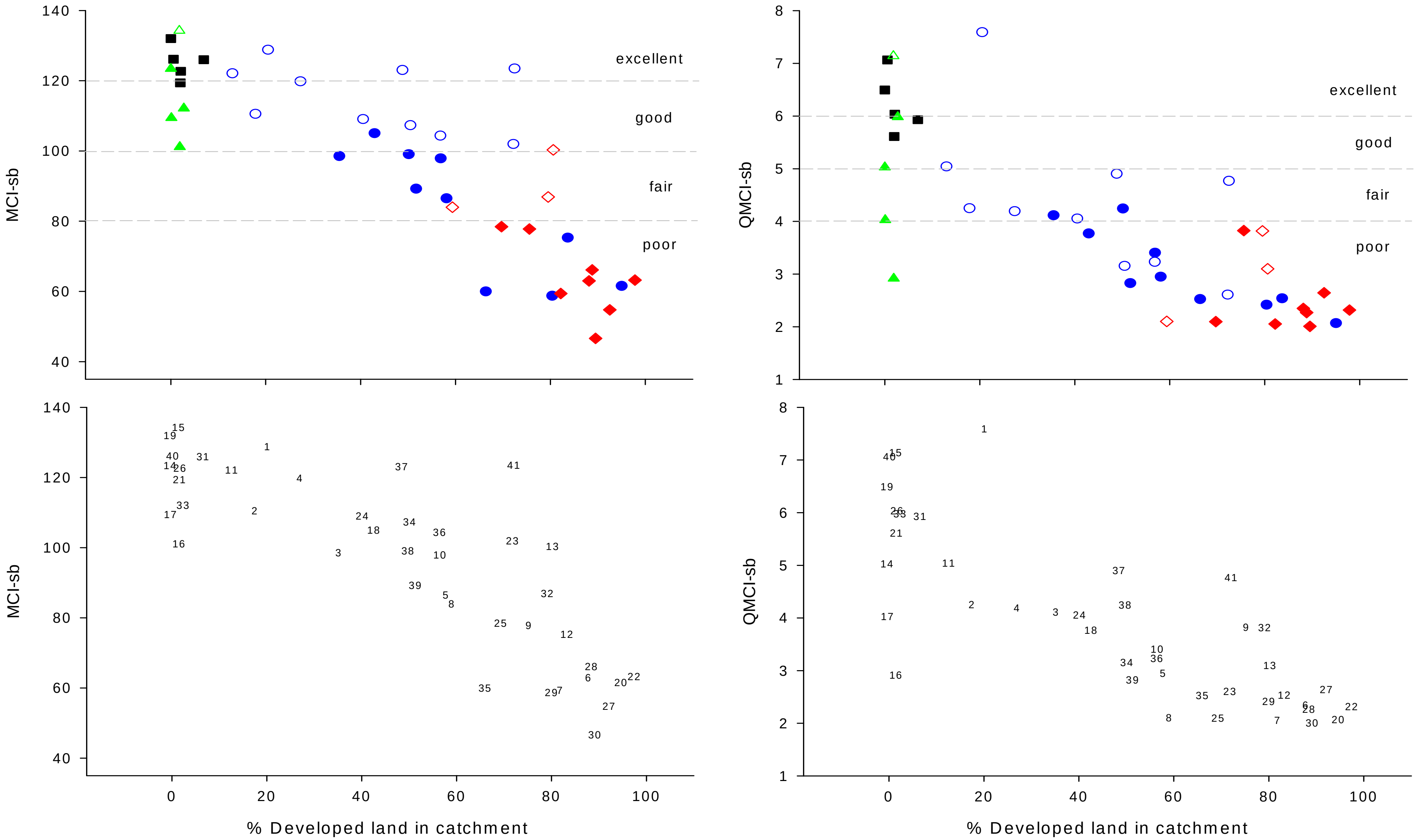

Figure 5 MCI-sb and QMCI-sb versus % developed land in the catchment. See Appendix 1 for the key to the site codes shown on the lower pair of graphs. Key to land-use classes: ■ reference (> 95% native bush), △ partial forestry (includes 70% native bush), ▲ full forestry (> 95% exotic forest), ○ rural lifestyle, ● full rural, ◇ partial urban (8-25% urban), ◆ full urban (>40% urban).

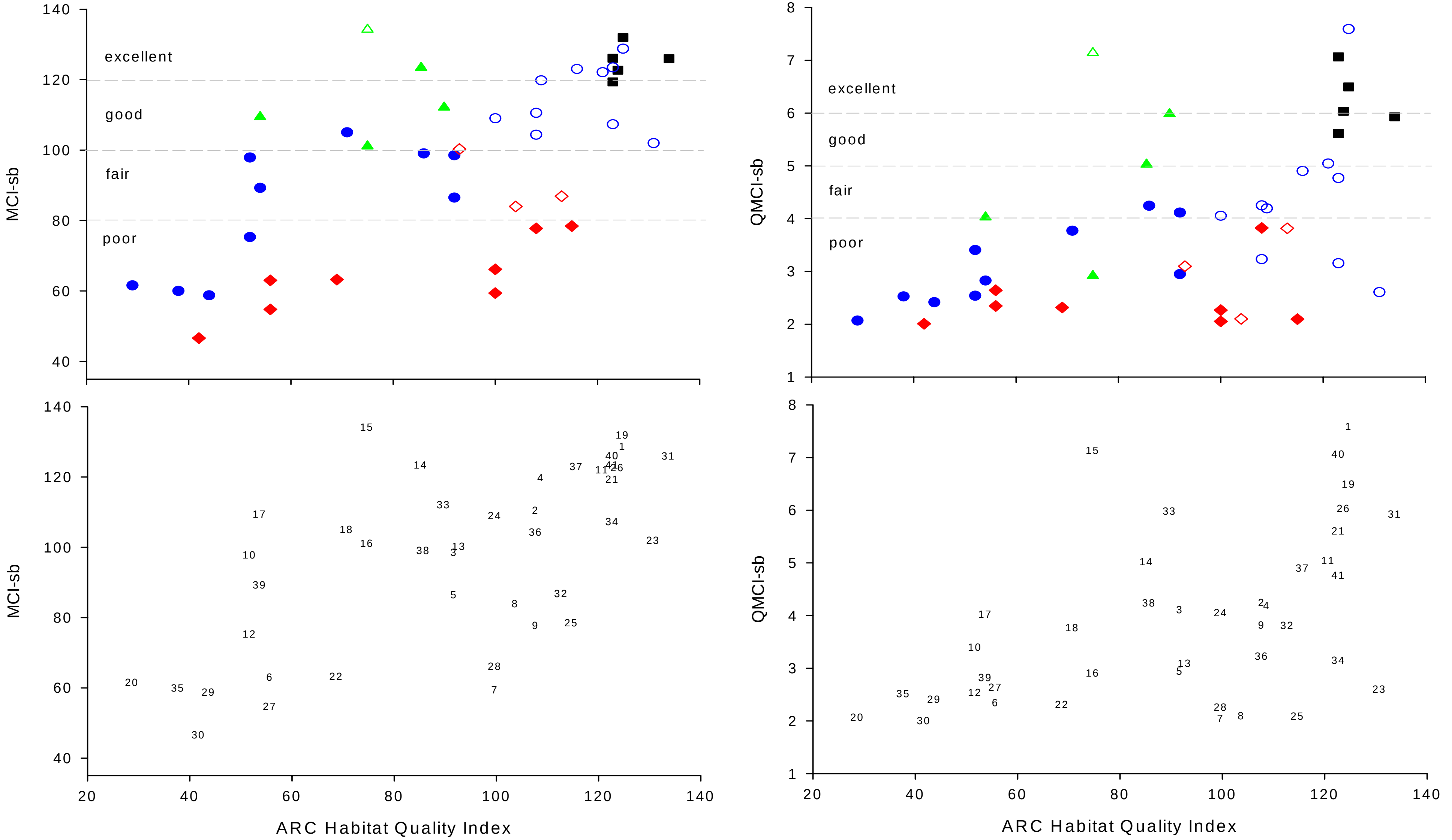

Figure 6 MCI-sb and QMCI-sb versus ARC Habitat Quality Index. See Appendix 1 for the key to the site codes shown on the lower pair of graphs. Key to land-use classes: ■ reference (> 95% native bush), △ partial forestry (includes 70% native bush), ▲ full forestry (> 95% exotic forest), ○ rural lifestyle, ● full rural, ◇ partial urban (8-25% urban), ◆ full urban (>40% urban).

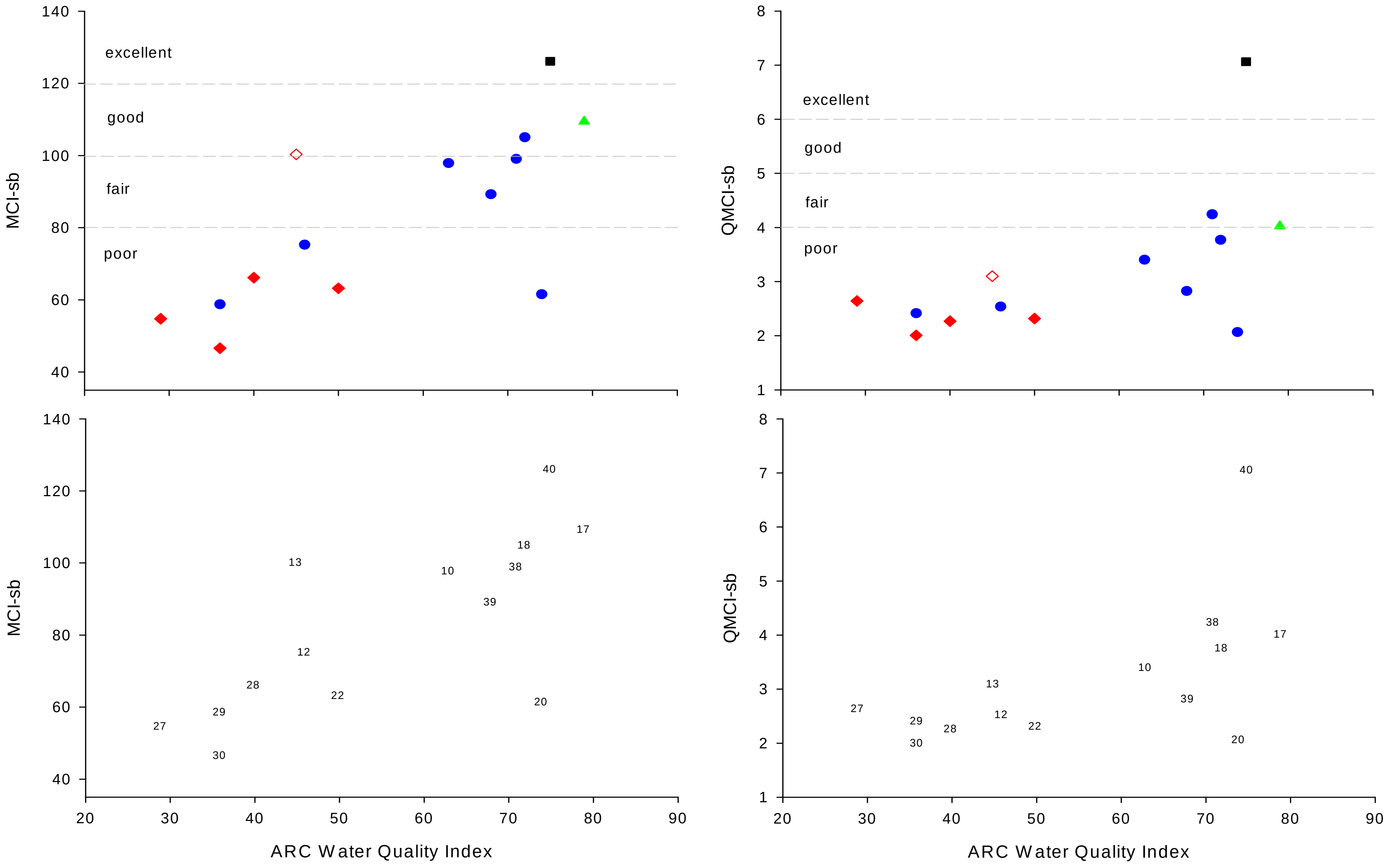

Figure 7 MCI-sb and QMCI-sb versus ARC Water Quality Index. See Appendix 1 for the key to the site codes shown on the lower pair of graphs. Key to land-use classes: ■ reference (> 95% native bush), ▲ full forestry (> 95% exotic forest), ● full rural, ◇ partial urban (8-25% urban), ◆ full urban (>40% urban).

5.1 Predictive relationships with land-use

Land-use is an important catchment-scale variable affecting biological communities in wadeable streams. In general, as the percentage of developed land (i.e., lifestyle, rural and urban) in the catchment increases, stream health declines (Figure 5). Highest biotic indices tend to be associated with sites in reference condition and in mature exotic forests. Heavily urbanised catchments and intensive rural land-use tend to be associated with "poor" (or "fair") quality stream communities.

Rural lifestyle development can be extensive (50 – 70 % of the catchment) while maintaining the site in the "excellent" quality class according to the MCI-sb, although the QMCI-sb is indicative of only a "fair" quality assessment (e.g., Site VAUU #37 & Site WHAR #41, Figure 5). The differing assessments of the MCI-sb and QMCI-sb are not really in conflict. The excellent assessment of the MCI-sb indicates that conditions remain suitable for a wide range of macroinvertebrates that prefer excellent water quality and habitat quality, but the "fair" quality assessment by the QMCI-sb indicates that there is sufficient enrichment for more tolerant macroinvertebrates to become numerically dominant. High values of the HQI (116 & 123) for these two sites indicate that the decline in stream health detected by the QMCI-sb is more likely to be related to water quality than the physical habitat. Unfortunately, no water quality data are available to confirm this conclusion for these sites.

Two other rural lifestyle sites with a similar level of catchment development (60 – 70%) are Site OKU1 (#23) and Site VAUM (#36), and yet they were assigned to the "fair" quality class by the MCI-sb and the "poor" quality class by the QMCI-sb (Figure 5). Closer examination of the development that has occurred in these catchments might enable water managers to determine what features of the development in the VAUU and WHAR catchments have enabled development to occur while maintaining a higher level of stream health than in the VAUM and OKU1 catchments.

5.2 Predictive relationships with habitat quality (riparian management)

Habitat quality is an important local-scale variable affecting the biological community and can help define the relative contributions of physical and water quality stressors. The HQI is a measure of site- or reach-specific instream and riparian physical habitat quality. High HQI values are characteristic of reference sites but sites within most other land-use classes can show a wide range of HQI values (Figure 6). HQIs at urban sites, for example, ranged from 42 to 115 and yet biotic indices classified all of these sites in the "poor" quality class. Urban sites with high HQI values (Sites 7, 8, 9, 25, 28, 32) (Figure 6) must, therefore, have poor instream communities by virtue of water quality degradation. The low WQI of 40 for the one site from this group for which water quality data are available (Site OTEH, #28) is consistent with this interpretation.

Understanding relationships between biology and habitat quality has direct application to the management of riparian zones. Riparian Zone Management (RZM) has been a major concern of ARC over the last 5 years with the completion of regional guidelines (ARC 2001b), training for non-scientists, and annual funding provided to property owners for fencing and planting.

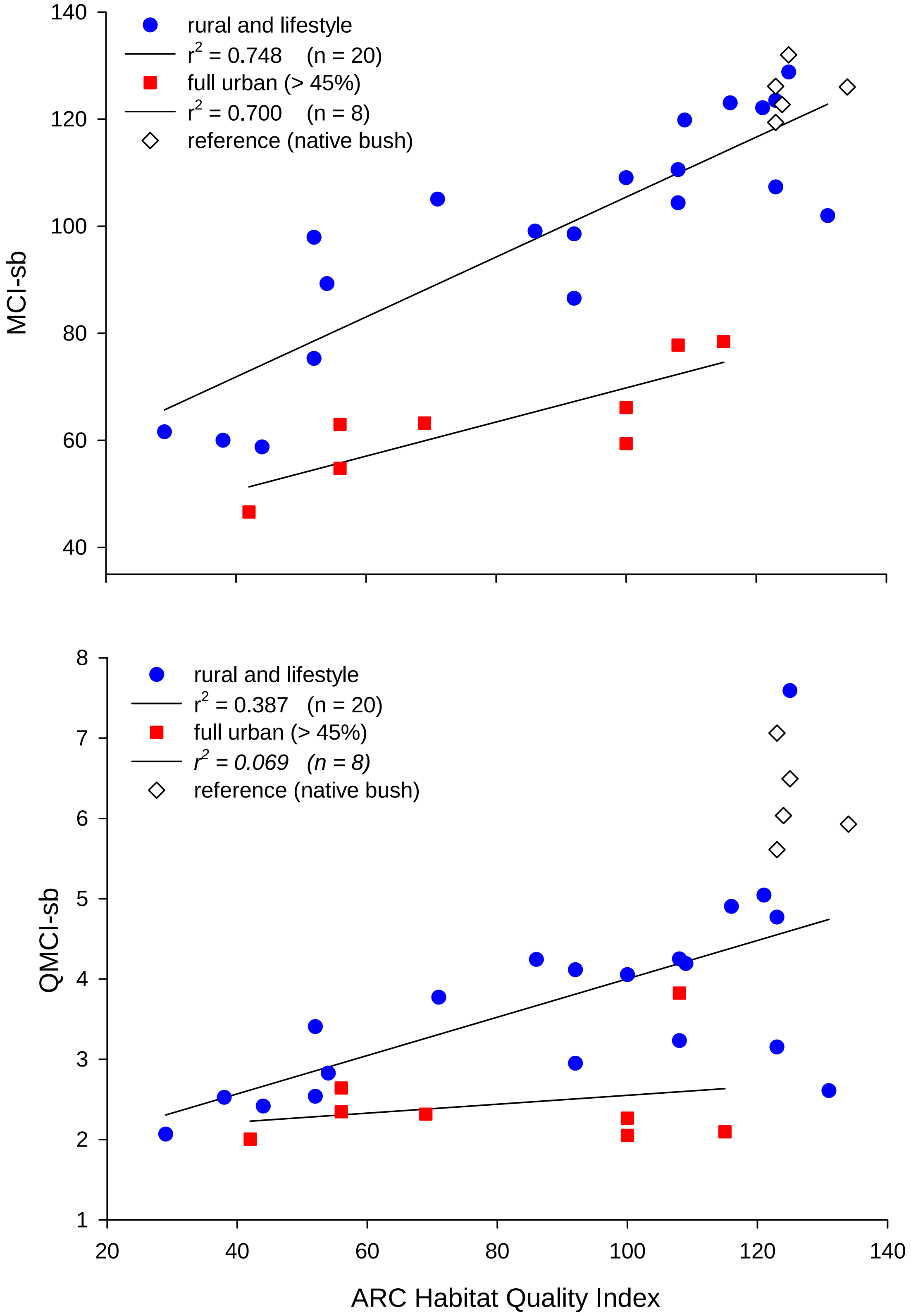

Figure 8 Scatter plots of MCI-sb and QMCI-sb vs ARC Habitat Quality Index. Separate linear regressions for rural and urban sites are shown. Reference sites included for comparison. Italicised r^2 values are not statistically significant (P> 0.05).

Figure 8 presents an example of how the MCI-sb and QMCI-sb are associated with the HQI. We plotted rural and urban sites separately to focus on the relationships within these very different land use classes. Only the fully urban sites were included (> 45% urban land use) to reduce the variability across an urban density gradient. There were too few sites to adequately define such a relationship for the forestry land use class. Significant positive linear correlations were found between the MCI-sb and the HQI for both rural (r^2 = 748, p< 0.001) and urban (r^2 = 700, p = 0.002) land use classes. For the QMCI-sb, the relationship was significant in the rural class (r^2 = 0.387, p = 0.003), but was not significant in the urban class (r^2=0.069, p = 0.529).

These results provide support for the RZM programme, indicating that the maintenance and restoration of native vegetation along stream channels has a positive effect on stream quality. Approximately 75% of the variability in the MCI-sb is explained by the HQI variable alone. The data also indicate that riparian management had a positive effect in urban areas, even though the biota is adversely affected by other stressors (e.g., water quality).

5.3 Predictive relationships with water quality

Water quality is an important catchment- (e.g., nutrients) and local- (e.g., DO) scale variable affecting biological communities in streams. We found a strong relationship between the MCI-sb and the WQI-sb (Figure 7). However, habitat quality can also influence stream communities, as discussed in the previous section. For a given HQI value, a higher biotic index value would be expected from a rural catchment compared with an urban catchment (Figure 8). Since the HQI measures instream and riparian habitat conditions, something else must be responsible for the reduction in urban stream health. It is logical to conclude that urban streams tend to have poorer water quality than rural streams. Recent analyses of ARC's water quality network data support this conclusion (ARC 2000).

Although it is not statistically correct to calculate mean values from medians, the data in Table 13 suggest that urban streams have more turbid water, lower dissolved oxygen levels, and higher levels of bacteria, nutrients and conductivity than rural streams. This is also reflected in lower WQI-sb values (where higher values indicate better water quality). In addition, there are likely to be contaminants such as oils and grease, and industrial effluents, that are not routinely measured but which will contribute to poorer water quality in urban streams. Of course, rural streams can also suffer from pollution by agri-chemicals, which are not measured as part of ARC's water quality programme.

Table 13 Mean values for selected water quality variables at rural and urban SB streams in the Auckland region. Values are means of site median values.

Water Quality Parameter	Rural sites (N=7)	Urban sites (N=4)
Dissolved oxygen (% saturation)	86.1	76.7
Dissolved oxygen (mg/l)	8.8	7.8
Faecal coliforms	737	1300
Ammoniacal nitrogen (g/m^3)	0.032	0.053
Nitrate nitrogen (g/m^3)	0.619	0.808
Total phosphorus (g/m^3)	0.054	0.081
Suspended solids (g/m^3)	5.35	8.95
Turbidity (NTU)	7.0	10.7
Water temperature (^{o}C)	15.3	15.4
Conductivity (mS/m)	16.5	23.1
Water Quality Index (WQI-sb)	61	39

The outliers in Figure 7 (LUCA, #13 and NGAK, #20) can be explained from available data. First, LUCA is in the early stages of urban development with 22% of the catchment urbanised (Appendix 2). Habitat quality at the site is reasonably good (HQI = 93, Appendix 3) with good native riparian cover, a natural channel, and good instream habitat. Only the OTEH (#28) and WEST (#40) water quality sites had better HQI scores than LUCA. The combination of good habitat quality and a lower degree of urban development may be supporting the better instream communities than the remaining WQ sites. The catchment is undergoing intensive development pressure, and new rules are in place to control development and protect and enhance riparian areas. Time will tell whether the site moves vertically, horizontally, or stays where it is on Figure 7. Second, NGAK was channelised five years ago, severely degrading habitat quality, and resulting in the lowest HQI score (29) in the data set (Appendix 3). Improvements in habitat quality would likely improve the MCI-sb score, and move the site closer to the regression with the other sites.

5.4 The role of the MCI-sb and QMCI-sb in managing SB streams

Although beyond the scope of this report, which is concerned primarily with the development and testing of new biotic indices for SB streams, we have gained further insight into the differing performance of the MCI and QMCI (including the SB versions) and the relative impacts of catchment land-use and SB stream habitat quality on the health of macroinvertebrate communities.

Although the MCI, SQMCI and QMCI were developed as indices of enrichment in HB streams with quality thresholds for their interpretation (Table 4), freshwater ecologists know that different interpretations can result from applying the MCI and SQMCI or QMCI to the same data from a site. Often, a site will be classified into a higher quality class based on the MCI than the SQMCI or QMCI. This has caused some to wonder which is correct, or to be confused regarding why indices designed to assess the enrichment status of a site do not always provide the same assessment.

Firstly, it must be appreciated that there is no single objective method for determining the pollution status of a site. There are many factors involved and no single “right answer”. In fact, often it has been assumed that the MCI provided the “right answer”.

Secondly, the MCI and QMCI (and their SB variants) really are different indices[2]. The MCI and variants deal with lists of taxa (i.e., presence-absence data). High values of the MCI (i.e., > 120) indicate that the average tolerance score of the taxa present at the site is high (> 6) and the site would be classified as “excellent”. If that same site has a QMCI or SQMCI score (i.e., 5.0 – 6.0) that results in classification into a lower quality class (“good”), it means that the dominant taxon/taxa had a relatively lower score (< 6). In such a case one could conclude that while conditions are not bad enough to exclude many clean-water taxa, there was sufficient enrichment to stimulate the proliferation of one (or more) taxa indicative of enriched conditions.

Although we advocate the collection of coded-abundance macroinvertebrate data for SOE monitoring - it is useful to know which taxa are dominant - we recommend caution when using any version of the SQMCI or QMCI to report on the results of SOE monitoring because interpretation of these indices can be confounded by temporal changes in dominance that are unrelated to the pollution status of the site. The QMCI or SQMCI will reflect the temporal change in community composition much more than the MCI, because taxonomic composition of macroinvertebrate communities is a much more conservative measure than the numerical composition. SOE monitoring normally is undertaken over a period of several weeks because it simply is not practical to get around all of the sites more quickly. If rivers are in recession, periphyton may be proliferating and the dominance of chironomids could be increasing. If two sites had identical communities on Day 1, but only one of those sites was sampled then, and the second site was sampled 30 days later, the communities would likely be different. If this occurs, then the use of the semi-quantitative and quantitative biotic indices may complicate the interpretation of SOE data. In such cases the MCI or MCI-sb would be preferred.

---

[2] The SQMCI (and SQMCI-sb) is essentially the same index as the QMCI (or QMCI-sb) but requires coded abundance rather than quantitative data.

Semi-quantitative and quantitative versions of the MCI are most suitable for synoptic surveys (when all samples are collected within a day or two) and upstream vs downstream compliance monitoring, where temporal changes in community composition are unlikely to confound interpretation.

Figure 9 is a distance-weighted least squares 3D surface plot showing how the MCI-sb is influenced by the quality of the instream and riparian habitat (HQI) and the percentage of developed land in the catchment. For a SB stream to have excellent macroinvertebrate communities (i.e., MCI-sb > 120) the HQI must exceed 110 and catchment development must be less than 70%. At the other extreme, when a catchment is fully developed it is likely that conditions will be suitable for macroinvertebrate communities indicative of "fair" conditions (MCI-sb 80 - 100) at best and this would require the HQI to be very high (> 125). "Poor" macroinvertebrate communities (MCI-sb < 80) can also exist in catchments that are not highly developed (ca.10 -30%) if the instream habitat is poor (HQI < 60).

Figure 10 presents a similar plot for the QMCI-sb. This plot indicates that degradation of macroinvertebrate communities (i.e., increasing dominance by tolerant taxa) can occur quite rapidly with a decrease in habitat quality or increasing catchment development. For example, "excellent" conditions (defined here as dominance by high-scoring macroinvertebrate taxa (MCI-sb score > 6)) require less than 30% catchment development and an HQI exceeding 112. Further catchment development is likely to result in a steep decline in QMCI-sb even if HQI scores are high. At the other extreme, if the HQI is less than 50 and catchment development exceeds about 55%, then "poor" macroinvertebrate communities dominated by tolerant taxa (QMCI-sb < 4.0) are almost inevitable.

It may not be coincidental that significant changes to macroinvertebrate community composition occur when catchment development exceeds 30%. Quinn & Hickey (1990b) wrote "With development to pasture, marked impacts on the community composition of river invertebrates do not appear to occur until a large proportion of the catchment ... is developed (i.e., > 30% DEVEL class where median DEVEL = 70%). Development of 1-10 and 10-30% of the catchment appears to increase invertebrate biomass without causing any reduction in taxonomic richness, diversity, or loss of the potentially more sensitive ephemeropteran, trichopteran, and plecopteran species." The QMCI-sb, then, would seem to be a good indicator of the changes in macroinvertebrate communities that Quinn & Hickey (1990b) described.

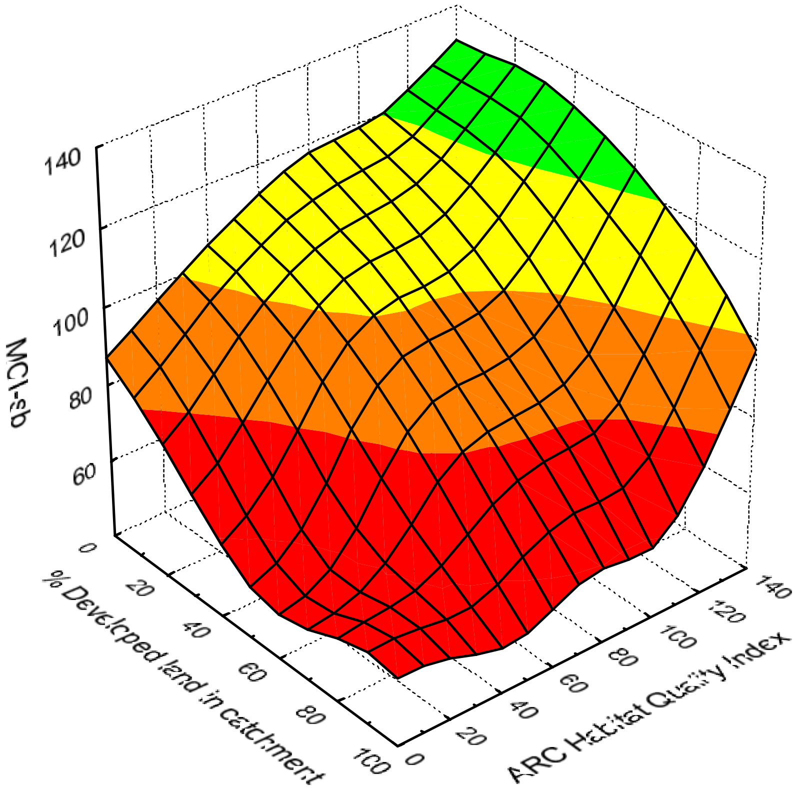

Figure 9 Surface plot showing the relationships between MCI-sb, the percentage of developed land in the catchment, and the ARC Habitat Quality Index.
Key to MCI-sb interpretation: 🟩 Excellent (> 120) 🟨 Good (100 – 120), 🟧 Fair (80 – 100), 🟥 Poor (<80).

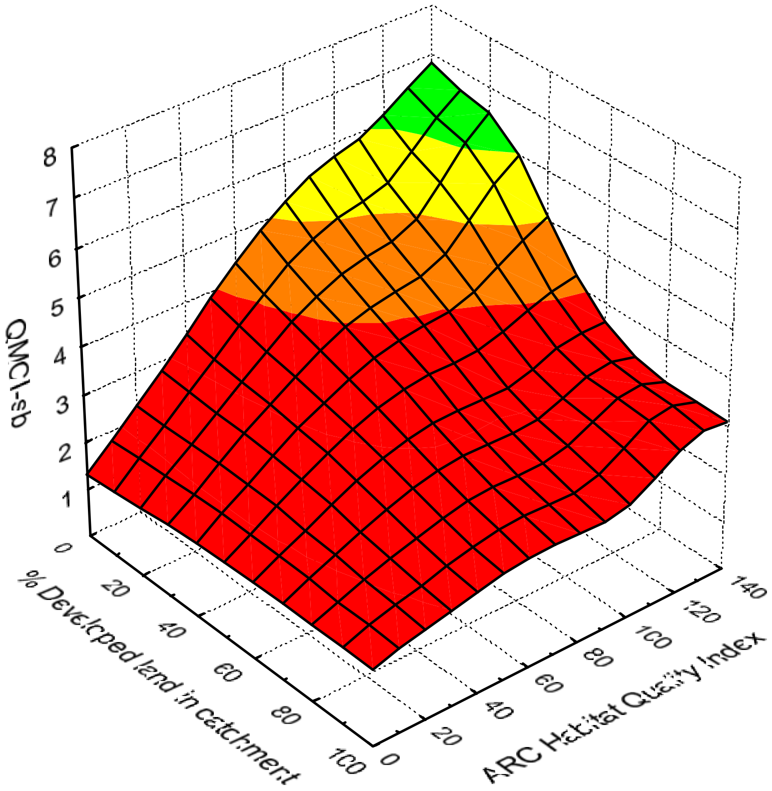

Figure 10 Surface plot showing the relationships between QMCI-sb, the percentage of developed land in the catchment, and the ARC Habitat Quality Index.
Key to QMCI-sb interpretation: 🟩 Excellent (> 6) 🟨 Good (5 – 6), 🟧 Fair (4 – 5), 🟥 Poor (<4).

There are lessons for water managers here.

- To maintain (or restore) “excellent” macroinvertebrate communities, it is essential to have high quality riparian and instream habitat and a low level of catchment development.
- Even in an undeveloped catchment, degradation of the riparian and instream habitat can result in severe reduction in the health of the stream ecosystem.
- In a fully developed catchment where the instream and riparian habitat is also degraded it may not be possible to return aquatic communities to reference condition or to prevent tolerant taxa dominating macroinvertebrate communities. However, by improving the instream and riparian habitat conditions it should be possible to create conditions that permit a range of more sensitive macroinvertebrates to exist (although they would be unlikely to dominate community composition).
- If habitat quality is maintained in healthy state, then a catchment can be developed to 30% before communities become dominated by tolerant macroinvertebrate taxa and 70% before there is appreciable loss of intolerant taxa.
- Streams in forestry and rural catchments with good habitat quality (e.g., mature forestry and lifestyle) approach the “excellent” biological conditions found in native bush catchments.
- Streams in forestry catchments have water quality sufficient to support “excellent” biological communities, although habitat quality is adversely affected by sediment deposition.
- In rural areas, riparian restoration, including the fencing of stock and the establishment of native riparian buffers, has the potential to achieve “excellent” biological conditions. Although we have no water quality data for catchments in “lifestyle” rural land use (low stock densities and good riparian protection), biological and physical habitat conditions approach those found in native bush catchments.
- It may not be possible for urban streams to attain “excellent” biological conditions without improvements in water quality, although substantial improvement would likely be achieved from riparian restoration, including the planting of native trees to shade the channel.

Clearly, the conclusions drawn from these graphs are generalisations that may not apply in all situations. However, these graphs suggest that if water managers adopt policies that control the extent and nature of catchment development, and maintain or improve instream and riparian habitats, then the health of SB ecosystems can be maintained and improved.

6. SUMMARY AND FUTURE DIRECTIONS

Taxon tolerance scores that form the basis of new biotic indices for SB streams (MCI-sb & QMCI-sb) were derived using an objective iterative process from a macroinvertebrate dataset collected in 2000 – 2004 from SB streams in the Auckland region. The Auckland dataset, which was collected deliberately to include a range of the best and worst sites within different land-use classes, was an ideal basis for developing new biotic indices.

The new taxon-specific tolerance scores for SB streams are shown in Appendix 8. These scores are recommended for calculating presence-absence (MCI-sb), coded abundance (SQMCI-sb), and quantitative (QMCI-sb) metric scores for data collected from SB streams using protocol C2 (Stark et al., 2001). The equations for calculating SB versions of the MCI are identical to those for the original versions of the MCI developed for HB streams (see Section 3). The only difference is that the list of taxon scores developed specifically for SB streams (column SB in Appendix 8) must be used.

To avoid confusion we recommend that the metrics developed for SB streams be denoted MCI-sb, SQMCI-sb, and QMCI-sb. The terms MCI, SQMCI, and QMCI refer only to the original versions that were developed for HB streams (Stark 1985, 1993, 1998).

Correlation analyses indicate that the MCI-sb and QMCI-sb perform much better than the MCI and QMCI when applied to SB streams. In particular, there is a greater range from the worst to the best sites and higher correlations with environmental variables. This suggests that these indices should prove useful for assessing the health of SB streams. MCI-sb and QMCI-sb values also correlated highly with environmental variables such as the percentage of developed land in the catchment, and ARC's habitat and water quality indices.

While single hand-net samples from SB streams provide robust estimates of the MCI-sb (two samples must differ by around 12 MCI-sb units for them to be considered significantly different), the QMCI-sb performs relatively poorly in this respect. A detectable difference of nearly 1.4, equivalent to nearly 28% of an average value (5.0) of this index, does not inspire great confidence that a site will be assigned to the correct quality class. We suspect that this reflects the greater between-replicate variability in community composition in SB stream samples. HB samples tend to be collected from relatively uniform stony riffles, whereas the protocol for SB streams involves sampling multiple habitats (submerged wood, bank margins and macrophytes) that vary in occurrence and proportion between sites and samples.

We advocate the collection of relative abundance data for SOE monitoring because it is useful to know which taxa are dominant, and the additional information provides for a greater depth of ecological understanding. For reasons outlined above and for better precision in scoring and quality classification (than the quantitative or semi-quantitative versions), we suggest that the MCI (HB streams) and MCI-sb (SB streams) be used for SOE reporting.

To date, there has been no testing of the performance of the SB indices with independent data collected from SB streams in the Auckland region. This will be possible as data from additional SB streams become available.

The applicability of the MCI-sb to SB streams in other regions of New Zealand also requires evaluation. Few suitable datasets (i.e. covering the full range of stream "health") appear to exist, but running the Chessman process on data from the Waikato region (Collier 2004) yielded taxon scores that were similar to those derived from the Auckland data.

Given that the MCI was developed using data from the Taranaki region and was found to perform well nationwide, it is our belief that the MCI-sb will also be useful throughout New Zealand (although taxon tolerance scores will need to be derived for taxa not encountered in the Auckland dataset). During 2005, funding from MfE and other regional councils will be used to evaluate the performance of the MCI-sb in other regions of New Zealand. Macroinvertebrate data from SB streams are sparse in most regions of New Zealand, so we may be limited to applying the Auckland-derived MCI-sb to data from other regions and evaluating its performance. If suitable datasets are available (i.e., covering the best and worst SB stream sites), then the Chessman process could be used to derive new scores. Ultimately, it is hoped that the existence of protocols for sampling SB streams (Stark et al. 2001) and biotic indices for interpreting the data might stimulate regional councils to include more SB stream sites in their SOE monitoring programmes. The application of the MCI-sb (and variants) to data collected from SB streams is identical to that for the MCI (apart from the new taxon-specific tolerance scores), and is essentially a rapid desk-top exercise. We urge ecologists and water managers in other regional councils to give it a try.

7. ACKNOWLEDGMENTS

We wish to thank Bruce Chessman (Department of Natural Resources, New South Wales, Australia) for discussion and clarification of the method he developed for deriving taxon scores. Without Bruce's help the new indices would not have been developed. We also wish to thank Mike McMurtry (ARC) and Joanne Wilks (ARC) for their assistance with field work and data management. Mike McMurtry prepared the site location map, and compiled land-use data. Joanne Wilks prepared the water quality indices. Shane Kelly (ARC) provided statistical advice. Mike Scarsbrook, Graham McBride, and Bob Wilcock (NIWA) provided advice on the water quality index. Special thanks are due to Chris Hatton (Manager Environmental Research, ARC) for believing in the merits of this project. Finally, we thank the Ministry for the Environment for providing some additional financial support for this work.

8. LITERATURE CITED

Allibone, R.; Horrox, J.; Parkyn, S. 2001: Stream classification and instream objectives for Auckland's urban streams. Prepared by the National Institute of Water and Atmospheric Research (NIWA) for the Auckland Regional Council, Environmental Research, 21 Pitt Street, Auckland. 79 pages.

ANZECC & ARMCANZ 2000: National water quality management strategy: Australian and New Zealand Guidelines for freshwater and marine water quality. Australian and New Zealand Environment and Conservation Council and Agricultural Management Council of Australia and New Zealand, Canberra, Australia.

Auckland Regional Council 2000: Year 2000 summary report, baseline water quality, streams, lakes and saline waters. Technical Publication 132, prepared by R. Wilcock and M. Stroud, National Institute of Water and Atmospheric Research (NIWA) for the ARC, Environmental Management, Environmental Research, 21 Pitt Street, Auckland, 219 pages.

Auckland Regional Council 2001a: Habitat quality assessment protocol (documentation and electronic field sheets). Environmental Management, Environmental Research, 21 Pitt Street, Auckland.

Auckland Regional Council 2001b: Riparian zone management: strategy, guidelines, and planting guide. Technical Publication TP148, Environmental Management, 21 Pitt Street, Auckland.

Chessman, B. C. 2003: New sensitivity grades for Australian river macroinvertebrates. *Marine and Freshwater Research 54*:95-103.

Chessman, B. C.; Growns, J. E.; Kotlash, A. R. 1997: Objective derivation of macroinvertebrate family sensitivity grade numbers for the SIGNAL biotic index: application to the Hunter River system, New South Wales. *Marine and Freshwater Research 48*:159-172.

Collier, K. J. 2004: Invertebrate community dynamics in soft-bottomed streams of northern New Zealand: a spatio-temporal hierarchy. *New Zealand Journal of Marine and Freshwater Research 38*: 1-18.

Dean, T. L.; Richardson, J. 1999. Response of seven species of native freshwater fish and a shrimp to low dissolved oxygen. *New Zealand Journal of Marine and Freshwater Research 33*: 99-106.

Grabow, G. L.; Spooner, J.; Lombardo, L. A.; Line, D. E.; Tweedy, K. L. 1998: Has water quality improved? Use of a spreadsheet for statistical analysis of paired watershed, upstream/downstream and before/after monitoring designs. Sixth National Nonpoint-Source Monitoring Workshop. Cedar Rapids, Iowa. 12p.

http://www.bae.ncsu.edu/programs/extension/wqg/grabow/sasfact.pdf

Maxted, J. R.; Evans, B. F.; Scarsbrook, M. R. 2003: Development of standard protocols for macroinvertebrate assessment of soft-bottomed streams in New Zealand. *New Zealand Journal of Marine and Freshwater Research 37(4)*: 793-807.

Ministry for the Environment 1999: The use of macroinvertebrates in water management, recommendations of the New Zealand Macroinvertebrate Working Group, Wellington, New Zealand. 118 p.

Ministry for the Environment 2004a: NZ land cover database version 2. Digital database for the Auckland region, Wellington.

Ministry for the Environment 2004b: NZ land cover database version 2; illustrated guide to targeted classes (version 4.0), Wellington.

Narf, R. P.; Lange, E. L.; Wildman, R. C. 1984: Statistical procedures for applying Hilsenhoff's Biotic Index. *Journal of Freshwater Ecology 2(5*):441-448.

National Institute of Water and Atmospheric Research 2004: River Environment Classification. Digital database for the Auckland region, available on the NIWA web site at http://www.niwa.co.nz/ncwr/rec/.

Quinn, J. M.; Boothroyd, I. K. G.; Smith, B. J. 2004: Riparian buffers mitigate effects of pine plantation logging on New Zealand streams 2. Invertebrate communities. *Forest Ecology and Management 191*:129-146.

Quinn, J. M.; Hickey, C. W. 1990a: Characterisation and classification of benthic invertebrate communities in 88 New Zealand rivers in relation to environmental factors. *New Zealand Journal of Marine and Freshwater Research 24*:387-409.

Quinn, J. M.; Hickey, C. W. 1990b: Magnitude of effects of substrate particle size, recent flooding, and catchment development on benthic invertebrates in 88 New Zealand rivers. *New Zealand Journal of Marine and Freshwater Research 24*:411-427.

Quinn, J. M.; Steel, G. L.; Hickey, C. W.; Vickers, M. L. 1994: Upper thermal tolerances of twelve New Zealand stream invertebrate species. *New Zealand Journal of Marine and Freshwater Research 28*: 391-397.

Richardson, J.; Boubée, J. A. T.; West, D. W. 1994. Thermal tolerances and preferences of some native New Zealand freshwater fish. *New Zealand Journal of Marine and Freshwater Research 28*: 399-407.

Stark, J. D. 1985: A macroinvertebrate community index of water quality for stony streams. Water & Soil Miscellaneous Publication 87. Wellington, Ministry of Works and Development. 53p.

Stark, J. D. 1993: Performance of the Macroinvertebrate Community Index: Effects of sampling method, sample replication, water depth, current velocity, and substratum on index values. *New Zealand Journal of Marine and Freshwater Research 27*: 463-478.

Stark, J. D. 1998: SQMCI: a biotic index for freshwater macroinvertebrate coded abundance data. New *Zealand Journal of Marine and Freshwater Research 32(1)*: 55-66.

Stark, J. D.; Boothroyd, I. K. G.; Harding, J. S.; Maxted, J. R.; Scarsbrook, M. R. 2001: Protocols for sampling macroinvertebrates in wadeable streams. *New Zealand Macroinvertebrate Working Group Report No. 1*. Prepared for the Ministry for the Environment, Wellington, New Zealand. 57 p.

Winterbourn, M. J.; Gregson, K. L. D.; Dolphin, C. H. 2000: Guide to the aquatic insects of New Zealand (Third Edition). Bulletin of the Entomological Society of New Zealand 13. 102p.

Appendix 1 SB stream sites in the Auckland region.

No.	Site code	Stream name	Easting	Northing	AREA	DISTSEA	ALT	WIDTH	THLDEP
1	**AWN1**	Awanohi Upper 1	2660564	6498549	102.16	3.24	38	1.50	0.40
2	**AWN2**	Awanohi Upper 2	2660978	6499344	184.78	2.285	24	1.09	0.32
3	**AWNL**	Awanohi Lower	2661879	6500421	229.00	0.5	5	4.00	0.97
4	**AWNM**	Awanohi Mid	2661091	6499391	235.31	2.16	18	1.23	0.29
5	**AWNT**	Awanohi Rural Trib	2660948	6499412	51.13	2.31	18	1.07	0.25
6	**AWRL**	Awaruku Lower	2666586	6499755	229.00	0.5	5	2.48	0.64
7	**AWRM**	Awaruku Mid	2665624	6499090	129.70	1.7	15	1.90	0.60
8	**CAMP**	Campbells	2667499	6493031	55.21	0.7	15	0.80	0.30
9	**CHAT**	Chatswood	2663312	6485716	46.90	0.5	22	1.30	0.20
10	**HOTE**	Hoteo (WQ)	2645806	6534265	26729.00	21.7	17	-	-
11	**KAUR**	Kauritutahi (Awhitu)	2652469	6454888	65.89	4.4	55	0.90	0.15
12	**KUME**	Kumeu (WQ)	2649711	6490504	4580.00	41	25	3.50	1.07
13	**LUCA**	Lucas (WQ)	2662232	6496226	539.00	0.5	25	1.47	0.33
14	**MAHD**	Mahurangi (Dibble)	2651183	6535637	44.50	30.9	150	0.90	0.14
15	**MAHF**	Mahurangi (Frith Rd)	2658805	6541842	451.00	52.5	130	1.96	0.19
16	**MAHK**	Mahurangi (Kraaks)	2653890	6536008	69.10	40.7	90	1.72	0.21
17	**MAHU**	Mahurangi (WQ)	2658200	6526601	466.00	12	58	2.98	0.44
18	**MATA**	Matakana (WQ)	2664159	6538133	1395.70	1.4	15	2.44	0.40
19	**MTAU**	Mt Auckland	2641118	6528410	84.11	3.4	15	-	-
20	**NGAK**	Ngakaroa (WQ)	2685538	6443280	487.40	13.9	130	1.68	0.42
21	**NUKU**	Nukumea Upper	2659709	6513269	87.10	2.5	25	1.29	0.65
22	**OAKL**	Oakley (WQ)	2662346	6479208	1204.00	0.3	5	3.31	0.57
23	**OKU1**	Okura trib. 1	2664517	6500683	50.85	0.62	15	0.94	0.30
24	**OKU2**	Okura trib. 2	2663168	6500464	119.32	0.45	15	1.05	0.30
25	**ONEP**	Onepoto	2665453	6486993	87.60	0.8	16	1.97	0.33
26	**OTAN**	Otanerua	2660330	6513934	47.00	2.58	30	1.03	0.50
27	**OTAR**	Otara (WQ)	2678741	6470043	1796.00	0.6	5	3.02	0.62
28	**OTEH**	Oteha (WQ)	2662012	6494552	1003.00	1	7	7.98	0.97
29	**PAPA**	Papakura (WQ)	2681465	6461940	3558.00	2	10	4.57	0.51
30	**PUHI**	Puhinui (WQ)	2676889	6465924	1159.00	5.8	18	3.05	0.75
31	**PUHO**	Puhoi	2655453	6521655	22.20	9.2	38	1.77	0.23
32	**PUHT**	Puhunui trib. (Totara Pk)	2680457	6464961	211.70	10.9	47	1.95	0.39
33	**RIVE**	Riverhead	2647657	6494771	401.00	39.3	41	1.50	0.51
34	**SHAK**	Shakespear	2674450	6508593	24.30	0.9	23	0.70	0.15
35	**VAUL**	Vaughan Lower	2665939	6500463	227.50	0.1	3	1.37	0.30
36	**VAUM**	Vaughan Mid	2665323	6500150	147.60	1	10	1.40	0.62
37	**VAUU**	Vaughan Upper	2664741	6499887	100.30	0.5	17	1.60	0.28
38	**WAIR**	Wairoa (WQ)	2693077	6463483	14988.00	12.1	15	7.30	0.71
39	**WAIW**	Waiwera (WQ)	2659061	6515382	2970.00	4.2	10	6.49	1.03
40	**WEST**	West Hoe	2658699	6512425	29.20	2.3	38	0.88	0.35
41	**WHAR**	Wharauroa	2643561	6494798	676.20	31.7	22	3.42	0.26

AREA = catchment area (ha), DISTSEA = distance from sea (km), ALT = site altitude (m above mean sea level), WIDTH = mean stream width (m), THLDEP = mean thalweg depth (m). WQ = routine water quality sampling site.

Appendix 2 Catchment landuse data for 41 SB streams in the Auckland region (from LCDB2 2002). (* < 0.1%). See Appendix 1 for key to site codes.

No.	Site code	LUC	NAT	OLDFOR	NEWFOR	ETRSH	FOR	CROP	PASGRA	RUR	URB	OTHER	DEVPER
1	**AWN1**	RUR1	69.4	10.1	-	-	10.1	-	19.9	19.9	0.6	-	20.5
2	**AWN2**	RUR1	76.3	5.9	-	-	5.9	-	17.5	17.5	0.3	-	17.8
3	**AWNL**	RUR2	54.9	7.5	0.5	1.6	9.6	-	35.4	35.4	0.1	-	35.5
4	**AWNM**	RUR1	61.0	7.5	0.6	3.6	11.7	-	27.1	27.1	0.3	-	27.3
5	**AWNT**	RUR2	8.9	13.1	2.6	17.3	33.0	-	58.1	58.1	-	-	58.1
6	**AWRL**	URB2	9.9	1.5	-	0.5	2.0	-	10.2	10.2	77.9	-	88.1
7	**AWRM**	URB2	14.5	2.4	-	0.9	3.3	-	1.6	1.6	80.6	-	82.2
8	**CAMP**	URB1	38.7	2.0	-	-	2.0	-	33.4	33.4	26.0	-	59.4
9	**CHAT**	URB2	24.4	-	-	-	-	-	2.7	2.7	72.9	-	75.6
10	**HOTE**	RUR2	19.6	13.7	9.4	0.4	23.6	0.1	56.5	56.6	0.2	0.1	56.9
11	**KAUR**	RUR1	86.2	0.9	-	-	0.9	-	13.0	13.0	-	-	13.0
12	**KUME**	RUR2	12.4	2.6	0.4	0.8	3.9	4.6	77.4	82.1	1.5	0.1	83.7
13	**LUCA**	URB1	9.5	9.0	-	0.9	9.9	-	58.8	58.8	21.8	-	80.6
14	**MAHD**	FOR2	-	94.7	5.3	-	100.0	-	-	-	-	-	-
15	**MAHF**	FOR1	67.4	30.8	-	-	30.8	-	1.8	1.8	-	-	1.8
16	**MAHK**	FOR2	-	4.5	93.6	-	98.1	-	1.9	1.9	-	-	1.9
17	**MAHU**	FOR2	1.7	0.1	98.1	-	98.2	-	0.1	0.1	-	-	0.1
18	**MATA**	RUR2	39.1	12.8	4.2	1.0	18.0	0.1	42.6	42.8	0.2	-	42.9
19	**MTAU**	REF	100.0	-	-	-	-	-	-	-	-	-	-
20	**NGAK**	RUR2	1.4	1.8	-	1.9	3.6	22.2	72.8	95.0	-	-	95.0
21	**NUKU**	REF	98.0	-	-	-	-	-	2.0	2.0	-	-	2.0
22	**OAKL**	URB2	2.0	0.1	-	-	0.1	-	18.1	18.1	79.8	-	97.8
23	**OKU1**	RUR1	14.2	12.3	-	1.3	13.6	-	72.2	72.2	-	-	72.2
24	**OKU2**	RUR1	35.0	18.2	-	6.3	24.5	-	40.5	40.5	*	-	40.5
25	**ONEP**	URB2	30.3	-	-	-	-	-	6.1	6.1	63.6	-	69.7
26	**OTAN**	REF	97.9	-	-	-	-	-	2.1	2.1	-	-	2.1
27	**OTAR**	URB2	5.8	1.5	0.1	*	1.7	0.4	84.5	84.8	7.6	0.1	92.5
28	**OTEH**	URB2	7.3	2.2	0.5	1.2	3.9	-	32.6	32.6	55.4	0.8	88.8
29	**PAPA**	RUR2	9.9	5.7	3.1	1.0	9.8	1.4	77.0	78.4	1.8	0.2	80.4
30	**PUHI**	URB2	8.7	1.7	-	-	1.7	-	44.7	44.7	44.8	-	89.5
31	**PUHO**	REF	93.1	-	-	-	-	-	6.9	6.9	-	-	6.9
32	**PUHT**	URB1	16.6	3.8	-	-	3.8	-	57.8	57.8	21.8	-	79.5
33	**RIVE**	FOR2	0.1	44.9	52.2	-	97.1	-	0.4	0.4	2.3	-	2.7
34	**SHAK**	RUR1	49.5	-	-	-	-	-	50.5	50.5	-	-	50.5
35	**VAUL**	RUR2	22.4	11.2	-	-	11.2	-	62.5	62.5	3.9	-	66.4
36	**VAUM**	RUR1	31.1	12.1	-	-	12.1	-	51.9	51.9	4.9	-	56.8
37	**VAUU**	RUR1	33.1	18.1	-	-	18.1	-	46.3	46.3	2.5	-	48.8
38	**WAIR**	RUR2	26.1	13.3	9.7	0.8	23.8	*	50.0	50.0	*	0.1	50.1
39	**WAIW**	RUR2	41.6	1.3	3.9	1.5	6.7	0.5	51.2	51.7	-	*	51.7
40	**WEST**	REF	99.4	-	-	-	-	-	0.6	0.6	-	-	0.6
41	**WHAR**	RUR1	24.8	1.2	1.6	-	2.8	0.5	72.0	72.5	-	-	72.5

LUC = overall land-use class (see Tables 1 and 2 for key to land-use classes), NAT = % native forest, OLDFOR = % old exotic forest, NEWFOR = % new exotic forest, ETRSH = % exotic trees & shrubs. FOR = OLDFOR+NEWFOR+ETRSH, CROP = % cropland, PASGRA = % pasture & grassland, RUR = CROP+PASGRA, URB = % urban, OTHER = % other land-uses, DEVPER (developed percentage) = RUR+URB+MISC.

Appendix 3 Habitat quality data for 41 SB stream sites in the Auckland region. See Appendix 1 for key to site codes.

No.	Site code (maximum points)	AHA (20)	AHD (20)	HH (20)	CA (20)	BS (20)	CS (20)	RW (20)	HQI (140)
1	AWN1	20	17	16	17	16	19	20	**125**
2	AWN2	12	16	13	18	14	19	16	**108**
3	AWNL	12	16	4	15	17	14	14	**92**
4	AWNM	16	17	14	18	8	18	18	**109**
5	AWNT	18	16	16	13	16	5	8	**92**
6	AWRL	14	11	6	5	18	0	2	**56**
7	AWRM	13	13	13	13	12	18	18	**100**
8	CAMP	16	16	9	15	18	16	14	**104**
9	CHAT	13	11	16	16	16	18	18	**108**
10	HOTE	12	11	5	18	0	4	2	**52**
11	KAUR	16	17	18	18	18	18	16	**121**
12	KUME	15	9	5	7	14	0	2	**52**
13	LUCA	14	15	13	14	11	14	12	**93**
14	MAHD	11	16	16	18	14	11	18	**86**
15	MAHF	5	4	15	16	4	13	18	**75**
16	MAHK	16	15	9	18	12	5	0	**75**
17	MAHU	3	3	11	16	0	9	12	**54**
18	MATA	15	13	12	15	5	5	6	**71**
19	MTAU	18	17	18	20	18	18	16	**125**
20	NGAK	14	3	2	3	4	2	1	**29**
21	NUKU	18	18	13	20	20	14	20	**123**
22	OAKL	15	13	13	6	14	6	2	**69**
23	OKU1	17	18	19	20	20	19	18	**131**
24	OKU2	15	13	17	14	12	17	12	**100**
25	ONEP	13	14	16	18	16	18	20	**115**
26	OTAN	19	19	15	19	18	18	16	**124**
27	OTAR	14	7	11	5	12	3	4	**56**
28	OTEH	15	13	9	16	16	17	14	**100**
29	PAPA	12	3	8	1	20	0	0	**44**
30	PUHI	15	5	6	6	8	0	2	**42**
31	PUHO	16	18	20	20	20	20	20	**134**
32	PUHT	17	15	10	16	18	19	18	**113**
33	RIVE	7	2	7	20	18	16	20	**90**
34	SHAK	18	17	15	20	18	17	18	**123**
35	VAUL	13	7	8	8	2	0	0	**38**
36	VAUM	16	13	11	19	19	18	12	**108**
37	VAUU	16	15	15	18	18	18	16	**116**
38	WAIR	18	18	16	18	14	2	0	**86**
39	WAIW	11	16	5	16	4	1	1	**54**
40	WEST	18	16	18	19	20	18	14	**123**
41	WHAR	18	18	17	18	18	18	16	**123**

AHA = aquatic habitat abundance, AHD = aquatic habitat diversity, HH = habitat heterogeneity, CA = channel alteration, BS = bank stability, CS = channel shade, RVW = riparian vegetation width.

Appendix 4 Median water quality data for 14 SB streams in the Auckland region. See Appendix 1 for key to site codes.

No.	SITE CODE	N	BD	DO	DOSAT	FC	NH4	NO3	TP	SS	TURB	TEMP	COND	WQI-W&S	WQI-sb
10	**HOTE**	144	0.485	8.75	87.0	140	0.033	0.413	0.061	6.70	8.25	15.5	18.1	47	63
	n		116	135	135	143	142	142	141	143	142	130	137		
12	**KUME**	144	0.420	8.45	83.0	800	0.045	0.443	0.070	9.30	11.75	15	16.1	28	46
	n		113	113	113	121	120	120	118	121	120	109	121		
13	**LUCA**	144	0.270	7.90	78.3	500	0.051	0.281	0.070	15.00	23.90	13.6	23.6	19	45
	n		113	116	116	123	124	123	121	124	123	111	124		
17	**MAHU**	144	0.520	9.40	90.0	155	0.030	0.253	0.030	5.80	10.00	13.5	18.0	66	79
	n		114	116	116	124	123	123	121	124	123	111	124		
18	**MATA**	144	0.770	8.15	81.0	330	0.030	0.089	0.040	4.30	5.35	14.9	18.2	67	72
	n		113	135	135	143	142	142	141	143	142	130	136		
20	**NGAK**	144	1.530	9.20	88.4	300	0.011	2.133	0.028	1.20	2.00	15.3	14.8	65	74
	n		115	117	117	124	125	124	122	125	125	110	125		
22	**OAKL**	144	0.800	8.25	83.0	1300	0.040	1.682	0.066	3.65	3.70	15.5	23.7	38	50
	n		104	103	103	111	112	111	108	112	112	98	112		
27	**OTAR**	144	0.430	6.10	61.8	1700	0.060	0.286	0.130	10.35	8.40	15.2	22.6	4	29
	n		109	134	134	143	144	143	140	144	144	127	144		
28	**OTEH**	144	0.330	7.75	74.0	500	0.050	0.506	0.060	11.80	20.85	14	24.65	11	40
	n		113	135	135	142	143	142	140	143	142	129	136		
29	**PAPA**	144	0.505	7.80	76.7	2300	0.050	0.596	0.080	4.50	6.30	15.25	18.7	14	36
	n		118	118	118	124	125	124	122	125	125	111	125		
30	**PUHI**	144	0.410	8.95	88.0	1700	0.060	0.758	0.070	10.00	9.60	17	21.4	13	36
	n		111	111	111	118	119	118	116	119	119	104	118		
38	**WAIR**	144	0.830	9.75	95.0	490	0.023	0.484	0.051	4.55	6.30	16	11.5	65	71
	n		106	126	126	143	144	143	141	144	144	119	143		
39	**WAIW**	144	0.470	9.25	92.0	800	0.030	0.174	0.050	6.90	9.00	15	18.4	52	68
	n		114	135	135	143	142	142	140	143	144	130	136		
40	**WEST**	25	1.000	9.60	88.8	220	0.040	0.059	0.030	6.30	11.00	98.0	12.7	-	75
	n		0	21	21	23	23	23	23	23	23	23	22		

N = number of sampling occasions (Jan 1991 – Dec 2003, except West Hoe Jan – Dec 2002), n = number of values for each determinand, BD = black disk (m) (Value for West Hoe estimated), DO = dissolved oxygen (mg/l), DOSAT = dissolved oxygen saturation (%), FC = faecal coliforms (MPN/100ml). NH4 = ammoniacal nitrogen (g/m^3), NO3 = nitrate nitrogen (g/m^3), TP = total phosphorus (g/m^3), SS = suspended solids (g/m^3), TURB = turbidity (NTU), TEMP = water temperature (°C), Conductivity (mS/m).

Key to Water Quality Indices:

WQI-W&S	ARC index developed by Wilcock & Stroud (ARC 2000) using median data for BD, DOSAT, FC, NH4, NO3, TP, SS, TURB from 13 SB sites and 3 HB sites.
WQI-sb	ARC index using median data for DOSAT, FC, NH4, NO3, TP, SS from 14 SB sites.

Appendix 5 Macroinvertebrate taxon codes used in Appendix 6.

Code	Taxon name	Code	Taxon name	Code	Taxon name
Acan	*Acanthophlebia*	Hemi	*Hemicordulia*	Para1	*Paradixa*
Acar	Acarina	Hexa	Hexatomini	Para2	*Paralimnophila*
Acro	*Acroperla*	Hiru	Hirudinea	Para3	*Paranephrops*
Amel	*Ameletopsis*	Huds	*Hudsonema*	Para4	*Paratya*
Amph	Amphipoda	Hydr1	*Hydrobiosis*	Paro	*Paroxyethira*
Anis	*Anisops*	Hydr2	Hydrophilidae	Pauc	*Paucispinigera*
Anth	Anthomyiidae	Hygr	*Hygraula*	Phys	*Physa*
Anti1	*Antipodochlora*	Hyri	*Hyridella*	Plat	Platyhelminthes
Anti2	*Antiporus*	Isop	Isopoda	Poly1	*Polypedilum*
Aote	*Aoteapsyche*	Isot	*Isothraulus*	Poly2	*Polyplectropus*
Aphr	*Aphrophilia*	Lati	*Latia*	Pota	*Potamopyrgus*
Arac	*Arachnocolus*	Limn	*Limnophora*	Psil	*Psilochorema*
Arch	*Archichauliodes*	Limo	*Limonia*	Psyc	Psychodidae
Aust1	*Austroclima*	Lobo	*Lobodimaesa*	Ptil	Ptilodactylidae
Aust2	*Austrolestes*	Lymn	*Lymnaea*	Pycn1	*Pycnocentria*
Aust3	*Austronella*	Maor	*Maoridiamesa*	Pycn2	*Pycnocentrodes*
Aust4	*Austroperla*	Maui	*Mauiulus*	Rall	*Rallidens*
Aust5	*Austrosimulium*	Mega	*Megaleptoperla*	Rhan	*Rhantus*
Cera	Ceratopogonidae	Mela	*Melanopsis*	Sald	Saldidae
Chir1	Chironomidae	Micr	*Microvelia*	Scio	Sciomyzidae
Chir2	*Chironomus*	Misc	*Mischoderus*	Scir	Scirtidae
Coll	Collembola	Molo	*Molophilus*	Siga	*Sigara*
Colo	*Coloburiscus*	Musc	Muscidae	Span	*Spaniocerca*
Cope	*Copelatus*	Nema1	Nematoda	Spha	Sphaeriidae
Culi	Culicidae indet.	Nema2	Nematomorpha	Stap	Staphylinidae
Dele	*Deleatidium*	Neme	Nemertea	Stra	Stratiomyidae
Dipt	Diptera	Neol	*Neolimnia*	Taba	Tabanidae
Dixi	Dixidae	Neoz	*Neozephlebia*	Tany1	Tanypodinae
Doli	Dolichopodidae	Nesa	*Nesameletus*	Tany2	*Tanytarsus*
Dolo	*Dolomedes*	Neso	*Nesoperla*	Tepa	*Tepakia*
Ecno	*Ecnomina*	Neur	*Neurochorema*	Tipu	Tipulidae
Elmi	Elmidae	Oece	*Oecetis*	Trip	*Triplectides*
Empi	Empididae	Oeco	*Oeconesus*	Urop	*Uropetala*
Enoc	Enochrus	Olig	Oligochaeta	Xant	*Xanthocnemis*
Erio	Eriopterini	Olin	*Olinga*	Zela1	*Zelandobius*
Ferr	*Ferrisia*	Orth1	Orthocladiinae	Zela2	*Zelandoperla*
Gyra	*Gyraulus*	Orth2	*Orthopsyche*	Zela3	*Zelandoptila*
Harr	*Harrisius*	Ostr	Ostracoda	Zela4	*Zelandotipula*
Heli	*Helicopsyche*	Oxye	*Oxyethira*	Zeph	*Zephlebia*

Appendix 6 Mean counts of 117 macroinvertebrate taxa at 41 SB stream sites in the Auckland region. See Appendix 5 for key to taxa codes and Appendix 1 for key to site codes. The number of samples collected from each site is shown in Appendix 7(column labelled 'N').

Site code	Acan	Acar	Acro	Amel	Amph	Anis	Anth	Anti1	Anti2	Aote	Aphr	Arac	Arch	Aust1	Aust2	Aust3	Aust4	Aust5	Cera
AWN1	-	0.50	-	-	0.50	-	-	0.50	-	-	-	0.50	-	-	-	-	-	-	-
AWN2	-	-	0.50	-	5.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AWNL	-	-	-	-	5.00	-	-	-	0.50	-	-	-	-	-	-	-	-	-	-
AWNM	-	-	-	-	8.67	-	-	-	-	-	-	-	0.67	0.33	-	-	-	0.33	-
AWNT	-	-	-	-	10.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AWRL	-	-	-	-	2.75	-	-	-	-	-	-	-	-	-	-	-	0.13	1.50	-
AWRM	-	0.11	-	-	0.22	0.33	-	-	-	-	-	-	-	-	0.33	-	-	-	-
CAMP	-	-	-	-	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CHAT	-	-	-	-	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-	1.00
HOTE	-	-	-	-	20.00	-	-	-	-	5.00	-	-	-	-	-	-	-	-	-
KAUR	-	-	-	-	10.00	-	-	0.67	-	-	-	-	-	1.67	-	-	-	0.67	-
KUME	-	-	-	-	80.00	-	-	-	-	-	-	-	-	-	0.25	-	-	5.00	-
LUCA	-	-	-	-	2.75	-	-	0.50	-	-	-	-	-	-	-	-	-	0.50	-
MAHD	-	-	-	-	0.33	-	-	0.33	0.33	-	0.33	0.67	0.67	-	-	-	-	0.33	-
MAHF	0.25	-	-	0.75	0.50	-	-	-	-	-	0.25	-	0.50	0.25	-	-	0.50	1.75	0.25
MAHK	-	-	0.25	-	-	-	0.25	0.50	0.25	-	-	-	0.25	2.75	-	0.25	-	7.75	-
MAHU	-	-	-	-	0.25	-	-	0.25	-	11.25	-	-	0.50	1.25	-	-	-	0.25	-
MATA	-	-	-	-	8.75	0.25	-	0.25	-	-	1.25	-	0.25	0.25	-	-	-	5.00	-
MTAU	-	-	-	-	20.00	-	-	-	-	-	-	5.00	-	-	-	-	-	-	-
NGAK	-	0.25	-	-	-	-	-	0.25	-	-	-	-	-	-	-	-	-	4.00	-
NUKU	-	0.10	-	-	2.60	-	-	0.10	-	0.10	-	1.10	-	-	-	-	0.30	-	-
OAKL	-	0.25	-	-	5.00	-	-	-	-	-	-	-	-	-	-	-	-	0.50	-
OKU1	-	0.60	-	-	1.40	-	-	-	-	-	-	1.00	0.40	-	-	-	-	-	-
OKU2	-	-	-	-	10.50	-	-	-	-	-	-	-	-	-	-	-	-	1.00	-
ONEP	-	-	-	-	0.33	-	-	-	-	-	-	-	-	-	-	-	-	0.33	-
OTAN	-	-	-	-	0.50	-	-	0.25	-	-	0.25	0.25	-	-	-	-	0.25	-	-
OTAR	-	-	-	-	30.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OTEH	-	0.25	-	-	0.25	0.25	-	0.25	-	-	-	-	-	-	-	-	-	-	-
PAPA	-	-	-	-	155.25	-	-	-	-	-	-	-	-	-	-	-	-	2.75	-
PUHI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.50	-	-	-	-
PUHO	-	-	-	-	2.71	-	-	0.14	-	-	-	0.43	0.29	-	-	-	0.29	-	-
PUHT	-	-	-	-	0.25	1.50	-	0.75	0.25	-	-	-	-	-	-	-	-	-	-
RIVE	-	-	-	-	1.00	-	-	0.67	-	-	-	-	-	-	-	-	-	2.00	-
SHAK	-	0.14	-	-	12.86	-	-	-	-	0.14	-	1.14	-	-	-	-	-	-	-
VAUL	-	-	-	-	1.10	-	-	-	-	-	-	-	-	-	0.50	-	-	0.10	-
VAUM	-	0.44	-	-	31.11	-	-	-	-	-	-	3.22	-	-	0.22	-	-	0.11	-
VAUU	-	0.30	-	-	105.00	-	-	-	-	-	0.10	6.60	0.30	-	-	-	-	-	-
WAIR	-	0.25	-	-	80.00	-	-	-	-	7.50	0.25	-	0.75	0.50	-	0.25	-	6.25	-
WAIW	-	-	-	-	5.00	-	-	-	-	1.25	-	-	-	-	-	-	-	-	-
WEST	-	0.25	-	-	0.63	-	-	0.25	-	0.13	-	1.38	-	-	-	-	1.00	-	-
WHAR	-	-	-	-	-	-	-	-	-	1.67	-	-	0.67	0.67	-	-	-	0.33	-

Appendix 6 continued

Site code	Chir1	Chir2	Coll	Colo	Cope	Culi	Dele	Dipt	Dixi	Doli	Dolo	Ecno	Elmi	Empi	Enoc	Erio	Ferr	Gyra	Harr
AWN1	-	-	-	-	-	-	-	-	0.50	-	-	1.00	-	-	-	-	-	-	-
AWN2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.50	0.50
AWNL	-	0.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.50
AWNM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AWNT	-	-	0.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AWRL	-	0.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AWRM	2.78	-	0.11	-	-	-	-	-	-	-	-	-	-	-	-	-	2.33	-	0.11
CAMP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CHAT	-	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.00	-
HOTE	-	-	-	-	-	-	-	-	-	-	-	-	1.00	-	-	-	-	-	1.00
KAUR	-	-	-	3.33	-	-	-	-	-	-	-	0.67	3.33	-	-	0.33	-	-	-
KUME	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.25
LUCA	-	-	-	0.25	-	-	0.25	-	-	-	0.25	-	0.25	-	-	-	-	-	-
MAHD	-	-	-	2.00	-	-	0.67	-	-	-	-	-	0.33	-	-	-	-	-	-
MAHF	-	-	-	2.75	-	-	0.25	-	-	-	-	-	0.75	0.25	-	-	-	-	-
MAHK	-	-	-	0.25	-	-	1.75	-	-	-	-	-	5.25	-	-	-	2.50	-	-
MAHU	-	-	-	3.00	-	-	0.25	-	-	-	-	-	1.75	-	-	-	-	-	-
MATA	-	0.25	-	-	-	-	-	-	-	-	-	-	0.25	0.25	-	-	-	-	0.25
MTAU	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NGAK	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NUKU	6.00	-	0.10	0.30	-	-	-	0.10	-	0.10	-	-	0.20	0.10	-	-	-	-	0.20
OAKL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.50	12.50	1.50
OKU1	-	-	-	0.20	0.20	-	0.20	-	-	-	-	-	-	-	-	-	0.40	-	0.20
OKU2	-	-	-	-	-	-	-	-	-	-	-	-	0.50	-	-	-	-	-	-
ONEP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.67
OTAN	-	0.25	-	0.25	-	-	-	-	-	-	-	-	-	0.25	-	-	-	-	-
OTAR	-	0.25	-	-	-	0.25	-	-	-	-	-	-	-	-	-	-	0.25	11.50	-
OTEH	-	1.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.75
PAPA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PUHI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.75	-	-
PUHO	-	-	-	-	-	-	-	-	0.14	-	-	-	0.14	-	-	-	-	-	0.14
PUHT	-	1.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.25
RIVE	-	-	-	0.33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SHAK	0.14	-	-	-	-	-	0.14	-	-	-	-	-	-	-	-	-	-	-	0.14
VAUL	0.10	-	-	-	-	-	-	0.30	-	-	-	-	-	-	0.10	-	-	-	-
VAUM	24.56	-	0.22	-	-	-	-	-	-	-	-	-	0.11	-	-	-	0.56	-	0.56
VAUU	14.00	0.10	0.70	-	-	-	-	0.20	-	-	-	-	-	-	-	0.10	0.10	-	0.10
WAIR	-	-	-	-	-	-	-	-	-	-	-	-	3.75	0.25	-	-	-	-	0.50
WAIW	-	-	-	-	-	-	-	-	-	-	-	-	2.00	-	-	-	-	1.50	1.50
WEST	-	-	-	0.75	-	-	-	-	-	-	-	-	2.38	-	-	-	-	-	0.13
WHAR	-	-	-	0.67	-	-	-	-	-	-	-	-	0.33	-	-	-	0.33	-	0.33

Appendix 6 continued

Site code	Heli	Hemi	Hexa	Hiru	Huds	Hydr1	Hydr2	Hygr	Hyri	Isop	Isot	Lati	Limn	Limo	Lobo	Lymn	Maor	Maui	Mega	Mela
AWN1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AWN2	-	-	-	0.50	-	-	-	-	-	-	-	-	-	0.50	-	-	-	-	-	-
AWNL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.50
AWNM	-	-	-	-	-	-	-	-	-	-	-	-	-	0.33	-	-	-	-	-	-
AWNT	-	-	0.50	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AWRL	-	-	-	18.50	-	-	-	-	-	0.88	-	-	-	-	-	0.25	-	-	-	5.63
AWRM	-	-	-	0.67	-	0.11	-	-	-	-	-	-	-	0.11	-	0.56	-	-	-	-
CAMP	-	-	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CHAT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HOTE	-	-	-	1.00	-	-	-	-	-	-	-	20.00	-	-	-	-	-	-	-	-
KAUR	-	-	-	-	-	0.67	0.33	-	-	-	-	-	-	0.33	-	-	-	-	-	-
KUME	-	-	-	-	-	-	-	-	-	-	-	5.00	-	-	-	0.50	-	-	-	-
LUCA	-	0.25	-	0.25	-	-	-	-	0.25	-	-	-	-	0.25	-	-	-	-	-	-
MAHD	-	-	-	-	-	0.33	-	-	-	-	-	-	-	-	-	-	-	-	0.67	-
MAHF	-	-	0.25	-	-	0.25	0.25	-	-	-	0.25	0.25	-	-	0.25	-	-	-	0.50	-
MAHK	-	-	0.25	-	-	0.75	-	-	-	-	-	-	-	-	-	12.50	0.25	0.25	0.50	-
MAHU	-	-	-	0.25	0.25	0.50	0.25	-	-	-	-	-	-	0.25	-	0.25	-	-	0.50	-
MATA	-	-	-	-	-	2.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MTAU	-	-	1.00	-	-	-	-	-	-	-	-	-	-	1.00	-	-	-	-	-	-
NGAK	-	-	-	6.75	-	-	-	0.75	-	-	-	-	-	-	-	0.50	-	-	-	-
NUKU	-	-	0.40	-	-	0.10	-	-	0.30	0.20	-	-	-	0.10	-	-	-	-	-	0.40
OAKL	-	-	-	1.25	-	-	-	0.50	-	-	-	-	-	-	-	-	-	-	-	-
OKU1	-	-	-	0.40	-	-	0.20	-	-	-	-	-	-	-	-	-	0.20	-	-	-
OKU2	-	-	-	-	1.00	-	0.50	-	-	-	-	-	-	-	-	0.50	-	-	-	-
ONEP	-	-	-	-	-	-	-	-	-	-	-	-	-	0.33	-	-	-	-	-	-
OTAN	-	-	0.75	-	-	-	-	-	0.25	-	-	-	-	-	-	-	-	-	-	-
OTAR	-	0.25	-	0.75	-	-	-	-	-	-	-	-	-	-	-	2.50	-	-	-	-
OTEH	-	-	-	0.25	-	-	-	-	-	-	-	-	-	0.25	-	3.00	-	-	-	0.25
PAPA	-	-	-	1.75	-	-	-	-	-	-	-	-	-	-	-	0.25	-	-	-	-
PUHI	-	0.50	-	0.50	-	-	-	0.25	-	-	-	-	-	-	-	0.25	-	-	-	-
PUHO	-	-	-	-	-	0.14	0.29	-	-	-	0.14	-	-	-	-	-	-	-	-	-
PUHT	-	-	-	-	-	-	-	-	-	-	-	-	-	0.25	-	-	-	-	-	-
RIVE	-	-	-	-	-	-	-	-	-	-	-	2.00	-	-	-	-	0.33	-	-	-
SHAK	-	-	0.29	0.43	-	0.14	-	-	-	-	-	-	-	0.14	-	-	-	-	-	-
VAUL	-	0.20	-	7.30	-	-	-	-	-	1.10	-	-	-	-	-	2.30	-	-	-	35.70
VAUM	-	-	0.22	0.56	0.22	-	-	-	0.11	0.22	0.67	-	0.11	0.11	-	-	-	-	-	-
VAUU	-	-	0.70	0.10	0.60	-	0.10	-	-	1.50	1.30	-	0.10	0.80	-	-	-	-	-	-
WAIR	-	-	-	0.25	-	0.50	-	-	-	-	-	2.75	-	-	-	-	-	-	-	-
WAIW	-	-	-	-	-	-	0.25	0.25	-	-	-	-	-	-	-	0.75	-	-	0.25	0.25
WEST	-	-	0.13	-	0.25	0.13	-	-	-	-	0.13	-	-	0.25	-	-	-	-	-	-
WHAR	0.33	-	-	-	0.33	-	-	-	-	-	-	1.00	-	-	-	-	-	-	1.00	-

Appendix 6 continued

Site code	Micr	Misc	Molo	Musc	Nema1	Nema2	Neme	Neol	Neoz	Nesa	Neso	Neur	Oece	Oeco	Olig	Olin	Orth1	Orth2	Ostr	Oxye
AWN1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.00	-	0.50	-	-	-
AWN2	-	-	-	-	-	-	-	0.50	-	-	-	-	-	-	-	-	-	12.50	-	-
AWNL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AWNM	-	-	0.33	-	-	-	-	-	2.00	-	-	-	-	-	0.33	-	-	1.00	-	-
AWNT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.50	-	0.50	0.50	-	-
AWRL	0.25	-	-	-	-	-	0.63	-	-	-	-	-	-	-	1.00	-	0.88	-	-	3.13
AWRM	0.11	0.22	-	-	-	-	0.56	0.11	-	-	-	-	-	-	3.67	-	-	-	-	-
CAMP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.00	-	-	-
CHAT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.00	-	-	-	-	-
HOTE	-	-	-	-	-	-	-	1.00	-	-	-	-	-	-	1.00	-	-	-	-	-
KAUR	-	0.67	0.33	-	-	-	-	-	-	-	-	-	-	-	0.33	-	0.33	20.00	-	-
KUME	0.25	-	-	0.25	-	-	-	-	-	-	-	-	-	-	1.25	-	0.50	-	-	1.50
LUCA	-	-	-	-	0.25	-	-	0.25	-	-	-	-	-	-	1.75	-	-	6.75	-	-
MAHD	-	-	-	0.33	-	-	0.33	0.33	-	3.67	-	-	-	-	0.67	-	-	-	-	0.33
MAHF	-	-	-	-	-	-	-	-	0.25	5.00	-	-	-	-	0.50	-	0.25	0.50	-	0.25
MAHK	-	-	-	-	-	-	-	0.50	-	-	-	-	-	-	0.75	-	1.25	0.25	5.00	2.75
MAHU	0.25	0.75	-	-	-	-	0.25	-	-	-	-	0.25	-	-	-	-	-	-	-	0.25
MATA	-	0.50	0.25	-	-	-	0.25	0.25	-	-	-	-	-	-	1.00	-	0.50	4.00	-	0.50
MTAU	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NGAK	0.25	-	-	0.25	-	-	1.75	-	-	-	-	-	-	-	0.25	-	1.75	-	-	7.75
NUKU	-	0.10	-	-	-	0.10	-	-	1.30	-	-	-	-	-	1.10	0.20	0.30	0.10	-	-
OAKL	-	-	-	-	-	-	0.25	-	-	-	-	-	-	-	0.75	-	0.50	-	-	0.75
OKU1	0.20	-	-	-	-	-	-	0.40	0.20	-	0.20	-	-	-	0.60	-	0.40	1.20	-	-
OKU2	-	0.50	-	-	-	-	-	0.50	0.50	-	-	-	-	-	1.00	-	-	0.50	-	-
ONEP	0.33	-	-	-	-	-	-	-	-	-	-	-	-	-	0.67	-	-	-	-	-
OTAN	-	-	0.25	-	-	-	-	-	-	-	-	-	-	-	-	-	0.25	-	-	-
OTAR	-	-	-	-	-	-	0.25	-	-	-	-	-	-	-	1.75	-	6.75	-	2.75	8.75
OTEH	-	-	-	-	0.25	-	-	-	-	-	-	-	-	-	2.00	-	1.50	-	-	0.25
PAPA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.75	-	1.00	-	-	135.25
PUHI	-	-	-	0.25	-	0.25	-	-	-	-	-	-	-	-	0.75	-	12.50	-	-	2.75
PUHO	0.29	-	-	-	-	-	-	-	-	-	-	-	-	-	0.14	-	0.29	-	-	-
PUHT	-	0.50	-	-	-	-	-	-	-	-	-	-	-	-	1.75	-	-	-	0.25	-
RIVE	0.33	-	-	-	-	-	-	-	-	-	-	-	-	-	0.67	-	0.67	0.33	-	-
SHAK	-	-	-	-	-	-	-	0.29	-	-	-	-	-	-	0.29	0.14	0.43	-	-	-
VAUL	0.10	-	-	0.30	0.10	-	0.20	0.10	-	-	-	-	-	-	2.10	-	-	-	0.30	1.00
VAUM	0.11	-	-	-	0.11	-	0.78	0.11	1.44	-	-	-	-	0.11	7.44	-	-	-	-	0.22
VAUU	0.10	0.50	-	0.10	-	-	-	-	5.00	-	-	-	-	0.20	2.70	-	0.20	-	-	-
WAIR	-	-	-	-	-	-	0.25	-	-	-	-	0.25	-	-	0.25	-	0.50	-	-	0.50
WAIW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.25	-	0.25	-	0.25	2.75
WEST	0.13	-	-	-	-	-	-	0.13	0.75	-	-	-	-	-	1.13	-	0.13	0.50	-	-
WHAR	0.33	-	-	-	-	-	-	-	-	-	-	-	1.00	-	0.33	2.33	0.33	-	-	-

Appendix 6 continued

Site code	Para1	Para2	Para3	Para4	Paro	Pauc	Phys	Plat	Poly1	Poly2	Pota	Psil	Psyc	Ptil	Pycn1	Pycn2	Rall	Rhan	Sald	Scio
AWN1	0.50	-	1.00	0.50	-	-	-	-	3.00	0.50	-	0.50	-	-	-	-	-	-	-	-
AWN2	0.50	-	1.00	20.00	-	-	-	-	0.50	0.50	60.00	0.50	-	-	12.50	-	-	-	-	-
AWNL	-	-	-	20.00	-	-	2.50	-	0.50	-	60.00	-	-	-	0.50	-	-	-	-	-
AWNM	-	-	0.33	15.00	-	-	-	-	0.67	0.33	46.67	0.33	-	-	8.67	-	-	-	-	-
AWNT	1.00	-	-	20.00	-	-	0.50	-	-	-	60.00	-	-	-	-	-	-	-	-	-
AWRL	-	-	-	120.00	-	-	22.75	2.63	-	-	450.00	-	-	-	0.13	-	-	-	-	-
AWRM	-	-	-	23.89	-	-	37.78	4.78	-	-	500.00	-	-	-	-	-	-	-	-	0.22
CAMP	-	-	1.00	20.00	-	-	5.00	-	-	-	500.00	-	-	1.00	-	-	-	-	-	-
CHAT	-	-	-	-	-	-	20.00	-	20.00	-	1.00	-	-	-	-	-	-	-	-	-
HOTE	-	-	-	1.00	1.00	-	1.00	1.00	1.00	1.00	100.00	-	-	-	1.00	-	-	-	-	-
KAUR	0.67	-	0.67	-	-	-	-	0.33	3.67	2.00	73.33	3.67	-	0.33	5.00	-	-	-	-	-
KUME	-	-	-	8.75	-	-	5.00	0.25	0.75	-	500.00	-	-	-	-	0.25	-	-	-	-
LUCA	-	-	1.00	2.50	-	-	3.75	0.25	-	0.75	100.00	-	-	-	2.75	-	-	-	-	-
MAHD	3.33	-	0.33	-	-	-	-	-	-	0.67	46.67	1.00	-	0.67	-	0.33	-	-	-	-
MAHF	4.00	-	1.75	-	-	-	-	-	0.50	0.50	16.25	-	-	0.25	-	-	-	-	-	-
MAHK	-	-	0.75	-	-	-	-	-	0.25	2.00	200.00	0.50	-	0.25	-	-	-	-	-	-
MAHU	0.50	-	0.50	1.00	0.75	-	-	0.50	0.50	0.50	80.00	0.25	-	0.25	-	-	-	-	-	-
MATA	-	0.25	0.50	0.50	-	-	1.25	-	3.00	0.75	300.00	0.25	-	-	-	-	-	-	-	-
MTAU	5.00	-	1.00	-	-	-	-	-	5.00	5.00	5.00	1.00	-	-	-	-	-	-	-	-
NGAK	-	-	-	25.00	0.25	-	40.00	2.00	0.50	-	500.00	-	-	-	-	-	-	-	-	-
NUKU	2.90	0.10	1.10	10.20	0.10	-	-	-	1.40	1.00	8.60	0.30	-	0.30	0.80	0.10	-	-	-	0.10
OAKL	-	-	-	11.25	-	-	7.75	-	-	-	300.00	-	-	-	-	-	-	-	-	-
OKU1	0.20	-	0.40	17.00	-	-	-	-	0.40	0.40	420.00	0.20	-	-	11.00	-	-	-	0.20	-
OKU2	-	0.50	-	12.50	-	-	-	-	1.00	1.00	60.00	0.50	-	-	10.50	-	-	-	-	-
ONEP	-	-	-	-	-	-	15.00	0.33	-	-	100.00	0.33	-	0.33	0.33	-	-	-	-	-
OTAN	0.25	0.25	0.75	12.50	-	-	-	-	2.00	0.50	2.50	0.25	-	-	-	-	-	-	-	-
OTAR	-	-	-	6.50	-	-	12.50	0.50	-	-	80.00	-	-	-	-	-	-	-	-	-
OTEH	-	-	-	0.50	-	-	8.75	3.75	5.25	-	300.00	-	-	-	-	-	-	-	-	-
PAPA	-	-	-	7.75	0.25	-	12.50	3.00	-	-	500.00	-	-	-	-	-	-	-	-	-
PUHI	-	-	-	-	-	-	16.25	1.75	-	-	4.00	-	-	-	-	-	-	0.50	-	-
PUHO	6.57	0.29	2.57	2.71	-	-	-	-	1.43	5.00	25.00	0.29	0.14	-	0.14	-	-	-	-	-
PUHT	0.50	-	0.50	-	-	-	26.75	-	0.50	0.25	12.50	-	-	-	-	-	-	-	-	-
RIVE	-	0.33	0.33	0.33	-	-	-	-	-	-	15.00	1.00	-	0.67	0.67	-	-	-	-	-
SHAK	7.43	0.14	-	2.43	-	-	-	-	1.00	2.57	271.43	0.14	-	-	3.86	-	-	-	-	-
VAUL	-	-	0.10	140.00	-	-	9.60	0.30	-	0.10	404.00	-	-	-	-	0.10	-	-	0.10	-
VAUM	5.89	-	-	12.89	-	-	15.78	3.56	0.44	5.44	304.44	0.22	-	-	1.89	-	-	-	-	0.11
VAUU	8.70	-	5.50	6.80	-	-	0.10	0.10	7.20	6.80	122.50	0.30	-	-	4.10	-	-	-	0.10	0.10
WAIR	-	-	-	16.25	-	-	6.50	-	0.50	-	180.00	-	-	-	0.50	3.00	0.50	-	-	-
WAIW	-	-	0.25	40.00	1.25	-	1.50	0.25	1.50	0.50	300.00	-	-	-	-	0.50	-	-	-	-
WEST	2.50	0.13	2.00	1.75	-	0.13	-	-	0.88	2.50	2.25	0.38	-	0.75	0.25	-	-	-	-	-
WHAR	5.00	-	0.67	20.00	-	-	-	-	1.00	0.33	73.33	1.67	-	-	-	0.33	-	-	-	-

Appendix 6 continued

Site code	Scir	Siga	Span	Spha	Stap	Stra	Taba	Tany1	Tany2	Tepa	Tipu	Trip	Urop	Xant	Zela1	Zela2	Zela3	Zela4	Zeph
AWN1	-	-	-	-	-	-	-	0.50	0.50	-	-	0.50	-	-	-	-	-	-	60.00
AWN2	-	-	-	-	0.50	-	-	0.50	-	-	-	3.00	-	3.00	-	-	1.00	-	12.50
AWNL	-	-	-	-	-	-	0.50	0.50	-	0.50	-	20.00	-	0.50	-	-	-	-	20.00
AWNM	-	-	-	-	-	-	0.33	0.67	-	2.33	-	2.33	-	0.33	-	-	0.33	-	10.00
AWNT	-	-	-	-	-	-	-	1.00	-	-	-	3.00	-	20.00	-	-	-	0.50	-
AWRL	-	-	-	-	-	-	-	-	0.13	-	0.13	-	-	9.50	-	-	-	0.13	-
AWRM	-	-	-	5.22	-	-	-	0.22	-	-	0.11	-	-	76.67	-	-	-	0.11	-
CAMP	-	-	-	1.00	-	-	-	-	-	-	-	-	-	20.00	-	-	-	-	-
CHAT	-	-	-	-	-	-	-	-	-	-	-	-	-	5.00	-	-	-	-	-
HOTE	-	-	-	-	-	-	-	-	5.00	-	-	-	-	-	-	-	1.00	-	5.00
KAUR	-	-	-	0.33	-	-	-	1.00	2.00	-	-	0.33	-	-	-	-	-	-	41.67
KUME	-	-	-	-	-	-	-	-	-	-	-	1.50	-	4.00	-	-	-	-	6.50
LUCA	-	0.25	0.25	0.75	-	-	-	0.50	-	-	-	20.00	-	2.00	-	-	0.25	-	4.00
MAHD	-	-	0.33	-	-	-	-	-	-	0.33	-	0.33	-	0.67	-	-	0.33	-	20.00
MAHF	-	-	0.25	-	-	-	-	0.25	0.25	-	-	6.75	-	-	-	0.25	-	-	100.00
MAHK	-	1.75	-	-	-	0.25	-	0.25	0.25	0.50	-	5.50	-	7.75	-	-	-	-	12.50
MAHU	-	-	-	-	-	-	-	0.50	0.75	-	-	12.50	-	1.50	-	-	-	-	20.00
MATA	-	-	-	-	0.25	-	-	-	0.75	-	-	20.00	-	0.25	-	-	0.25	0.25	80.00
MTAU	5.00	-	-	-	-	-	-	5.00	-	1.00	-	-	-	-	-	-	-	-	20.00
NGAK	-	-	-	-	-	0.25	-	-	0.50	-	-	4.00	-	5.00	-	-	-	-	0.25
NUKU	0.20	-	-	-	0.10	-	-	0.40	0.10	0.60	0.10	1.10	-	1.90	0.10	-	0.30	0.10	22.00
OAKL	-	-	-	0.25	-	-	-	-	-	-	-	4.00	-	11.50	-	-	-	-	-
OKU1	-	-	-	0.60	-	-	-	0.60	-	-	-	36.00	-	3.40	-	-	1.60	0.20	5.40
OKU2	-	-	-	-	-	-	-	0.50	-	-	-	20.00	-	1.00	-	-	0.50	-	10.50
ONEP	-	-	-	1.00	-	-	-	0.67	-	-	-	-	-	5.00	-	-	-	-	0.33
OTAN	-	-	-	-	-	-	-	0.50	-	0.25	-	1.75	-	0.75	-	-	0.25	-	16.25
OTAR	-	-	-	-	-	-	-	-	0.50	-	-	-	-	7.75	-	-	-	-	-
OTEH	-	-	-	0.25	-	-	-	0.50	1.25	-	-	1.50	-	8.75	-	-	-	-	-
PAPA	-	-	-	-	-	-	-	-	0.25	-	-	-	-	0.75	-	-	-	-	1.25
PUHI	-	1.50	-	-	-	-	-	-	0.25	-	-	-	-	20.00	-	-	-	-	-
PUHO	0.14	-	-	-	0.29	-	0.14	0.57	-	0.43	-	0.57	-	-	-	-	-	-	20.00
PUHT	-	0.50	-	-	-	-	-	1.50	-	-	-	40.00	-	2.00	-	-	-	-	1.25
RIVE	-	-	-	-	-	-	-	-	-	0.33	-	0.33	-	-	-	-	0.33	-	46.67
SHAK	0.14	-	-	2.43	-	0.14	-	5.86	-	1.14	-	12.86	-	2.14	-	-	0.29	-	7.29
VAUL	-	0.30	-	4.20	0.20	-	-	0.10	-	-	0.10	-	0.10	19.60	-	-	-	0.10	-
VAUM	0.44	-	-	34.22	0.11	-	-	0.89	-	6.89	0.11	9.56	-	11.89	-	-	-	0.11	17.89
VAUU	2.60	-	-	0.20	0.20	-	0.10	1.50	-	8.60	0.70	5.80	-	0.30	-	-	1.20	-	42.50
WAIR	-	-	-	-	-	-	-	-	0.25	-	-	7.75	-	0.25	-	-	-	-	40.00
WAIW	-	-	-	0.25	-	-	-	0.50	0.50	-	-	4.00	-	1.00	-	-	0.25	-	12.50
WEST	0.13	-	-	-	0.13	-	-	0.25	-	-	-	0.13	-	1.75	-	-	0.13	-	30.00
WHAR	-	-	-	-	-	-	-	0.33	0.33	0.67	-	100.00	-	0.33	-	0.33	-	-	46.67

Appendix 7 Macroinvertebrate metric values for 41 SB stream sites in the Auckland region. See Appendix 1 for key to site codes.

No.	Site code	N	Taxa	EPT	EPTnoH	MCI	QMCI	MCI-sb	QMCI-sb
1	**AWN1**	2	11.5	4.0	4.0	101	6.4	129	7.6
2	**AWN2**	2	16.0	5.5	5.5	112	5.3	111	4.2
3	**AWNL**	2	10.5	3.0	3.0	97	4.9	99	4.1
4	**AWNM**	3	14.3	6.7	6.7	120	5.1	120	4.2
5	**AWNT**	2	11.5	1.5	1.5	89	4.5	87	2.9
6	**AWRL**	8	9.9	0.5	0.3	76	4.1	63	2.3
7	**AWRM**	9	9.6	0.1	0.1	77	4.0	59	2.1
8	**CAMP**	1	10.0	-	-	90	4.1	84	2.1
9	**CHAT**	1	9.0	-	-	62	3.2	78	3.8
10	**HOTE**	1	19.0	5.0	4.0	88	4.1	98	3.4
11	**KAUR**	3	19.0	7.3	7.3	113	5.8	122	5.0
12	**KUME**	4	10.8	2.0	1.5	82	4.1	75	2.5
13	**LUCA**	4	16.0	5.3	5.3	104	4.5	100	3.1
14	**MAHD**	3	16.3	8.3	8.0	125	5.5	123	5.0
15	**MAHF**	4	17.8	8.8	8.5	120	6.5	134	7.1
16	**MAHK**	4	19.8	8.5	7.8	106	4.3	101	2.9
17	**MAHU**	4	17.8	7.5	6.5	105	4.8	109	4.0
18	**MATA**	4	17.5	5.5	5.0	95	4.8	105	3.8
19	**MTAU**	1	15.0	5.0	5.0	119	5.9	132	6.5
20	**NGAK**	4	14.0	2.5	1.3	70	3.9	62	2.1
21	**NUKU**	10	18.1	6.6	6.5	108	5.2	119	5.6
22	**OAKL**	4	11.8	1.8	1.0	74	4.0	63	2.3
23	**OKU1**	5	16.0	4.8	4.8	105	4.3	102	2.6
24	**OKU2**	2	17.5	6.5	6.5	104	4.9	109	4.1
25	**ONEP**	3	9.3	1.0	1.0	91	4.0	78	2.1
26	**OTAN**	4	11.8	3.5	3.5	106	5.7	123	6.0
27	**OTAR**	4	12.5	1.0	-	64	3.9	55	2.6
28	**OTEH**	4	12.0	0.8	0.5	74	3.9	66	2.3
29	**PAPA**	4	11.0	1.5	0.3	67	3.9	59	2.4
30	**PUHI**	4	10.8	0.8	-	67	3.6	47	2.0
31	**PUHO**	7	13.6	4.4	4.4	109	5.5	126	5.9
32	**PUHT**	4	11.5	1.5	1.5	84	4.3	87	3.8
33	**RIVE**	3	12.0	4.0	4.0	108	5.8	112	6.0
34	**SHAK**	7	14.9	4.9	4.9	102	4.4	107	3.2
35	**VAUL**	10	12.0	0.8	0.2	77	4.0	60	2.5
36	**VAUM**	9	18.7	6.3	6.1	101	4.3	104	3.2
37	**VAUU**	10	20.2	7.2	7.2	113	5.0	123	4.9
38	**WAIR**	4	16.8	6.8	6.3	97	4.9	99	4.2
39	**WAIW**	4	15.8	4.5	3.5	92	4.3	89	2.8
40	**WEST**	8	15.0	5.3	5.3	114	6.3	126	7.1
41	**WHAR**	3	19.0	9.3	9.3	116	5.1	123	4.8

N = number of samples, Taxa = mean taxa richness (number of taxa per sample), EPT = mean number of Ephermeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly) taxa per sample. EPTnoH = mean number of EPT taxa per sample (excluding Hydroptilidae), MCI = mean Macroinvertebrate Community Index, QMCI = mean Quantitative Macroinvertebrate Community Index, sb denotes versions of indices for SB streams.

Appendix 8 Taxon-specific tolerance scores for MCI-based biotic indices in HB and SB streams.

Taxon	HB	SB	Taxon	HB	SB	Taxon	HB	SB
INSECTA			**Neuroptera**			**Trichoptera** (cont.)		
Ephemeroptera			***Kempynus***	5	-	Ecnominidae	8	-
Acanthophlebia	7	9	**Diptera**			*Helicopsyche*	10	8
Ameletopsis	10	10	Anthomyiidae	3	4	*Hudsonema*	6	7
Arachnocolus	8	8	*Aphrophila*	5	6	*Hydrobiosella*	9	-
Atalophlebioides	9	-	*Austrosimulium*	3	4	*Hydrobiosis*	5	6
Austroclima	9	6	*Calopsectra*	4	-	*Hydrochorema*	9	-
Austronella	7	5	Ceratopogonidae	3	7	*Kokiria*	9	-
Coloburiscus	9	8	Chironomidae	2	5	*Neurochorema*	6	5
Deleatidium	8	6	*Chironomus*	1	4	*Oecetis*	6	7
Ichthybotus	8	-	*Corynoneura*	2	-	Oeconesidae	9	6
Isothraulus	8	8	*Cryptochironomus*	3	-	*Olinga*	9	8
Mauiulus	5	4	*Culex*	3	-	*Orthopsyche*	9	7
Neozephlebia	7	7	Culicidae	3	3	*Oxyethira*	2	2
Nesameletus	9	9	Diptera indet.	3	4	*Paroxyethira*	2	4
Oniscigaster	10	-	Dixidae	4	9	*Philorheithrus*	8	-
Rallidens	9	5	Dolichopodidae	3	8	*Plectrocnemia*	8	-
Siphlaenigma	9	-	Empididae	3	7	*Polyplectropus*	8	8
Tepakia	8	8	Ephydridae	4	-	*Psilochorema*	8	7
Zephlebia	7	8	Eriopterini	9	8	*Pycnocentrella*	9	-
Plecoptera			*Harrisius*	6	5	*Pycnocentria*	7	7
Acroperla	5	5	Hexatomini	5	7	*Pycnocentrodes*	5	5
Austroperla	9	9	*Limnophora*	3	5	*Rakiura*	10	-
Cristaperla	8	-	*Limonia*	6	6	*Synchorema*	9	-
Halticoperla	8	-	*Lobodiamesa*	5	8	*Tiphobiosis*	6	-
Megaleptoperla	9	7	*Maoridiamesa*	3	5	*Triplectides*	5	5
Nesoperla	5	4	*Mischoderus*	4	5	*Triplectidina*	5	-
Spaniocerca	8	8	*Molophilus*	5	7	*Zelandoptila*	8	7
Spaniocercoides	8	-	Muscidae	3	3	*Zelolessica*	10	-
Stenoperla	10	-	*Nannochorista*	7	-	**Lepidoptera**		
Taraperla	7	-	*Neocurupira*	7	-	*Hygraula*	4	2
Zelandobius	5	6	*Neolimnia*	3	4	**Collembola**	6	6
Zelandoperla	10	9	Neoscatella	7	-	**ACARINA**	5	5
Megaloptera			*Nothodixa*	4	-	**ARACHNIDA**		
Archichauliodes	7	7	Orthocladiinae	2	3	*Dolomedes*	5	5
Odonata			*Parochlus*	8	-	**CRUSTACEA**		
Aeshna	5	-	*Paradixa*	4	8	Amphipoda	5	5
Antipodochlora	6	6	*Paralimnophila*	6	7	Copepoda	5	-
Austrolestes	6	2	*Paucispinigera*	6	8	Cladocera	5	-
Hemicordulia	5	2	Pelecorhyncidae	9	-	Isopoda	5	5
Procordulia	6	-	*Peritheates*	7	-	Ostracoda	3	3
Uropetala	5	1	Podonominae	8	-	*Paraleptamphopus*	5	-
Xanthocnemis	5	2	*Polypedilum*	3	7	*Paracalliope*	5	-
Hemiptera			Psychodidae	1	8	*Paranephrops*	5	8
Anisops	5	3	Sciomyzidae	3	4	*Paratya*	5	4
Diaprepocoris	5	-	Stratiomyidae	5	3	Tanaidacea	4	-
Microvelia	5	5	Syrphidae	1	-	**MOLLUSCA**		
Saldidae	5	4	Tabanidae	3	7	*Ferrissia*	3	3
Sigara	5	3	Tanypodinae	5	6	*Glyptophysa = Physastra*	5	-
Coleoptera			Tanytarsini	3	4	*Gyraulus*	3	3
Antiporus	5	5	*Tanytarsus*	3	4	*Hyridella*	3	6
Berosus	5	-	Thaumaleidae	9	-	*Latia*	3	6
Copelatus	5	4	Tipulidae	5	5	*Lymnaea*	3	2
Dytiscidae	5	-	*Zelandotipula*	6	4	*Melanopsis*	3	3
Elmidae	6	7	**Trichoptera**			*Physa (= Physella)*	3	1
Enochrus	5	3	*Alloecentrella*	9	-	*Potamopyrgus*	4	2
Homeodytes	5	-	*Aoteapsyche*	4	6	Sphaeriidae	3	3
Hydraenidae	8	-	*Beraeoptera*	8	-	**OLIGOCHAETA**	1	4
Hydrophilidae	5	6	*Confluens*	5	-	**HIRUDINEA**	3	2
Liodessus	5	-	*Conuxia*	8	-	**PLATYHELMINTHES**	3	2
Podaena	8	-	*Costachorema*	7	-	**NEMATODA**	3	3
Ptilodactylidae	8	7	*Cryptobiosella*	9	-	**NEMATOMORPHA**	3	4
Rhantus	5	2	*Diplectrona*	9	-	**NEMERTEA**	3	3
Scirtidae	8	6	*Ecnomina*	8	8	**COELENTERATA**		
Staphylinidae	5	6	*Edpercivalia*	9	-	*Hydra*	3	-

Appendix 9 Rank and linear correlations between MCI, QMCI, MCI-sb, and QMCI-sb and selected environmental variables. Statistically significant correlations ($P < 0.05$) are ***italicised***. Absolute value of skewness < 1.0 (bold skewness values) indicates data approximate normality.

		Spearman rank correlations		Pearson linear correlations Untransformed variables			Pearson linear correlations $\text{Log}_{10}(x+1)$ transformed variables		
MCI vs	**N**	**Rs**	**p**	**r^2**	**p**	**Skewness**	**r^2**	**p**	**Skewness**
Catchment									
AREA	41	***-0.419***	***0.006***	0.019	0.385	4.575	***0.152***	***0.012***	**0.854**
DISTSEA	41	***0.344***	***0.028***	0.084	0.066	1.879	0.092	0.054	**0.790**
ALT	41	***0.503***	***0.001***	***0.110***	***0.034***	2.332	***0.224***	***0.002***	**0.374**
WIDTH	39	***-0.439***	***0.005***	***0.127***	***0.026***	1.942	***0.169***	***0.009***	1.032
THLDEP	39	***-0.508***	***0.001***	***0.187***	***0.006***	1.024	***0.203***	***0.004***	**0.732**
Land-use									
NAT	41	***0.476***	***0.002***	***0.289***	***<0.001***	**0.860**	0.093	0.052	**-0.845**
OLDFOR	41	0.113	0.480	***0.138***	***0.017***	3.988	0.059	0.127	**0.362**
NEWFOR	41	0.025	0.876	0.026	0.314	3.670	0.023	0.347	2.086
ETRSH	41	***-0.316***	***0.044***	0.003	0.743	5.008	0.013	0.477	2.257
FOR	41	0.183	0.251	***0.111***	***0.033***	2.370	0.061	0.118	**0.244**
CROP	41	***-0.330***	***0.035***	0.075	0.083	6.001	***0.112***	***0.032***	4.356
PASGRA	41	***-0.472***	***0.002***	***0.156***	***0.011***	**0.211**	***0.163***	***0.009***	**-0.750**
RUR	41	***-0.471***	***0.002***	***0.169***	***0.008***	**0.344**	***0.167***	***0.008***	**-0.734**
URB	41	***-0.627***	***<0.000***	***0.333***	***<0.001***	1.787	***0.409***	***<0.001***	1.013
MISC	41	***-0.419***	***0.006***	0.091	0.055	5.631	***0.104***	***0.039***	5.295
DEVPER	41	***-0.818***	***<0.000***	0.640	<0.001	**-0.206**	***0.462***	***<0.001***	-1.139
Habitat quality									
AHA	41	0.229	0.150	0.002	0.808	-1.369	0.003	0.731	-2.612
AHD	41	***0.548***	***<0.000***	***0.225***	***0.002***	-1.025	***0.135***	***0.018***	-1.598
HH	41	***0.559***	***<0.000***	***0.292***	***<0.001***	**-0.399**	***0.262***	***0.001***	-1.190
CA	41	***0.721***	***<0.000***	***0.577***	***<0.001***	-1.267	***0.501***	***<0.001***	-2.145
BS	41	0.222	0.162	0.024	0.334	-1.023	0.011	0.517	-2.258
CS	41	***0.486***	***0.001***	***0.289***	***<0.001***	**-0.572**	***0.338***	***<0.001***	-1.225
RW	41	***0.489***	***0.001***	***0.304***	***<0.001***	**-0.524**	***0.263***	***0.001***	-1.101
HQI	41	***0.556***	***<0.000***	***0.328***	***<0.001***	**-0.467**	***0.343***	***<0.001***	**-0.974**
Water quality									
BD	14	0.244	0.401	0.002	0.885	1.664	0.005	0.805	1.225
DOSAT	14	***0.546***	***0.044***	0.246	0.071	-1.153	0.246	0.071	-1.466
FC	14	***-0.688***	***0.007***	***0.505***	***0.004***	1.087	***0.476***	***0.006***	**0.014**
NH4	14	-0.447	0.109	0.119	0.226	**-0.284**	0.116	0.233	**-0.312**
NO3	14	***-0.684***	***0.007***	***0.285***	***0.049***	1.924	***0.359***	***0.024***	1.421
TP	14	***-0.575***	***0.032***	***0.342***	***0.028***	1.305	***0.343***	***0.028***	1.212
SS	14	-0.042	0.887	0.002	0.879	**0.572**	0.012	0.706	**-0.756**
TURB	14	0.317	0.270	0.079	0.329	1.372	0.111	0.245	**-0.165**
TEMP	14	***-0.553***	***0.040***	***0.383***	***0.018***	**0.006**	***0.395***	***0.016***	**-0.153**
TEMPMAX	13	-0.378	0.203	0.091	0.317	**0.205**	0.098	0.299	**0.123**
COND	14	-0.451	0.106	0.187	0.122	**-0.216**	0.198	0.111	**-0.604**
DO	14	***0.591***	***0.026***	***0.294***	***0.045***	-1.056	***0.287***	***0.048***	-1.396
WQI-W&S	13	***0.680***	***0.011***	***0.338***	***0.037***	**0.006**	***0.380***	***0.025***	**-0.802**
WQI-sb	14	***0.735***	***0.003***	***0.472***	***0.007***	**-0.135**	***0.487***	***0.006***	**-0.407**

Appendix 9 continued.

		Spearman rank correlations		Pearson linear correlations Untransformed variables			Pearson linear correlations $Log_{10}(x+1)$ transformed variables		
MCI-sb vs	**N**	**Rs**	**p**	**r^2**	**p**	**Skewness**	**r^2**	**p**	**Skewness**
Catchment									
AREA	41	***-0.439***	***0.004***	0.006	0.643	4.575	***0.151***	***0.012***	**0.854**
DISTSEA	41	***0.339***	***0.030***	0.061	0.118	1.879	0.084	0.066	**0.790**
ALT	41	***0.525***	***<0.000***	0.090	0.056	2.332	***0.243***	***0.001***	**0.374**
WIDTH	39	***-0.420***	***0.008***	***0.124***	***0.028***	1.942	***0.165***	***0.010***	1.032
THLDEP	39	***-0.485***	***0.002***	***0.194***	***0.005***	1.024	***0.208***	***0.003***	**0.732**
Land-use									
NAT	41	***0.586***	***<0.000***	***0.420***	***<0.001***	**0.860**	***0.182***	***0.005***	**-0.845**
OLDFOR	41	0.057	0.724	0.081	0.070	3.988	0.026	0.312	**0.362**
NEWFOR	41	-0.035	0.827	0.013	0.483	3.670	0.012	0.490	2.086
ETRSH	41	***-0.374***	***0.016***	0.006	0.639	5.008	0.026	0.318	2.257
FOR	41	0.109	0.497	0.060	0.124	2.370	0.024	0.338	**0.244**
CROP	41	-0.300	0.056	0.070	0.094	6.001	***0.106***	***0.038***	4.356
PASGRA	41	***-0.478***	***0.002***	***0.171***	***0.007***	**0.211**	***0.167***	***0.008***	**-0.750**
RUR	41	***-0.475***	***0.002***	***0.183***	***0.005***	**0.344**	***0.171***	***0.007***	**-0.734**
URB	41	***-0.625***	***<0.000***	***0.357***	***<0.001***	1.787	***0.450***	***<0.001***	1.013
MISC	41	***-0.392***	***0.011***	0.079	0.074	5.631	0.090	0.057	5.295
DEVPER	41	***-0.834***	***<0.000***	***0.689***	***<0.001***	**-0.206**	***0.468***	***<0.001***	-1.139
Habitat quality									
AHA	41	***0.327***	***0.037***	0.011	0.513	-1.369	0.000	0.940	-2.612
AHD	41	***0.548***	***<0.000***	***0.231***	***0.001***	-1.025	***0.139***	***0.016***	-1.598
HH	41	***0.615***	***<0.000***	***0.347***	***<0.001***	**-0.399**	***0.300***	***<0.001***	-1.190
CA	41	***0.737***	***<0.000***	***0.636***	***<0.001***	-1.267	***0.535***	***<0.001***	-2.145
BS	41	0.280	0.077	0.039	0.215	-1.023	0.012	0.501	-2.258
CS	41	***0.568***	***<0.000***	***0.354***	***<0.001***	**-0.572**	***0.412***	***<0.001***	-1.225
RW	41	***0.554***	***<0.000***	***0.363***	***<0.001***	**-0.524**	***0.322***	***<0.001***	-1.101
HQI	41	***0.641***	***<0.000***	***0.410***	***<0.001***	**-0.467**	***0.414***	***<0.001***	**-0.974**
Water quality									
BD	14	0.270	0.350	0.010	0.734	1.664	0.019	0.639	1.225
DOSAT	14	0.407	0.149	0.200	0.109	-1.153	0.199	0.110	-1.466
FC	14	***-0.750***	***0.002***	***0.552***	***0.002***	1.087	***0.582***	***0.002***	**0.014**
NH4	14	-0.465	0.094	0.171	0.141	**-0.284**	0.168	0.146	**-0.312**
NO3	14	***-0.754***	***0.002***	***0.303***	***0.041***	1.924	***0.389***	***0.017***	1.421
TP	14	***-0.588***	***0.027***	***0.339***	***0.029***	1.305	***0.342***	***0.028***	1.212
SS	14	-0.081	0.782	0.004	0.824	**0.572**	0.000	0.940	**-0.756**
TURB	14	0.273	0.345	0.031	0.548	1.372	0.059	0.403	**-0.165**
TEMP	14	***-0.639***	***0.014***	***0.377***	***0.020***	**0.006**	***0.382***	***0.018***	**-0.153**
TEMPMAX	13	-0.461	0.113	0.083	0.338	**0.205**	0.088	0.324	**0.123**
COND	14	-0.451	0.106	0.237	0.077	**-0.216**	0.242	0.074	**-0.604**
DO	14	0.464	0.095	0.247	0.071	-1.056	0.238	0.077	-1.396
WQI-W&S	13	***0.699***	***0.008***	***0.425***	***0.016***	**0.006**	***0.430***	***0.015***	**-0.802**
WQI-sb	14	***0.741***	***0.002***	***0.542***	***0.003***	**-0.135**	***0.548***	***0.002***	**-0.407**

Appendix 9 continued.

		Spearman rank correlations		Pearson linear correlations Untransformed variables			Pearson linear correlations $\text{Log}_{10}(x+1)$ transformed variables		
QMCI vs	**N**	**Rs**	**p**	**r^2**	**p**	**Skewness**	**r^2**	**p**	**Skewness**
Catchment									
AREA	41	***-0.348***	***0.026***	0.025	0.321	4.575	***0.100***	***0.044***	**0.854**
DISTSEA	41	***0.379***	***0.015***	0.077	0.080	1.879	***0.103***	***0.041***	**0.790**
ALT	41	***0.502***	***0.001***	***0.124***	***0.024***	2.332	***0.220***	***0.002***	**0.374**
WIDTH	39	***-0.361***	***0.024***	0.074	0.094	1.942	0.093	0.059	1.032
THLDEP	39	***-0.329***	***0.041***	0.088	0.066	1.024	0.090	0.063	**0.732**
Land-use									
NAT	41	***0.578***	***<0.000***	***0.460***	***<0.001***	**0.860**	***0.150***	***0.012***	**-0.845**
OLDFOR	41	0.134	0.403	***0.095***	***0.049***	3.988	0.032	0.265	**0.362**
NEWFOR	41	0.019	0.906	0.001	0.816	3.670	0.001	0.822	2.086
ETRSH	41	-0.285	0.071	0.006	0.641	5.008	0.030	0.277	2.257
FOR	41	0.157	0.326	0.040	0.210	2.370	0.012	0.488	**0.244**
CROP	41	-0.280	0.076	0.035	0.243	6.001	0.058	0.131	4.356
PASGRA	41	***-0.476***	***0.002***	***0.226***	***0.002***	**0.211**	***0.232***	***0.001***	**-0.750**
RUR	41	***-0.474***	***0.002***	***0.227***	***0.002***	**0.344**	***0.234***	***0.001***	**-0.734**
URB	41	***-0.616***	***<0.000***	***0.284***	***<0.001***	1.787	***0.363***	***<0.001***	1.013
MISC	41	***-0.362***	***0.020***	0.050	0.159	5.631	0.057	0.133	5.295
DEVPER	41	***-0.844***	***<0.000***	***0.675***	***<0.001***	**-0.206**	***0.531***	***<0.001***	-1.139
Habitat quality									
AHA	41	0.280	0.076	0.001	0.828	-1.369	0.006	0.640	-2.612
AHD	41	***0.522***	***<0.000***	0.080	0.073	-1.025	0.028	0.296	-1.598
HH	41	***0.497***	***0.001***	***0.238***	***0.001***	**-0.399**	***0.197***	***0.004***	-1.190
CA	41	***0.620***	***<0.000***	***0.298***	***<0.001***	-1.267	***0.242***	***0.001***	-2.145
BS	41	0.234	0.141	0.033	0.256	-1.023	0.020	0.378	-2.258
CS	41	***0.436***	***0.004***	***0.205***	***0.003***	**-0.572**	***0.219***	***0.002***	-1.225
RW	41	***0.462***	***0.002***	***0.259***	***0.001***	**-0.524**	***0.217***	***0.002***	-1.101
HQI	41	***0.522***	***<0.000***	***0.230***	***0.002***	**-0.467**	***0.226***	***0.002***	**-0.974**
Water quality									
BD	14	0.415	0.140	0.087	0.307	1.664	0.114	0.238	1.225
DOSAT	14	***0.570***	***0.033***	0.138	0.191	-1.153	0.133	0.199	-1.466
FC	14	***-0.659***	***0.010***	***0.293***	***0.045***	1.087	***0.309***	***0.039***	**0.014**
NH4	14	***-0.578***	***0.030***	0.082	0.322	**-0.284**	0.080	0.328	**-0.312**
NO3	14	***-0.666***	***0.009***	0.197	0.112	1.924	0.279	0.052	1.421
TP	14	***-0.603***	***0.022***	***0.286***	***0.049***	1.305	***0.292***	***0.046***	1.212
SS	14	-0.204	0.483	0.021	0.620	**0.572**	0.003	0.841	**-0.756**
TURB	14	0.147	0.615	0.006	0.798	1.372	0.022	0.615	**-0.165**
TEMP	14	-0.496	0.072	***0.365***	***0.022***	**0.006**	***0.377***	***0.020***	**-0.153**
TEMPMAX	13	-0.314	0.295	0.127	0.231	**0.205**	0.132	0.222	**0.123**
COND	14	***-0.596***	***0.025***	***0.331***	***0.031***	**-0.216**	***0.361***	***0.023***	**-0.604**
DO	14	***0.618***	***0.019***	0.228	0.084	-1.056	0.208	0.101	-1.396
WQI-W&S	13	***0.776***	***0.002***	***0.472***	***0.010***	**0.006**	***0.411***	***0.018***	**-0.802**
WQI-sb	14	***0.785***	***0.001***	***0.409***	***0.014***	**-0.135**	***0.388***	***0.017***	**-0.407**

Appendix 9 continued.

		Spearman rank correlations		Pearson linear correlations Untransformed variables			Pearson linear correlations $\text{Log}_{10}(x+1)$ transformed variables		
QMCI-sb vs	**N**	**Rs**	**p**	**r^2**	**p**	**Skewness**	**r^2**	**p**	**Skewness**
Catchment									
AREA	41	***-0.337***	***0.031***	0.009	0.550	4.575	***0.100***	***0.044***	**0.854**
DISTSEA	41	***0.334***	***0.033***	0.064	0.110	1.879	0.094	0.051	**0.790**
ALT	41	***0.482***	***0.001***	0.092	0.054	2.332	***0.206***	***0.003***	**0.374**
WIDTH	39	***-0.323***	***0.045***	0.072	0.098	1.942	0.085	0.072	1.032
THLDEP	39	***-0.335***	***0.037***	0.091	0.062	1.024	0.092	0.061	**0.732**
Land-use									
NAT	41	***0.584***	***<0.000***	***0.487***	***<0.001***	**0.860**	***0.184***	***0.005***	**-0.845**
OLDFOR	41	0.078	0.629	0.065	0.107	3.988	0.008	0.577	**0.362**
NEWFOR	41	0.018	0.913	0.000	0.912	3.670	0.000	0.944	2.086
ETRSH	41	***-0.370***	***0.017***	0.024	0.330	5.008	0.079	0.074	2.257
FOR	41	0.083	0.606	0.021	0.362	2.370	0.000	0.939	**0.244**
CROP	41	-0.233	0.142	0.049	0.164	6.001	0.075	0.082	4.356
PASGRA	41	***-0.452***	***0.003***	***0.253***	***0.001***	**0.211**	***0.279***	***<0.001***	**-0.750**
RUR	41	***-0.453***	***0.003***	***0.257***	***0.001***	**0.344**	***0.282***	***<0.001***	**-0.734**
URB	41	***-0.541***	***<0.000***	***0.215***	***0.002***	1.787	***0.278***	***<0.001***	1.013
MISC	41	-0.256	0.106	0.050	0.161	5.631	0.055	0.139	5.295
DEVPER	41	***-0.808***	***<0.000***	***0.632***	***<0.001***	**-0.206**	***0.520***	***<0.001***	-1.139
Habitat quality									
AHA	41	0.264	0.096	0.005	0.676	-1.369	0.002	0.771	-2.612
AHD	41	***0.451***	***0.003***	0.063	0.113	-1.025	0.022	0.350	-1.598
HH	41	***0.527***	***<0.000***	***0.263***	***0.001***	**-0.399**	***0.222***	***0.002***	-1.190
CA	41	***0.637***	***<0.000***	***0.330***	***<0.001***	-1.267	***0.263***	***0.001***	-2.145
BS	41	0.277	0.079	0.048	0.168	-1.023	0.022	0.360	-2.258
CS	41	***0.472***	***0.002***	***0.240***	***0.001***	**-0.572**	***0.246***	***0.001***	-1.225
RW	41	***0.496***	***0.001***	***0.302***	***<0.001***	**-0.524**	***0.243***	***0.001***	-1.101
HQI	41	***0.539***	***<0.000***	***0.268***	***0.001***	**-0.467**	***0.256***	***0.001***	**-0.974**
Water quality									
BD	14	0.332	0.246	0.060	0.400	1.664	0.087	0.307	1.225
DOSAT	14	0.394	0.164	0.115	0.235	-1.153	0.107	0.255	-1.466
FC	14	***-0.589***	***0.027***	0.244	0.073	1.087	***0.314***	***0.037***	**0.014**
NH4	14	-0.383	0.176	0.048	0.453	**-0.284**	0.046	0.460	**-0.312**
NO3	14	***-0.793***	***0.001***	0.247	0.071	1.924	***0.321***	***0.035***	1.421
TP	14	-0.365	0.200	0.194	0.115	1.305	0.199	0.110	1.212
SS	14	-0.077	0.794	0.018	0.648	**0.572**	0.000	0.959	**-0.756**
TURB	14	0.130	0.658	0.001	0.908	1.372	0.023	0.606	**-0.165**
TEMP	14	-0.438	0.117	0.264	0.060	**0.006**	0.277	0.053	**-0.153**
TEMPMAX	13	-0.110	0.720	0.013	0.707	**0.205**	0.016	0.683	**0.123**
COND	14	***-0.534***	***0.049***	***0.341***	***0.028***	**-0.216**	***0.370***	***0.021***	**-0.604**
DO	14	0.451	0.106	0.197	0.112	-1.056	0.173	0.139	-1.396
WQI-W&S	13	***0.575***	***0.040***	***0.381***	***0.025***	**0.006**	0.286	0.060	**-0.802**
WQI-sb	14	***0.583***	***0.029***	***0.345***	***0.027***	**-0.135**	***0.316***	***0.037***	**-0.407**