

### **3. WATER QUALITY AND BIOLOGICAL SITE ANALYSES**

#### **Site and Parameter Selection**

##### *Water Quality*

The water quality data set used in this study was obtained from the Environment Protection Authority Fixed Site Network and the Victorian Water Quality Monitoring Network (Hunter 1993; Hunter and Hedger 1995; Hunter and Loone 1996; Hunter and Zampatti 1994). To characterise the water quality across Victoria, sites were chosen with continuity of sampling between and including the years 1990 to 1995. At all sites, sampling was typically undertaken at monthly intervals, although some sampling data were not available at certain sites. Sites with more than four samples missing for any one year were omitted from the analyses. Site selection was also restricted to rivers and streams due to a lack of useable information relating to lakes and impoundments. Only sites that were not excessively impacted were included.

The water quality indicators chosen were those considered to be the most ecologically significant. They included colour (Pt/Co units), electrical conductivity at 25°C ( $\mu\text{s}/\text{cm}$ ), turbidity (NTU), nitrates and nitrites (mg/L), total Kjeldahl nitrogen (mg/L), total nitrogen (mg/L), reactive phosphorus for nine sites from EPA Fixed Site Network and soluble reactive phosphorus (mg/L) for the remaining sites, and total phosphorus (mg/L). This selection process resulted in 92 sites across Victoria being suitable for analysis.

##### *Macroinvertebrate Assemblages*

The macroinvertebrate data set used in the analyses was collected by EPA as part of the Monitoring River Health Initiative (MRHI). Edge habitat sweep samples were used (Tiller and Metzeling: In Prep.), collected from relatively unimpacted reference sites (CEPA *et al.* 1994). Results from sampling conducted between 1990 and 1996 at each site on four occasions (two spring and two autumn runs) were used. Sites could not be sampled if they were dry. The number of sites available throughout Victoria for analysis was 200.

Unlike many of the studies conducted to evaluate the US-EPA ecoregions, the selection of macroinvertebrate and water quality sites was not restricted to areas most representative of the ecoregion cores. This was primarily due to two factors: 1) the location of water bodies across Victoria restricted the site possibilities for sampling; and 2) there was a reliance upon existing site data. This procedure is valid given that: if the selected sites were only representative of the core area of an ecoregion, then recovery criteria and reference sites established based on these sites could potentially lead to the remainder of the ecoregion being misrepresented.

#### **Water Quality Analyses**

##### *Numerical Analyses*

Sites were classified based on their water quality using un-weighted pair-groups with mean averaging (UPGMA), a numerical classification that uses hierarchical clustering of sites into groups (Belbin 1993). Median values of the water quality data were used in the classification to assess central

tendencies of the data, and to avoid the complexity that extreme values could cause. Site groups were assessed using a dendrogram based on site dissimilarity.

For comparison with the 17 delineated ecoregions, the UPGMA site classification was used to separate 17 site groups. The groups were plotted on a map of the Victorian ecoregions to provide a picture of their spatial distribution and indicate their association with the ecoregions. The UPGMA site classification was similarly used to define seven and ten site groups, allowing comparison with the seven river regions and ten IBRA regions, respectively, using maps of the separate site group classifications and respective regionalisations.

The sites were also analysed using water quality data and principle components analysis (PCA), which is an ordination procedure that represents the site and water quality relationships in a low-dimensional space, summarising the variance in the data (Belbin 1993). The plotted sites of the PCA were overlain by the 17 ecoregions to reveal any clustering of sites that fell in the same ecoregion. The 17, 10 and 7 UPGMA site groups, respectively, were also separately overlain onto the plotted sites of the PCA. This was conducted to determine: (i) if either the UPGMA classification, or the ecoregional groupings were meaningfully distributed by the ordinations; and (ii) whether the two methods produced similar results.

Where sites occurred on the boundary between regions, they were placed into the region that was immediately upstream from the particular site. If more than one ecoregion was located upstream, then expert knowledge was applied to determine the placement of the site.

## **Macroinvertebrate Analyses**

### *Numerical Analyses*

Sites were classified into site groups based on species assemblage using UPGMA (Belbin 1993). Similar to the analyses for water quality, the classification of sites was limited to 17 groups for comparison with the 17 delineated ecoregions. Expert judgement in the process of establishing the 17 site groups was provided by Dr. Richard Marchant (Museum of Victoria) and Mr. Leon Metzeling (EPA Victoria). These groups were plotted on to a map of Victoria and visually compared with the ecoregions. To compare with the seven river regions and ten IBRA regions, the classification was again used to define seven and ten site groups, respectively. The association between the site groups and the regionalisations was assessed using map plots.

The placement of borderline sites into the upstream region, was conducted in the same manner as those for the water quality data set.

In addition, a classification of the sites by species assemblage was conducted using the program ALOC (Belbin 1993). ALOC provides a non-hierarchical clustering of sites into a specified number of groups. To enable a direct comparison with the 17 delineated ecoregions, the sites were classified into 17 groups. For visual comparison, the sites were plotted on a map of Victoria and overlain with the ecoregion boundaries. Similar classifications and visual comparisons were conducted for the seven river regions and ten IBRA regions.

The application of hierarchical and non-hierarchical classification programs provides a means of assessing the distribution of sites by checking to see if both programs produce similar results. Non-hierarchical classification assigns similar sites into clusters, but relationships among the clusters are not characterised. This classification, however, is not constrained by having to assign clusters into a

hierarchy, which is the function of the hierarchical classification program. Hierarchical classification, however, does indicate the relationships among the groups, although the classification will initially separate sites and any further divisions are bounded by those initial divisions.

### **3.4 Intrinsic Regionalisation**

In addition to the comparisons with the predetermined regionalisations, the distributions of water quality and macroinvertebrate sites were each analysed for any intrinsic regionalisation of the data. This was undertaken using the hierarchical dendrograms produced by the UPGMA classification of sites. The procedure consisted of plotting all sites on a map and highlighting the new group created by each sequential division. When the site groupings reached a stage where the next sequential division created a group that could not be readily defined geographically, the procedure was halted.

The distribution of the plotted sites was compared with maps of the environmental factors used in the Victorian ecoregion delineation process and with other regional environmental factors including median annual runoff (mm) (Holmes 1982), groundwater (mg/L TDS) (Lawrence 1982), current vegetation (NRS 1994; Paine 1982) and landuse (NRS 1994 and 1996c).