INFORMATION BULLETIN

BIOLOGICAL OBJECTIVES FOR RIVERS AND STREAMS – ECOSYSTEM PROTECTION

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Freshwater Sciences

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1 INTRODUCTION

1.1 Background

Over the last decade, there have been calls for the development of biological objectives[1] to supplement the existing water quality objectives used in environmental policies. The call for biological objectives is in recognition of the shortcoming of using only physical and chemical objectives in protecting the aquatic environment and, in particular, protecting aquatic ecosystems.

When using physical and chemical indicators alone, the underlying assumption has been that if these are met, then the aquatic environment can be considered to be in good health[2, 3]. The problems with this approach are that:

- antagonism or synergism between contaminants may not be taken into account, and may affect biota;
- being spot measurements they may not reflect long term water quality as intermittent inputs and flood events are often missed;
- the appropriate parameters may not be measured;
- it does not allow for assessment of other factors which affect distribution of biota, such as inadequate physical habitat, water volume, or introduced species[4].

A number of countries have been developing biological objectives to assess the health of aquatic ecosystems. The US EPA and the Environment Agency in the UK have encouraged the development and adoption of biological criteria for measuring river health[5, 6]. In Victoria, the *State Environment Protection Policies* (SEPP) for the Yarra River[7] and Western Port Bay and its Catchment[8] include numeric biological objectives for invertebrates, as well the presence of certain species of fish.

While water quality has been a major focus of attention in the past, a problem receiving increased recognition is physical degradation of the waterways and poor instream habitat[9]. Even with good water quality a healthy aquatic ecosystem cannot be supported if suitable habitat is not present. In this way the biota are an integrative measure, responding to all the aspects of water quality and quantity as well as habitat condition. As they depend on the stream throughout all or most of their life, the biota also integrate environmental conditions over time.

1.2 Context and scope

This document presents the biological objectives of the *State Environment Protection Policy (Waters of Victoria)*[10]. They are applicable to rivers and streams in the State which do not have more specific catchment based objectives already in place.

A fundamental feature of these objectives is that they are based on biological regions. This was needed due to the obvious differences between, say, an alpine stream and a stream in the Wimmera. The biota in these different regions are distinctive and require their own specific objectives. This approach is similar to that used in catchment based policies in which segments are defined, usually based upon land use. In this case, the regions have been defined by the biota.

The objectives are designed to maintain the quality of the better sites in the regions and set goals for improvement for other sites within the regions. In other words, these objectives aim to maintain or rehabilitate the health of aquatic ecosystems. This will be easier to achieve in some regions than in others due to differing degrees of catchment disturbance. In some streams, they may never be achieved due to major and irreversible impacts to the stream ecosystems. For example:

- rivers downstream of large water storages that act as irrigation supply channels;
- urban streams now in concrete channels or underground pipes.

Return of such rivers to a more natural state requires major financial and community support, without which they are unlikely to ever meet the objectives.

Victoria has endorsed the National Water Quality Management Strategy, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*[11] which introduces a risk based approach for developing guidelines and assessing impacts on aquatic ecosystems (see Appendix 1 for a framework for risk assessment). The G*uidelines*[11] specify water quality trigger values (or alert levels) which should initiate follow-up assessment. The biological objectives described in this document can be viewed as both a trigger (which initiate further investigation) or as a direct measure of the beneficial use being protected (the aquatic ecosystem).

Although data from some intermittent or seasonally flowing streams have been used to derive these objectives, these stream types are poorly represented in the reference site data set. Applying these objectives to such streams should be undertaken in accordance with the risk assessment approach[12].

No objectives have been developed for lakes or wetlands due to lack of data on these systems.

2 USING INVERTEBRATES AS BIOLOGICAL INDICATORS

Given the diversity of the aquatic ecosystem, it is not possible to assess and set objectives for every component. Many components of aquatic ecosystems have been measured from time to time such as phytoplankton, benthic diatoms, fish, bacteria, and invertebrates[13]. Some community process measures have also been proposed, such as stream metabolism[14].

The aquatic invertebrate community is commonly used in assessments of environmental health, pollution effects, and effectiveness of restoration measures[15, 16] It is the most commonly used component of the biota both in Australia and overseas[17] and was selected as the indicator for developing biological objectives.

As more data and information become available, other components of the biota such as benthic diatoms or fish, may also be chosen as indicators.

2.1 Aquatic invertebrates

Aquatic invertebrates are small animals, generally less than 1 cm long, and include mayfly and dragonfly nymphs, beetles, snails, worms, shrimp, and the like. They are very abundant in streams, occurring in all aquatic habitats. They can be found burrowed in mud, in or on woody debris (snags), on the surface of stones in fast flowing riffles and among macrophyte beds. As well as being important in their own right, invertebrates are critical to stream ecosystem functioning, both in the processing of energy, and as a food supply to yabbies, fish, platypus, and some birds.

2.2 Sensitivity to change

There are now considerable data available on the response of invertebrates to various forms of pollution, to changes in catchment use (for example, agriculture, forestry, urbanisation), and of their general habitat preferences and ecology. Some types are known to be sensitive to changes in environmental factors such as temperature, dissolved oxygen or nutrient status. Being of limited mobility, the presence or absence of invertebrate families reflects conditions at a site over time, allowing an assessment of intermittent stresses which are often missed in chemical monitoring programs.

The presence or absence of specific types of invertebrates is just one way in which information can be discerned about environmental quality. Other information can be obtained from how many different types of animals are found in a stream (biological diversity), the number of animals found in a stream (abundance), and the relationship between all animals present (community composition).

Streams with a high level of diversity are generally in good health. Streams which have low diversity are typically less healthy – often due to the impacts of pollution. In polluted habitats, sensitive species are eliminated and less sensitive species show an increase in numbers.

2.3 Taxonomic resolution

It is generally assumed that invertebrate species level identification rather than family, and quantitative abundance data, are desirable as these provide the greatest amount of information. However, reliable species identification for many invertebrates is often difficult, requiring a high level of skill, and is not possible for some groups of invertebrates.

Most monitoring programs around the world[18, 19] have chosen to use invertebrates identified to the level of family and simple presence /absence (or binary) data. This is considered appropriate as studies both in Australia[20, 21] and elsewhere[22] have shown sufficiently high similarity between family and species level patterns and their interpretations, and between quantitative and binary data, particularly when used in broadscale assessments[23].

The biological objectives require that specimens be identified to family, with the exception of certain groups which are left as class (see Section 4.1 for details), and Chironomidae which need to be identified to sub-family.

2.4 Sampling protocol

Biological data are very sensitive to the method used to collect the specimens. The EPA rapid bioassessment, live sorting method (as amended from time to time)[24] must be used to collect the data which are to be compared against the biological objectives. This was the method used to collect the data on which the objectives are based.

Samples need to be collected from two consecutive seasons - autumn (March – May) and spring (October – December) - and the data combined for assessment against the biological objectives.

Two stream habitats can be sampled – riffles and edges (including aquatic macrophytes) – as biological objectives have been developed for both.

It is essential for the application of these indicators and objectives that this sampling protocol is followed. Use of invertebrate data collected by other methods may lead to misleading interpretations.

3 BIOLOGICAL REGIONS

EPA has an extensive database of aquatic invertebrates covering the entire State, which was largely accumulated under the National River Health Program (NRHP)[25]. The availability of this information has been crucial for delineating regions and developing biological objectives across Victoria.

Under the NRHP, stream sites were designated as 'reference' sites for the purpose of building predictive models which could be used to assess river health.

A reference site does not mean that the site is pristine (although some streams in the upper Yarra closed catchment and far East Gippsland approach this description). A reference[26] site is a near natural, minimally impacted or best available site. This is in recognition that most streams in foothill and lowland areas in particular, have been greatly modified by human activities, and few, if any, unaltered or pristine examples of streams exist.

The reference sites were also used to develop the biological regions. All available invertebrate data from edge and riffle habitats at reference sites (including habitat assessments and water quality data) were used (Figure 1).

The regionalisation process involved the classification of sites using a combination of numerical (clustering, ordination and multi-linear regression analyses) and qualitative (expert judgement) methods. Regions were delineated primarily upon the patterns of community assemblage of aquatic invertebrates across Victoria, although environmental factors were also used to assist with the boundary positioning and the general descriptions of the regions[27, 28].

Each of the regions are described as follows and summarised in Table 1.

3.1 Highlands (B1)

This region is located in the high country of Victoria, with streams often on steep slopes, generally above 1000 m and subject to high rainfall. The vegetation tends to be native forest, woodland and grassland. Riparian shading varies from moderate to low cover, depending on the course of streams through forested or grassland areas, respectively.

The region includes mountain reaches in the Upper Murray, Mitta Mitta, Kiewa, Ovens, Goulburn, Yarra, Latrobe, Thomson, Macalister, Mitchell, Tambo and Snowy catchments.

The streams tend to be small, very close to their source and have the smallest catchment area above the sampled sites (Table 1). They also have the lowest water temperatures, and are subject to very low alkalinity, turbidity and salinity. The stream habitat is generally characterised by the presence of riffles and limited edge habitat, with coarse substrate and low macrophyte cover and diversity.

3.2 Forests A (B2)

Six separate areas form this region, comprising upland reaches in the Upper Murray, Mitta Mitta, Kiewa, Goulburn, Yarra, Latrobe and Thomson catchments, and rivers and streams in the Grampians, Strzeleki Ranges, Wilsons Promontory and far East Gippsland. Although discontiguous, they share similar environmental and biological characteristics.

The streams are generally located on moderately steep slopes at much lower altitudes than the Highlands Region, but at moderately high altitudes relative to the remaining regions. The region receives moderate to high rainfall. Tall forests and woodlands are the typical vegetation cover, with some forestry and grazing activities. Streams generally have considerable shading from the riparian zone, and tend to be further from their source with a greater upstream catchment area than the Highlands Region.

Cool waters with very low alkalinity, turbidity and salinity characterise the region, except in the Grampians where there is low to moderate salinity. Streams typically have both riffle and edge habitat with moderately coarse substrate, and very low macrophyte cover and diversity.

3.3 Forests B (B3)

The Forests B Region incorporates the upland reaches in the Ovens, Broken, Goulburn, Macalister, Mitchell, Tambo and Snowy catchments, and rivers and streams in the Otway Ranges. The discontiguous region generally covers an area similar in altitude to the Forests A Region, but stream slopes are less steep.

Rainfall is slightly less in this region than in Forests A Region, and supports tall open forests. A greater degree of clearing for forestry, grazing and some intensive agriculture occurs in this region compared with the Highlands Region and Forests A Region. This results in a lower level of riparian shading.

Streams are further from their source, with more than double the catchment area of streams in Forests A Region.

Alkalinity of the cool waters typical of this region is slightly elevated relative to the Highlands Region and Forests A Region, but still remains low compared to the rest of the State along with turbidity and salinity. Stream habitat is characterised by the presence of riffles and edges, with very coarse substrate and high macrophyte diversity and cover.

3.4 Cleared Hills And Coastal Plains (B4)

The urban area of Melbourne divides this region which is characterised by coastal plains in the south, and inland plains and low foothills in the north and east. This region includes upper reaches in the Campaspe, Loddon, Avoca, Wimmera and Hopkins catchments, mid reaches in the Ovens, Broken and Goulburn catchments, lowland reaches in the Barwon, Yarra, Latrobe, Thomson, Macalister, Mitchell, Tambo and Snowy catchments, all reaches in the Curdies, Moorabool, Werribee, Maribyrnong and Western Port Bay catchments, and river and stream reaches in South Gippsland.

Streams flow through an undulating landscape of low altitude with little gradient and relatively low rainfall. The region has been substantially cleared for intensive agriculture including dryland pasture and some irrigated pasture, resulting in poor riparian shading.

Warm stream waters with high alkalinity and low to moderate turbidity and salinity characterise the region. The edge habitat is more developed and extensive, and riffles are less common. The substrate tends to be composed of moderate to fine particles, and there is a very high diversity and moderate cover of macrophytes.

3.5 Murray And Western Plains Region (B5)

This region incorporates the west and north of the State and covers an area of low altitude plains with very little topographical relief and low rainfall. This region includes lowland reaches in the Kiewa, Ovens, Broken, Goulburn, Campaspe, Loddon, Avoca, Wimmera, Glenelg, and Hopkins catchments, the entire Corangamite catchment and the Portland and Millicent Coast basins. The region has been generally cleared for dryland and irrigated pasture, and broad-acre cropping. It also includes some patches of Mallee woodland. Riparian shading is, therefore, typically very poor.

The waters are warm and slow, often seasonally intermittent, tending toward pond-like waterways with high alkalinity, and moderate to high turbidity and salinity. The very fine substrate of the streams means that the principal habitat is along edges, with the high diversity and cover of macrophytes and woody debris being the dominant habitat for invertebrates. Riffles are uncommon.

3.6 North-west Victoria

Because of insufficient data in the north-west area of Victoria, and a very different aquatic environment, no specific biological objectives have been set for water bodies in this region. If required, the objectives from the Murray and Western Plains Region (B5) can be used as interim objectives where streams are present.

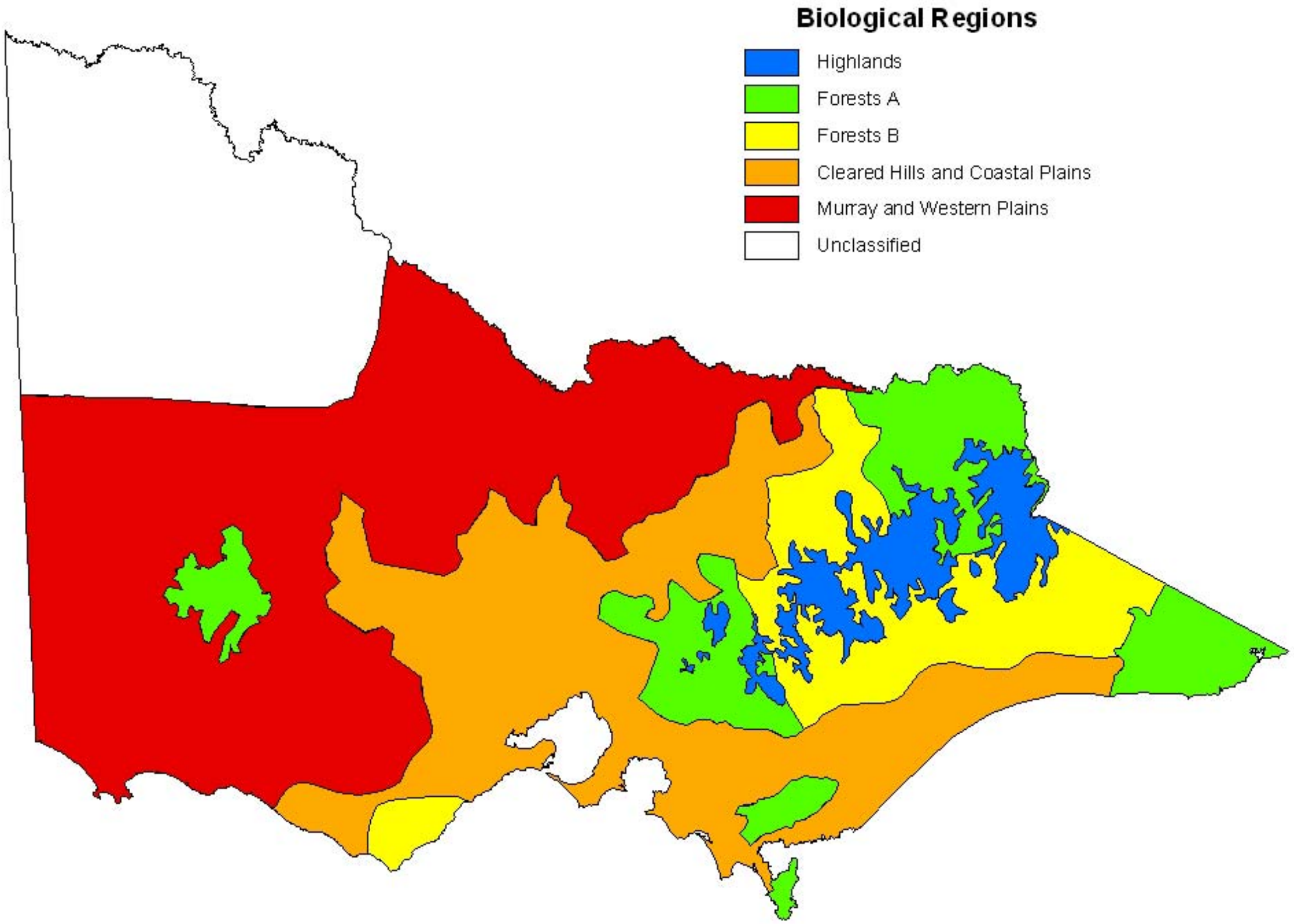

Figure 1: Biological regions in Victoria based on benthic invertebrates (SEPP WoV).

Table 1: Biological regions and their general descriptions (SEPP WoV)

Region	Altitude (m ASL)	Rainfall (mm)	Physiography	Vegetation/ Land use	Stream Habitat Features	Water Quality Features
Highlands (B1)	>1000	>1200 Subalpine/ Montane	Highlands	Alpine woodlands (e.g. Snowgum) and grasslands; and tall forest (e.g. Alpine Ash and Mountain Ash)	Riffle and some edge	Cool water with very low turbidity and salinity
Forests A (B2)	200 – 1000	700 – 1200 Temperate/ Montane	Mountains, foothills and steep valleys	Tall forest (e.g. Mountain Ash) and woodland (e.g. Stringybark); high riparian shading	Riffle and edge	Cool water with very low turbidity and salinity; except in the Grampians: low to moderate salinity
Forests B (B3)	200 – 1000	600 – 1200 Temperate/ Montane	Mountains and foothills; steep and broad valleys	Tall open forest (eg. Mountain Ash) with some clearing	Riffle and edge	Cool water with low turbidity and salinity

Cleared Hills and Coastal Plains (B4)	<800	300 – 1000	Hills, broad valleys and coastal plains	Generally cleared for dryland pasture and some irrigated pasture; poor riparian shading	Edges but riffles less common	Warm water, low to moderate turbidity and salinity
Murray and Western Plains (B5)	<300	200 – 600, except on the coast: <1 000	Plains	Generally cleared for dryland and irrigated pasture and broadacre cropping, with some areas of woodland and Mallee; poor riparian shading	Generally edge only (woody debris and macrophytes); and intermittent stream flow	Warm water with moderate to high turbidity and salinity

Indicative values for:

Turbidity (NTU):	very low <3	Salinity (TDS $mg.L^{-1}$):	very low <30
	low 3-5		low 30-100
	moderate 10-20		moderate 100-1000
	high 20-40		high >1000

4 THE BIOLOGICAL INDICATORS

The use of a number of indicators to measure ecosystem health is desirable as it improves the robustness and reliability of the assessment. When they are in accord, greater confidence may be placed on the outcome, and when there is a discrepancy, this can be used to indicate the type of environmental problem involved[13,29].

The five chosen biological indicators fall into three categories:

- a measure of diversity – number of families;
- biotic indices – the SIGNAL and EPT indices;
- measures of community composition – numbers of key families and AUSRIVAS predictive models.

4.1 Number of families

The number of invertebrate families found in streams can give a reasonable representation of the ecological health of a stream - healthy ecosystems generally have more families. However, this is too great a simplification of data to be adequate on its own.

Throughout a region, the expected number of families will vary according to quality of habitat and stream size, with larger streams, in general, supporting more taxa. Mild nutrient enrichment can also increase the numbers of families due to the increased food supply. Some streams may also be naturally diverse and could be considered as biodiversity 'hot spots.'

Reduction in the expected number of families present can be caused by poor quality habitat and by various pollutants. The presence of toxicants, for example, tends to reduce numbers of families.

The number of families indicator is calculated by simply summing the 'families' of invertebrates (with Chironomidae to sub-family). Acarina, Oligochaeta, Tricladida, Temnocephalidea, Cnidaria, Nematomorpha and Porifera are used at these higher taxonomic levels (for example, Acarina effectively contributes one to the total number of families) but are not identified further in the data used to derive the objectives. Use of families within these higher level groups would artificially elevate the number of families at a site and lead to misleading results.

Recent major changes in taxonomy of the Odonata were not used in the derivation of the objectives. For the purpose of the objectives, Aeshnidae and Telephlebiidae need to be summed to Aeshnidae; Synthemistidae, Austrocorduliidae, Cordulephyidae and Hemicorduliidae need to be summed to Corduliidae. Where other families simply changed names, the old name should be used. In cases where families were split into Victorian and non-Victorian taxa, the Victorian family name should be used.

Collembolla and crustaceans in the groups Cladocera, Ostrocoda, and Copepoda were not used at all in this or any of the other objectives.

4.2 The SIGNAL biotic index

A biotic index is an index of water pollution based on tolerance or intolerance of the biota to pollution.

The biotic index SIGNAL (Stream Invertebrate Grade Number - Average Level) has been accepted and used nationally in stream assessments. This particular index was originally developed in south-eastern Australia[30]. The output is a single number, between zero and ten, reflecting the degree of water pollution - high quality sites have high SIGNAL scores (Table 2).

Families of aquatic invertebrates have been awarded sensitivity scores, according to their tolerance or intolerance to various pollutants. These scores have been determined by examining data from studies of various pollutants in south-eastern Australian streams. The scores are a compromise in cases where species within a family respond in different ways to a pollutant, and where the family responds differently to different types of pollutants. The index is calculated by totalling these scores and dividing by the number of graded families present (most, but not all, families have SIGNAL grades). While SIGNAL is particularly good for assessing organic pollution, its usefulness for toxic impacts and other types of disturbance is less certain.

The list of invertebrate families and SIGNAL scores used is based largely on those in the original publication[30] (Appendix 2). Oligochaeta has been added and assigned a score of one. Families not present in the original publication have been given scores based on further unpublished developments by Chessman (personal communication) and are also included in Appendix 2.

Table 2: Generic key to SIGNAL scores

SIGNAL score	Water Quality
>7	Excellent
6-7	Clean water
5-6	Mild pollution
4-5	Moderate pollution
<4	Severe pollution

The SIGNAL index is currently being developed further by examining data collected nationally during the NRHP. The revised SIGNAL index is likely to represent a significant change from the existing set of taxa scores. Only the scores given in Appendix 2 should be used when assessing whether this objective is met.

4.3 The EPT biotic index

The EPT index is the total number of families within the generally pollution-sensitive insect orders of Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies). Any loss of families in these groups usually indicates disturbance[18]. The EPT index has been applied to many stream systems in the United States[31] and has been used in general site classifications within Australia[20, 21].

The EPT index cannot be used in all regions due to natural biogeographical variations in the animals' distributions. Due to their ecological preference for well oxygenated, cool water streams, stoneflies and some mayfly families are seldom found in the warmer, slower flowing waters which typify the Cleared Hills and Coastal Plains Region and the Murray and Western Plains Region. As a result, the numbers of EPT families within reference sites in these regions are very low, typically 6 - 10 families. Such low numbers could result in misclassification of a site simply due to sampling error, and therefore no EPT objectives were set.

4.4 AUSRIVAS

One of the main aims of the National River Health Program was the development of predictive models which could be used to assess river health[25]. As a result, the Co-operative Research Centre for Freshwater Ecology developed the Australian Rivers Assessment System (AUSRIVAS)[32] which consists of a suite of mathematical models, extending the approach originally developed in the UK[33].

AUSRIVAS predicts the macroinvertebrates which should be present in specific stream habitats under reference conditions. It does this by comparing a test site with a group of reference sites which are as free as possible of environmental impacts but which have similar physical and chemical characteristics to those found at the test site.

AUSRIVAS models were developed for separate habitats in most regions. Exceptions were the riffle and edge habitats in the Highlands Region, and the riffle habitat in the Murray and Western Plains Region. In these cases, there were too few reference sites available for building the models. Therefore there are no AUSRIVAS objectives for these habitats and regions. The AUSRIVAS models are accessible over the World Wide Web at the following URL: http://ausrivas.canberra.edu.au

One of the products of AUSRIVAS is a list of the aquatic invertebrate families and the probability of each family being found at a test site if it was equivalent to reference quality. By comparing the totalled probabilities of predicted families and the number of families actually found, a ratio can be calculated for each test site. This ratio is expressed as the observed number of families/expected number of families (the O/E index). The taxonomic issues raised in section 4.1 also apply to the use of AUSRIVAS.

The value of the O/E index can range from a minimum of zero (none of the expected families were found at the site) to around one (all of the families which were expected were found). It is also possible to derive a score of greater than one, if more families were found at the site than were predicted by the model. A site with a score greater than one might be an unexpectedly diverse location, or the score may indicate mild nutrient enrichment by organic pollution, allowing additional macroinvertebrates to colonise.

The O/E scores derived from the model can then be compared to bands (Table 3) representing different levels of biological condition, as recommended under the NRHP[29]. The width of the band varies between models but is constant within each model. The band label for the equivalent classifications remains constant across all models, that is Band A always corresponds to reference site quality.

Sometimes the AUSRIVAS models do not produce an O/E score and describe the test site as being 'outside the experience of the model'. This indicates that one or a combination of the environmental variables used to make the prediction places the test site beyond the scope of that encompassed by the reference sites used to build the model. In these cases, no assessment can be made using the AUSRIVAS objective.

4.5 Key Invertebrate Families

This indicator focuses mainly on the loss of taxa that are indicative of good habitat and water quality. The families selected are those which:

- are typically found in the types of stream in that region.

  For example, families such as Coloburiscidae and Austroperlidae occur in cool, forested streams typical of the upland and mountain areas of the State. Other families, such as Calamoceratidae, Coenagrionidae and Hydrophilidae become more common in the warmer streams of the foothills and lowlands.

- are representative of a particular habitat type - such as riffles, woody debris, fringing vegetation, macrophytes or pools.

- represent reasonable to good water quality, tending to disappear as conditions deteriorate.

  However, families found in lowland streams are generally tolerant of a broader range of water quality than those in upland streams.

- are commonly collected when present, using the recommended method[24] to sample edges and riffles.

The lists of desirable (or key) families were generated by examination of data throughout each region, focussing upon:

- the percentage occurrence of families at sites within each region, using families which occurred more than 50% of the time;

- the calculation of taxa fidelity scores for each region, and the evaluation of fidelity scores for taxa that occurred at ≥50% of sites using a fidelity criterion of ≥1.5;

- expert judgment from experienced aquatic ecologists/biologists as to which families were likely to occur in streams in good condition in each of the regions.

Lists of key families produced for the Yarra[7] and Western Port[8] catchments were also considered and incorporated where relevant.

The lists of key families (Table 4) assist in providing an indication of habitat availability as well as water quality. A separate list for each region is necessary to cater for changes in assemblages expected with changes in regional environmental features such as altitude, topography, stream size and flow and temperature. Edge and riffle habitats are not distinguished with this indicator – both should be sampled where present and the data combined when making an assessment. In Regions B1 to B4, both riffle and edge habitats should be sampled and the data summed when using this indicator. In Region B5, riffles are relatively scarce and only an edge sample is required.

The numerical objectives require the presence of a proportion of the listed families. It is unlikely that a site would contain all families, as the lists incorporate taxa from a range of habitat types, stream sizes, and stream types within each region. As key families represent the families expected to occur in streams in good condition, this indicator is similar in concept to AUSRIVAS which uses statistical models to predict the families expected to occur. The outputs of these two indicators are highly correlated.

Table 3: Example AUSRIVAS O/E family score categories

Band Label	O/E score	Band Name	Comments
X	>1.15	richer than reference	more families found than expected potential biodiversity 'hot spot' possible mild organic enrichment
A	0.85-1.14	reference	index value within range of the central 80% of reference sites
B	0.55-0.84	below reference	fewer families than expected potential mild impact on water quality, habitat or both, resulting in loss of families
C	0.25-0.54	well below reference	many fewer families than expected loss of families due to moderate to severe impact on water and/or habitat quality
D	<0.25	impoverished	very few families collected highly degraded very poor water and/or habitat quality

Table 4: Lists of Key Families for Regions (combined habitats) (SEPP WoV)

Region B1 List	Region B2 List	Region B3 List	Region B4 List	Region B5 List
Aeshnidae	Aeshnidae	Aeshnidae	Aeshnidae	Aeshnidae
Acarina	Acarina	Acarina	Acarina	Acarina
Aphroteniinae	Ameletopsidae	Ameletopsidae	Ancylidae	Ancylidae
Austroperlidae	Ancylidae	Ancylidae	Atyidae	Atyidae
Baetidae	Athericidae	Athericidae	Baetidae	Baetidae
Blepharoceridae	Austroperlidae	Atriplectidae	Caenidae	Caenidae
Calocidae	Baetidae	Atyidae	Calamoceratidae	Calamoceratidae
Ceratopogonidae	Blepharoceridae	Austroperlidae	Ceinidae	Ceinidae
Chironominae	Caenidae	Baetidae	Ceratopogonidae	Ceratopogonidae
Coloburiscidae	Calocidae	Caenidae	Chironominae	Chironominae
Conoesucidae	Ceratopogonidae	Calamoceratidae	Coenagrionidae	Coenagrionidae
Dixidae	Chironominae	Calocidae	Conoesucidae	Corbiculidae
Dugesiidae	Coloburiscidae	Ceinidae	Corixidae	Cordylophora
Elmidae	Conoesucidae	Ceratopogonidae	Dixidae	Corixidae
Eusiridae	Corduliidae	Chironominae	Dugesiidae	Culicidae
Eustheniidae	Corixidae	Coenagrionidae	Dytiscidae	Dytiscidae
Gripopterygidae	Corydalidae	Coloburiscidae	Ecnomidae	Ecnomidae
Helicophidae	Dixidae	Conoesucidae	Elmidae	Gerridae
Hydrobiosidae	Dugesiidae	Corduliidae	Gomphidae	Gomphidae
Hydropsychidae	Dytiscidae	Corixidae	Gripopterygidae	Gripopterygidae
Hydroptilidae	Ecnomidae	Corydalidae	Gyrinidae	Gyrinidae
Leptoceridae	Elmidae	Dixidae	Hydrobiidae	Hydrobiidae
Leptophlebiidae	Empididae	Dolichopodidae	Hydrobiosidae	Hydrometridae
Limnephilidae	Eusiridae	Dugesiidae	Hydrometridae	Hydrophilidae
Nannochoristidae	Eustheniidae	Dytiscidae	Hydrophilidae	Hydroptilidae
Neoniphargidae	Glossosomatidae	Ecnomidae	Hydropsychidae	Hyriidae
Notonemouridae	Gomphidae	Elmidae	Hydroptilidae	Janiridae
Oligochaeta	Gripopterygidae	Empididae	Leptoceridae	Leptoceridae
Orthocladiinae	Gyrinidae	Gerridae	Leptophlebiidae	Leptophlebiidae
Philopotamidae	Helicophidae	Glossosomatidae	Mesoveliidae	Mesoveliidae
Philorheithridae	Helicopsychidae	Gomphidae	Nepidae	Naucoridae
Psephenidae	Hydrobiosidae	Gripopterygidae	Notonectidae	Nepidae

Table 4: continued

Region B1 List	Region B2 List	Region B3 List	Region B4 List	Region B5 List
Scirtidae	Hydrophilidae	Gyrinidae	Oligochaeta	Notonectidae
Simuliidae	Hydropsychidae	Helicophidae	Orthocladiinae	Oligochaeta
Siphlonuridae	Leptoceridae	Helicopsychidae	Parastacidae	Orthocladiinae
Tanypodinae	Leptophlebiidae	Hydrobiidae	Physidae	Parastacidae
Tipulidae	Limnephilidae	Hydrobiosidae	Psephenidae	Physidae
	Notonemouridae	Hydrophilidae	Pyralidae	Planorbidae
	Oligochaeta	Hydropsychidae	Scirtidae	Pleidae
	Oniscigastridae	Hydroptilidae	Simuliidae	Pyralidae
	Orthocladiinae	Leptoceridae	Stratiomyidae	Simuliidae
	Philopotamidae	Leptophlebiidae	Tanypodinae	Stratiomyidae
	Philorheithridae	Mesoveliidae	Tipulidae	Tanypodinae
	Polycentropodidae	Notonectidae	Veliidae	Veliidae
	Psephenidae	Odontoceridae		
	Ptilodactylidae	Oligochaeta		
	Scirtidae	Oniscigastridae		
	Simuliidae	Orthocladiinae		
	Tanypodinae	Parastacidae		
	Tipulidae	Philopotamidae		
	Veliidae	Philorheithridae		
		Physidae		
		Planorbidae		
		Polycentropodidae		
		Psephenidae		
		Ptilodactylidae		
		Scirtidae		
		Simuliidae		
		Stratiomyidae		
		Synlestidae		
		Tanypodinae		
		Temnocephalidea		
		Tipulidae		
		Veliidae		

5 HOW THE OBJECTIVES WERE CALCULATED

The numerical objectives for each indicator were derived from the distribution of scores for each indicator from the reference sites within each region.

For the AUSRIVAS models this is inherent in the model building process with Band A (equal to reference quality) defined as the scores between the 10^{th} and 90^{th} percentile of scores recorded for the reference sites (Table 3). This approach is standard for all AUSRIVAS models across the country. It acknowledges the variability which exists within streams of similar type and also within the same stream over time.

A similar approach was adopted with the other indicators except that no upper percentile of reference site scores was used, the lower percentile acting as a trigger.

The lower percentile used also varied between regions due to the assessment of the quality of the reference sites within each region. For example, the Forests A Region contains many streams in National Parks, closed water supply catchments or forested areas. Although these streams are not pristine, they are clearly closer to their natural condition than streams in other areas. In contrast, the Cleared Hills and Southern Plains Region and the Murray and Western Plains Region have been greatly altered by human activities. As such, the reference streams in these regions must be further from their natural state in comparison with their counterparts in the other regions. Therefore, the trigger or target set by these reference sites was too low if the 10^{th} percentile was used.

In response to the poorer quality of the reference sites in Regions B4 and B5, the 30^{th} percentile of reference site scores was used to set objectives for the remaining four indicators[31]. The 10^{th} percentile was used for Regions B1 to B3.

6 THE OBJECTIVES

Objectives are generally provided for both riffle and edge habitats. It is possible that one habitat will pass while the other habitat fails to meet all objectives. When this discrepancy between habitats occurs, then the overall site assessment should be based on the worst outcome; in other words, the precautionary principle should be followed.

Some sites will be borderline pass or fail for one or more indicators. In some cases, this could highlight the need for further sampling of the site to clarify the assessment. In others, the judgement or opinion of qualified stream ecologists should be obtained to determine whether the stream being tested is anomalous within its assigned region. The reference sites within each region used to develop these objectives cover a broad range of sizes and stream types, but some anomalies will occur in applying these objectives.

An assessment of whether a stream site is of acceptable environmental quality will be based on it meeting the objectives of four of the biological indicators – Number of families, SIGNAL, AUSRIVAS and EPT. Key Families is similar in concept and results to AUSRIVAS and, to avoid redundancy, AUSRIVAS is preferred. Key families should be used if access to the models is not possible or if AUSRIVAS does not give a result for the site due to it being 'outside the experience of the model'.

In regions B1, B2 and B3, four objectives are to be used to assess a site. If a site fails to meet one of the objectives but meets all others, then this should be considered as an 'alert.' Failure to meet the objectives for two or more of the indicators should trigger further investigation using the risk based approach[12]. This may require more intensive and quantitative bioassessment procedures depending on the nature and scale of the impact. In regions B4 and B5, where only three objectives are available, then all three should be met. In these regions, failure to meet any one of the objectives should trigger further investigation.

6.1 Regional biological objectives

The biological objectives (Table 5) vary between regions. This is:

due to natural variations expected in aquatic ecosystems as a result of differences in factors such as topography and geomorphology;

in recognition of certain irreversible changes to regions, such as clearing and draining for agriculture.

Few of the reference sites upon which these objectives are based could be considered to be in pre-European condition. As such, some degree of change is acknowledged in the modified sections of the regions and has been incorporated into these objectives. However, it is reasonable to expect that land and water uses be managed to minimise degradation, and that the healthiest ecosystem possible is maintained.

6.2 Regional urban objectives

In the urban areas of each region, few of the streams will meet the regional objectives. In recognition of the irreversible changes that have occurred in such streams, specific objectives have been set that are lower than those for surrounding non-urban areas. This approach was used in the Yarra SEPP[7] where the urban tributaries have lower objectives than either the mainstream Yarra River or the nearby streams in agricultural areas.

The objectives for urban areas are also based on the distribution of scores within the reference sites but set at a lower threshold (Table 6). This is based on the average score minus two standard deviations for each indicator within each region. Professional judgement was used to raise the value if this approach led to a value that was too low and unacceptable as a target for environmental quality. This approach was not possible for the AUSRIVAS models. For this indicator, Band B of the relevant AUSRIVAS regional model is to be used. The resultant objectives should be regarded as the absolute minimum standard for these streams.

6.3 Applying the objectives

The appropriate regional urban objective (Table 6) will only apply if the catchment area above a sampling site is >50% urbanised AND the urban population is >3000.

If the catchment area above a sampling site is <50% urbanised, the regional biological objectives apply (Table 5).

Similarly, if the catchment area above a sampling site is >50% urbanised, but the urban population is <3 000, then the regional biological objectives should be applied (Table 5).

Determining which biological region a site falls into may be difficult where the site is close to the boundary of two regions. In this case, it is recommended that:

- the region which covers the catchment upstream of the sampling site is selected,

or

- the site characteristics or features which best match the general descriptions of the regions (Table 1) are used to select the appropriate region.

It is important to remember that these objectives can be used as goals for the restoration of some streams but represent the minimum standards for others. Some streams are in very good condition, exceeding the objectives, and should be maintained as such. These objectives should not be used as the target to which high quality streams can be degraded.

Table 5: Objectives for Biological Indicators of Environmental Quality (SEPP WoV).

Indicators / Region & Habitat	Number of Families Score	SIGNAL Index Score	EPT Index Score	Key Families Combined Habitat Score	AUSRIVAS O/E score	AUSRIVAS Band
B1 Riffle	22	5.8	10	18	N/A	N/A
B1 Edge	13	6.2	4		N/A	N/A
B2 Riffle	21	6.0	9	22	0.87 – 1.13	A
B2 Edge	22	5.7	7		0.86 – 1.15	A
B3 Riffle	23	6.0	10	26	0.87 – 1.13	A
B3 Edge	24	5.8	9		0.87 – 1.13	A
B4 Riffle	23	5.5	N/A	22	0.82 – 1.18	A
B4 Edge	26	5.5	N/A		0.85 – 1.15	A
B5 Edge	23	5.3	N/A	21	0.87 – 1.13	A

In order to meet the objectives, the test site value must be greater than or equal to the values given in the table, except for AUSRIVAS where the appropriate band must be obtained. (N/A – not available)

Table 6: Objectives for Biological Indicators of Regional Urban Environmental Quality (SEPP WoV).

Urban Indicators	Number of Families Score	SIGNAL Index Score	EPT Index Score	Key Families Combined Habitat Score	AUSRIVAS	
Region & Habitat					O/E Score	Band
B2 Riffle	18	5.6	6	18	0.61 - 0.87	B
B2 Edge	18	5.4	5		0.57 - 0.86	B
B3 Riffle	20	5.8	8	24	0.60 - 0.86	B
B3 Edge	21	5.6	7		0.61 - 0.86	B
B4 Riffle	21	5.3	N/A	20	0.47 - 0.81	B
B4 Edge	23	5.3	N/A		0.55 - 0.84	B
B5 Edge	22	5.0	N/A	16	0.61 - 0.87	B

In order to meet the objectives, the test site value must be greater than or equal to the values given in the table, except for AUSRIVAS where the appropriate band must be obtained. (N/A – not available)

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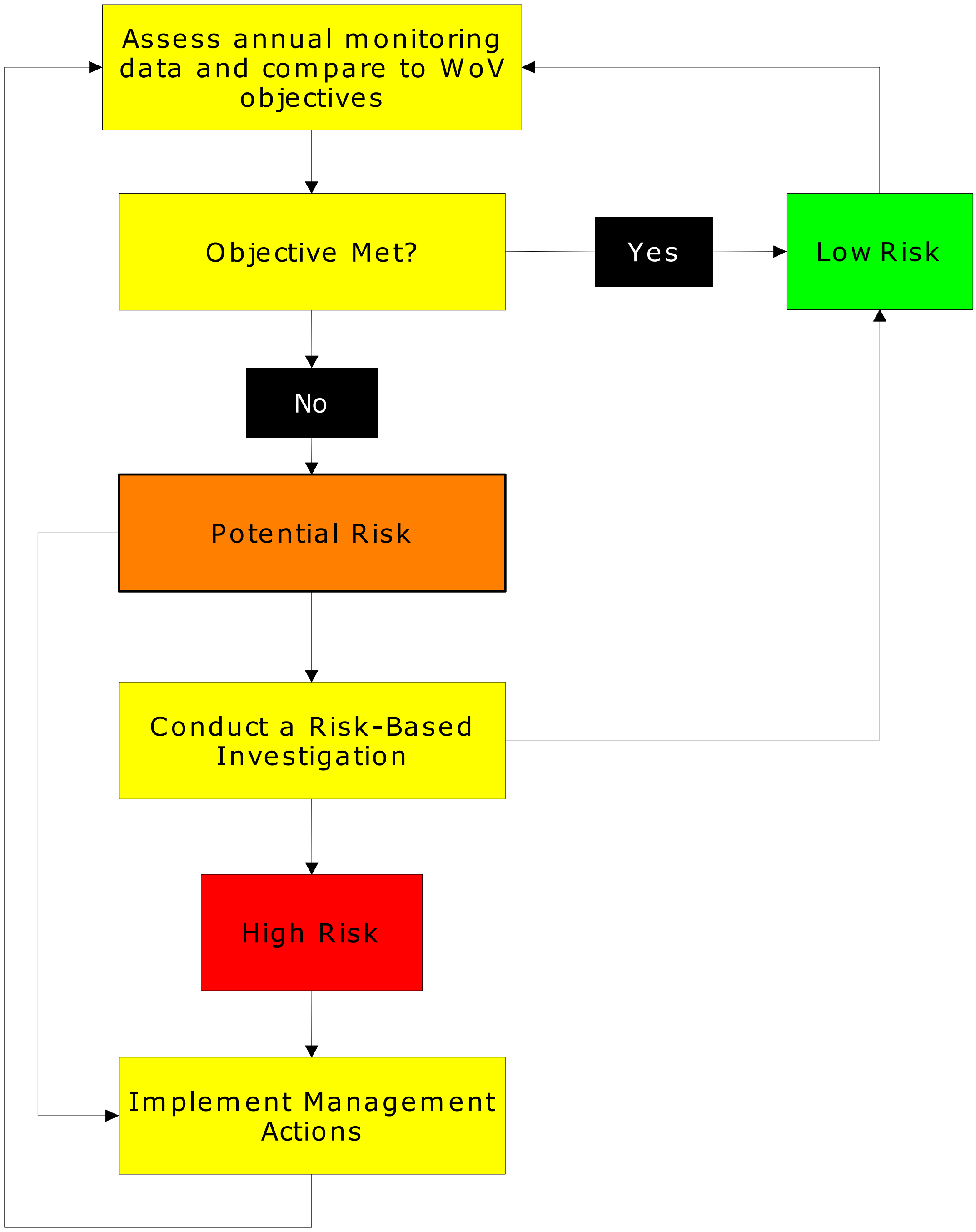
APPENDIX 1: RISK BASED DECISION FRAMEWORK (SEPP WoV)



For more details on the risk-based approach used by EPA, refer to: Environment Protection Authority Victoria, *Risk Assessment Approach – Ecosystem Protection*, Publication 790.1, 2003.

APPENDIX 2: SIGNAL GRADES USED IN CALCULATING BIOLOGICAL OBJECTIVES (SEPP WoV)

Family	Grade	Family	Grade	Family	Grade
Aeshnidae	6	Gerridae	4	Oligochaeta	1
Ameletopsidae	10	Glossiphoniidae	3	Oniscigastridae	10
Amphipterygidae	8	Glossosomatidae	8	Orthocladiinae	5
Ancylidae	6	Gomphidae	7	Osmylidae	8
Aphroteniinae	8	Gordiidae	7	Palaemonidae	5
Athericidae	7	Gripopterygidae	7	Paracalliopidae	7
Atriplectididae	10	Gyrinidae	5	Paramelitidae	5
Atyidae	6	Haliplidae	5	Parastacidae	7
Austroperlidae	10	Hebridae	6	Perthiidae	6
Baetidae	5	Helicophidae	10	Philopotamidae	10
Belostomatidae	5	Helicopsychidae	10	Philorheithridae	8
Blepharoceridae	10	Hydraenidae	7	Physidae	3
Caenidae	7	Hydridae	4	Planorbidae	3
Calamoceratidae	8	Hydrobiidae	5	Pleidae	5
Calocidae	8	Hydrobiosidae	7	Podonominae	6
Ceinidae	5	Hydrometridae	5	Polycentropodidae	8
Ceratopogonidae	6	Hydrophilidae	5	Protoneuridae	7
Chironominae	6	Hydropsychidae	5	Psephenidae	5
Clavidae	5	Hydroptilidae	6	Psychodidae	2
Coenagrionidae	7	Hygrobiidae	5	Ptilodactylidae	10
Coloburiscidae	10	Hymenosomatidae	4	Pyralidae	6
Conoesucidae	8	Isostictidae	7	Scirtidae	8
Corbiculidae	6	Janiridae	5	Sialidae	4
Corduliidae	7	Leptoceridae	7	Simuliidae	5
Corixidae	5	Leptophlebiidae	10	Sphaeriidae	6
Corydalidae	4	Lestidae	7	Sphaeromatidae	5
Culicidae	2	Libellulidae	8	Spionidae	5
Curculionidae	7	Limnephilidae	8	Spongillidae	5
Diamesinae	6	Lymnaeidae	3	Staphylinidae	5
Dixidae	8	Megapodagrionidae	7	Stratiomyidae	2

Dolichopodidae	6	Mesoveliidae	4	Synlestidae	7
Dugesiidae	3	Muscidae	3	Tabanidae	5
Dytiscidae	5	Nannochoristidae	10	Talitridae	5
Ecnomidae	4	Naucoridae	5	Tanypodinae	6
Elmidae	7	Nepidae	5	Tasimiidae	7
Empididae	4	Neurorthidae	8	Temnocephalidea	6
Ephydridae	2	Noteridae	9	Tetrastemmatidae	5
Erpobdellidae	3	Notonectidae	4	Thaumaleidae	7
Eusiridae	8	Notonemouridae	8	Tipulidae	5
Eustheniidae	10	Ochteridae	5	Veliidae	4
Gelastocoridae	6	Odontoceridae	8		