used for constructing and testing the new models. The extensive data screening procedures undertaken prior to model development for the latest version of the NSW AUSRIVAS models ensured that only quality assured environmental and biological data were used in all aspects of model construction. In testing the models, reference site data not used for model development were invaluable especially at sites that had been sampled for several years. A good selection of replicated test sites with quality assured data was also available for model testing. This was important for testing model performance at sites with known disturbances.

The results presented above show all macroinvertebrate identification were of an acceptable standard. A few identification problems, however, were highlighted during the quality control process and were dealt with appropriately in order to minimise the effect of future errors on model development and performance. As mentioned earlier, these included the combining of Corbiculidae and Sphaeriidae as a single taxon in the models and providing specialist checking to ensure correct identification of Corduliidae and Libellulidae. The combining of the 2 bivalve families (Corbiculidae and Sphaeriidae) is thought to have few consequences for group definitions, and hence model construction for the new models, and would be outweighed by the potential error of misidentification.

All data used to construct and test the new models were subjected to an objective screening procedure prior to model development. This procedure highlighted the problem of using biological data collected under unusual or extreme sampling conditions or those processed by untrained or inexperienced operators. Such data were removed prior to model development and thus has no implications for model development. However, these findings are also important for consideration in model performance, i.e. when using AUSRIVAS to provide site assessments. Examples of unusual sampling conditions found to affect AUSRIVAS outputs include sampling during or after extremely high or low flow events, sorting samples under poor or

artificial light and sampling under difficult circumstances such as heavy rain, particularly fast flow or slippery, steep banks. Sampling under these circumstances should be avoided if possible or at least taken into consideration when interpreting AUSRIVAS outputs from samples collected under such conditions.

Sampling marginal or unsuitable habitats was also found to provide poorer than expected assessments for a given site. Examples of an unsuitable riffle habitat include bedrock riffles and those dominated by fine substratum such as sand, gravel and/or pebble. Edges with fast flowing water were also considered unsuitable for sampling. These findings also highlighted the importance of sampling only when 10 metres or more of suitable habitat is available. Problems associated with low numbers of taxa for samples collected from western flowing rivers were addressed by providing only combined season models for this region.

Screening of the environmental data uncovered a few problems associated with collecting subjective field data using many different samplers. In particular, some estimates of substrate proportions were found to vary quite considerably among samples from the same site. This was particularly evident for the finer substrates such as silt and clay. In previous versions of the models such inconsistencies were found to vary group probabilities and hence AUSRIVAS outputs for some stream types. Therefore, during data preparation for the latest models inconsistent recordings for substratum were deleted and plausible substitutes created to provide greater consistency among samples from the same site. When choosing predictor variables for the latest version of the AUSRIVAS models preferences were given to less subjective measurements such as location, elevation and rainfall. As a consequence only three of the latest models use substratum percentage and none use fine substratum components such as clay, silt or sand.

A few discrepancies were also found between samples for variables such as mode stream width and alkalinity. Inconsistencies in alkalinity were checked against laboratory measurements and appear to have resulted from incorrect use of the field measuring kit. The few large inconsistencies in mode stream width were due to different samplers interpreting a channelled river section in a different way. Although these inconsistencies were fairly rare, they did highlight the need to provide intensive training, clear definitions and specific examples of how to record data in unusual

circumstances. Following the guidelines presented in the sampling manual (Turak and Waddell, 2001b) is also essential to ensure data is recorded in a consistent manner appropriate for use in AUSRIVAS.

The replacement of erroneous or missing environmental data with plausible substitutes was also important for allowing the opportunity to ensure that only good quality biological data was used for model development. It was also important for providing AUSRIVAS outputs that could be used for testing model performance and providing assessments of river condition.

Quality assured data was also important for providing accurate site assessments. This can be assured for all reference samples collected from 1994 to 1998. Site assessments for test sites, however, cannot be assured as the rigorous post-entry data screening procedure used to eliminate poor reference site data was not applied to most of the test site data. Since around 13% of the reference site data did not meet the QA/QC criteria it is possible that up to 13% of the test site data is also of poor quality. This figure is much higher than the 4% of poor quality test samples identified using the modified QA/QC criteria in this program. It is likely that a smaller proportion of test sites have been affected by poor collection compared with reference site data. Nevertheless it is possible that a considerable number of test samples will have unreliable site assessments due to poor sampling.

The issue of over-sampling and over-sorting may also have considerable effects on the AUSRIVAS results from test site data. The quality control and assurance side of this was partly addressed by training programs, which placed great emphasis on consistency and the rigorous application of the sampling protocols. However, the quality control procedures were not designed to detect errors associated with over-sampling and over-sorting. As a consequence it is not possible to estimate the number of test sites that have been incorrectly assessed by poor sampling.

Although quantitative estimates of errors associated with AUSRIVAS sampling are not currently available the results of the QA/QC program in NSW have indicated that a large number of samples contain poor quality data. It is probable that around 10% of all samples have been poorly collected, poorly sorted or impoverished due to other factors such as extreme flow events or unsuitable sampling conditions. These results

indicate that it is probably inappropriate to rely on single samples for assessing site condition especially if the outputs are intended for detecting change over time.

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Appendix 1 QA/QC results for macroinvertebrate identifications

Table A. Available QA/QC results for 5% of EPA samples collected during AWARH.

Site Code	Season	Habitat	% New Taxa	Bray Curtis	Sorensen's index	Pass/ Fail	Error
RICH505	Autumn 97	Riffle	6.9	0.02	0.95	Pass	Misidentification: Atyidae, Aphroteniinae
HAWK10	Autumn 97	Riffle	0	0.01	1.00	Pass	
KARU602	Autumn 97	Riffle	7.1	0.04	0.96	Pass	Missed Taxa
BELL702	Autumn 97	Riffle	4.8	0.01	0.98	Pass	Missed Taxa
NAMO520	Autumn 97	Riffle	0	0.02	1.00	Pass	
MANN10	Autumn 97	Riffle	7.3	0.03	0.94	Pass	Misidentification: Atyidae, Aphroteniina Missed Taxa
HAST24	Autumn 97	Riffle	0	0.02	1.00	Pass	
SNOWM3	Autumn 97	Riffle	0	0.01	1.00	Pass	
MANN501	Spring 97	Riffle	0	0.02	1.00	Pass	
BEGA505	Spring 97	Riffle	7.1	0.05	0.95	Pass	Misidentification: Libellulidae Missed Taxa
CLYD721	Spring 97	Riffle	0	0.01	1.00	Pass	
EAST601	Spring 97	Riffle	0	0.01	1.00	Pass	
SHOA05	Spring 97	Riffle	4.4	0.01	0.96	Pass	Misidentification: Saldidae
MANN10	Spring 97	Riffle	0	0.04	1.00	Pass	Missed Taxa
MANN13	Spring 97	Riffle	5.3	0.04	0.97	Pass	Missed Taxa
BELL702	Spring 97	Riffle	0	0.05	0.97	Pass	
HAWK556	Autumn 98	Riffle	0	0.00	1.00	Pass	
LACH126	Autumn 98	Riffle	11.8	0.04	0.94	Fail	Missed Taxa
SNOW541	Autumn 98	Riffle	0	0.02	1.00	Pass	
MACL104	Autumn 98	Riffle	6.7	0.01	0.97	Pass	Missed Taxa
BRUN540	Autumn 98	Riffle	0	0.01	1.00	Pass	
SHOA05	Autumn 98	Riffle	0	0.01	0.98	Pass	
SNOW107	Autumn 98	Riffle	3.8	0.04	0.98	Pass	Missed Taxa
HUNT03	Autumn 98	Riffle	0	0.03	1.00	Pass	
CLAR543	Autumn 98	Riffle	4.2	0.04	0.96	Pass	Missed Taxa
BEGA23	Spring 98	Edge	0	0	1.00	Pass	
BEGA101	Spring 98	Edge	3.45	0.02	0.96	Pass	Missed Taxa
BELL04	Spring 98	Edge	0	0	1.00	Pass	
BORD541	Spring 98	Edge	0	0	1.00	Pass	
CLAR541	Spring 98	Edge	0	0	1.00	Pass	
HACK563	Spring 98	Edge	10	0.04	0.90	Fail	Missed Taxa
HAST01	Spring 98	Edge	0	0	1.00	Pass	
HAWK544	Spring 98	Edge	0	0	1.00	Pass	
HUNT543	Spring 98	Edge	0	0.06	0.96	Pass	
MANN13	Spring 98	Edge	0	0.02	1.00	Pass	
MANN103	Spring 98	Edge	0	0	1.00	Pass	
MURR23	Spring 98	Edge	0	0	1.00	Pass	
MURR24	Spring 98	Edge	8.33	0.01	0.92	Pass	Misidentification: Corbiculidae, Polycentropodidae
SNOW04	Spring 98	Edge	0	0.03	1.00	Pass	
BEGA19	Spring 98	Riffle	2.7	0.03	0.97	Pass	Misidentification: Tipulidae
CLAR113	Spring 98	Riffle	5	0.02	0.97	Pass	Missed Taxa
EAST101	Spring 98	Riffle	0	0.03	1.00	Pass	
HAWK10	Spring 98	Riffle	4.35	0.01	0.96	Pass	Misidentification: Ecnomidae

Site Code	Season	Habitat	% New Taxa	Bray Curtis	Sorensen's index	Pass/ Fail	Error
MACL543	Spring 98	Riffle	4.35	0.03	0.98	Pass	Missed Taxa
MANN20	Spring 98	Riffle	0	0	1.00	Pass	
RICH540	Spring 98	Riffle	3.45	0.02	0.98	Pass	Missed Taxa
SNOW108	Spring 98	Riffle	0	0	0.97	Pass	
BELL17	Autumn 99	Edge	0	0	1.0	Pass	
BELL506	Autumn 99	Edge	0	0	1.0	Pass	
CLAR574	Autumn 99	Edge	0	0	1.0	Pass	
GEOR592	Autumn 99	Edge	6.52	0.01	0.97	Pass	Missed Taxa
HAST24	Autumn 99	Edge	2.94	0.02	0.97	Pass	Misidentification: Dytiscidae
HUNT573	Autumn 99	Edge	5.5	0.02	0.97	Pass	Missed Taxa
MACL543	Autumn 99	Edge	0	0	1.0	Pass	
MACL577	Autumn 99	Edge	0	0	1.0	Pass	
MACL583	Autumn 99	Edge	0	0	1.0	Pass	
MANN20	Autumn 99	Edge	0	0	1.0	Pass	
RICH575	Autumn 99	Edge	0	0	1.0	Pass	
SHOA573	Autumn 99	Edge	0	0	1.0	Pass	
BELL582	Autumn 99	Riffle	4.76	0.01	0.98	Pass	Missed Taxa
BELL587	Autumn 99	Riffle	0	0	1.0	Pass	
HUNT571	Autumn 99	Riffle	0	0	1.0	Pass	
HUNT588	Autumn 99	Riffle	0	0	1.0	Pass	
MACQ570	Autumn 99	Riffle	0	0	1.0	Pass	
MACQ572	Autumn 99	Riffle	0	0	1.0	Pass	

Table B. QA/QC results for 5% of DLWC samples collected during autumn and spring in 1997.

Site Code	Season	Habitat	% New taxa	Bray Curtis	Sorensen's index	Pass/ Fail	Error
MURR524	Autumn 97	Edge	0	0.00	1.00	Pass	
MURRM1	Autumn 97	Edge	18	0.13	0.80	Fail	Misidentification: numerous Trichoptera
MURR517	Autumn 97	Edge	0	0.00	1.00	Pass	
BIDG519	Autumn 97	Edge	0	0.01	1.00	Pass	
MURR24	Autumn 97	Edge	6	0.03	0.94	Pass	Misidentification: Terrestrial Coleoptera
BIDG05	Autumn 97	Edge	0	0.00	1.00	Pass	
BIDG504	Autumn 97	Edge	0	0.02	1.00	Pass	
NAMO511	Autumn 97	Edge	0	0.02	0.98	Pass	
NAMO506	Autumn 97	Riffle	0	0.01	1.00	Pass	
BORD507	Autumn 97	Riffle	0	0.03	1.00	Pass	
MURR23	Autumn 97	Riffle	5	0.10	0.97	Pass	Missed Taxa
MURRM5	Spring 97	Edge	0	0.02	1.00	Pass	
MURR504	Spring 97	Edge	14	0.05	0.86	Fail	Misidentification: Gerridae, Tanypodinae
BIDG513	Spring 97	Edge	7	0.02	0.96	Pass	Missed Taxa
LACH513	Spring 97	Edge	0	0.00	1.00	Pass	
NAMO505	Spring 97	Edge	0	0.00	1.00	Pass	
BORD501	Spring 97	Edge	0	0.00	1.00	Pass	
MACQ503	Spring 97	Edge	0	0.00	1.00	Pass	
BIDG502	Spring 97	Riffle	0	0.02	1.00	Pass	
LACH504	Spring 97	Riffle	0	0.02	0.91	Pass	
GWYD503	Spring 97	Riffle	29	0.06	0.74	Fail	Misidentification: numerous taxa
NAMO508	Spring 97	Riffle	33	0.73	0.36	Fail	Misidentification: numerous taxa