2. THE STATUS QUO

1999

2.1 INTRODUCTION

The purpose of this section is to summarise the current state of the River Health Programme. This includes the indices and ongoing related research, current training capabilities, site selection, sampling frequency and database management. It is not within the scope of this document to give details. For more information of the indices and other technical issues, the reader is referred to publications and specific individuals (see section five).

2.2 THE RHP AND THE LAW

2.2.1 Current National Legislation

It is important that the RHP be examined within the context of the law. This has been done in terms of the new National Water Act (No. 36 of 1998). The following includes a number of points made in a recent report.

For more details ...

Uys, 1998

The National Government (acting through the Minister) has the ultimate responsibility as custodian of the nation's water resources. The Minister may delegate some of his powers to government officials or water management institutions.

See National Water Act No 36 of 1998 Chapter 2.

A National Water Resource Strategy (NWRS) must be established by the Minister after public consultation. It is in accordance with this that all water resources will be protected, used, developed, managed, conserved and controlled. It will provide the framework within which water will be managed at regional or catchment level, in defined water management areas. This initiative is underway though is still in its early stages. It will rely on and synthesize inputs from many sources, including the RHP. It will adopt a consensus-seeking approach with the bulk of the strategy likely to become available for comment in September-October 2000 [Rowlston W, DWAF, personal communication]. Importantly, once in place and signed by the Minister, it will be binding on all authorities and institutions exercising powers or performing duties under the National Water Act. It is strongly recommended that the RHP ensures constant input to the NWRS.

A water resource classification system must also be prescribed by the Minister which may establish procedures to determine the Reserve.

The Reserve is defined as
the quantity and quality of water required
to satisfy basic human needs and
to protect aquatic ecosystems in order to secure their sustainable development and use.

All significant water resources will be classified in this way and resource quality objectives (RQOs) will be determined for each, aimed at balancing the need for protection and use of each resource. The RHP is ideally suited to assist in determining and monitoring the achievement of RQOs. However, nothing binds the Minister to consider the RHP [Uys, 1998].

Chapter 14 of the National Water Act states that national monitoring systems must be established. Furthermore, it states that they must provide for the collection of appropriate data and information necessary to assess, among other matters, "the health of aquatic ecosystems".

The National Water Act is a radical departure from the old Act. Involving a classification system, the concepts of the reserve and resource quality objectives, it is now much more soundly based on ecological principles. The RHP addresses these principles extremely well.

It is quite likely that the RHP will find another comfortable home within the new Environment Conservation Act. This is more broadly based than the National Water Act and includes such issues as sustainability and conservation of biodiversity. A project is underway that is examining the RHP within the context of environmental law [Uys, 1999] (as opposed to water law).

2.2.2 The RHP and Provincial Legislation

Although various regional government offices (of various departments) are giving support to biomonitoring programmes, there is little statutory legitimacy for the RHP. However, currently, at a provincial level, the RHP is incorporated in the Mpumalanga Provincial Strategic Planning Document, the Mpumalanga Conservation Bill and the National Parks Act [WRC, 1998].

2.2.3 Water Management Institutions

2.2.3.1 Catchment Management Agencies

See National Water Act No 36 of 1998 Chapter 7 & Schedule 3.

A catchment management agency (CMA) is a statutory body established at the discretion of the Minister to delegate water resource management to a local level and to involve local communities. It may be established for specific geographical areas, after public consultation, on the initiative of the community or stakeholders concerned. The proposal and procedure for its establishment and its powers and duties are detailed in the National Water Act. Its main functions are

- to investigate and advise on the <u>protection</u>, <u>use</u>, <u>development</u>, <u>conservation</u>, <u>management</u> and <u>control</u> of the water resources in its water management area,
- to develop a catchment management strategy, and
- to coordinate the related activities of the water management institutions within its water management area.

No catchment management agencies exist at this time. Before these agencies come into being, DWAF will act as agent in the meantime for the necessary water resource management. The process of establishing them is time-consuming (possibly up to five years [van Vliet H, DWAF, personal communication]). This is partly because a cautious bottom-up approach is being adopted involving public participation and consultation. The aim is to do more than just consult but rather engage interested parties [Karodia H, DWAF, personal communication].

See Government Gazette No 19641, 31 December 1998

A number of "forerunner" regions have been identified as water management areas. These have been proposed in the Government Gazette and comment was invited before 31 March 1999. The following map roughly indicates the location of the areas. For details of individual river catchments included in each area the original Government Gazette should be consulted.

There is currently a perception that these management areas are too large to be practically managed [van Zyl F, DWAF, personal communication]. In particular, involvement of all concerned parties on such a large scale is deemed inappropriate and impractical. This has resulted in a drive to create committees (under the Act) that will consist essentially of local water forums that concern themselves with single rivers or catchments. The aim is to provide these local committees with sufficient status that they are able to play a significant role in monitoring and ultimately pressurising local polluters and authorities. Such local organisations might include schools, bird clubs, tourism agencies, developers, NGO's as well as local government. However, some doubt has been expressed concerning the actual powers such committees will have [van Vliet H, DWAF, personal communication].

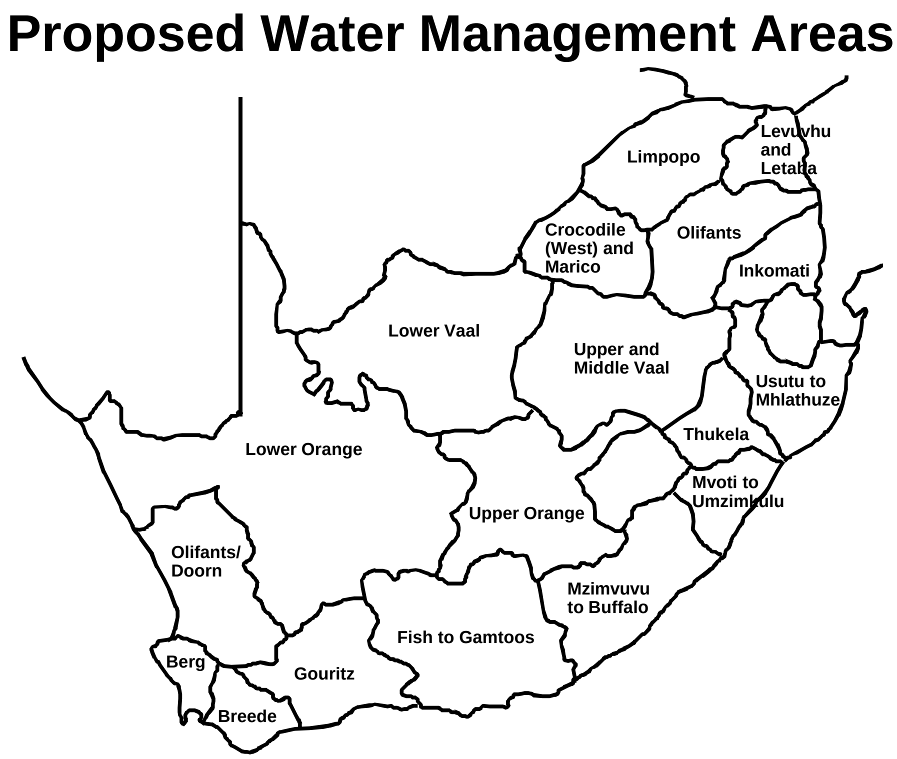


Figure 2.1. Water Management Areas proposed for catchment management agencies.

2.2.3.2 Water User Associations

See National Water Act No 36 of 1998 Chapter 8 & Schedule 5.

A water user association (WUA) is a cooperative association of individual water users who wish to undertake water-related activities for their mutual benefit. The purpose of WUA's is to represent specific water users relating to specific water use activities. It is not to undertake overall water resources management aimed at sustainability.

A water user association for a particular purpose would usually be established following a proposal to the Minister by an interested person, but such an association may also be established on the Minister's initiative. The functions of a water user association depend on its approved constitution. The following are a few examples that might typically be associated with a water user association:

1. To protect water resources.
2. To prevent any unlawful act likely to reduce the quality of water in any water resource.
3. To exercise general supervision over water resources.
4. To regulate flow.
5. To provide management services, training and support to rural communities and water services institutions, and to provide catchment management services on behalf of responsible authorities.

2.2.3.3 Water Boards

See Water Services Act No 108 of 1997 Chapter VI & X.

The primary activity of a water board is to provide water services to other water services institutions within its service area.

A water board must achieve a balance between (among other aspects) (i) striving to provide efficient, reliable and sustainable water services, (ii) striving to be financially viable, (iii) taking into account national and provincial policies, objects and developments, (iv) complying with health and environmental policies, and (v) taking reasonable measures to promote water conservation and water demand management, including promoting public awareness of these matters.

The Water Services Act further requires that a national information system of water services be established. One purpose is to record and provide data for the development, implementation and monitoring of national policy on water services. Another is to provide information to water services institutions, consumers and the public.

Therefore, water boards (among others) may well wish to involve themselves in a monitoring programme. It is usually in their interests to ensure that the quality of raw water that they use for purification and distribution is of consistent quality. Any major deterioration in quality may require changes to their process which could be costly for them.

The National Water Act provides for the restructuring of water boards as water user associations.

2.3 INDICES FOR BIOMONITORING

> *"A man would accomplish nothing*
> *if he waited till he could do it so well*
> *that no one could find fault with it"*
> Cardinal John Henry Newman (1801-1890)

2.3.1 Indicators and Indices

The design of a biomonitoring programme should be tailored to the particular type of water-body being assessed. For example, benthic macro-invertebrates and fish are often used as taxonomic groups to assess flowing water. Plants are used in wetlands. Algae and zooplankton can be used in lakes and estuaries.

Ecological Integrity is the cornerstone of measuring and assessing aquatic ecosystems.

Table 2.1. Biological ecosystem components associated with biomonitoring.

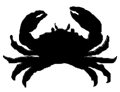
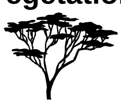
Ecosystem Component	Relevance to biomonitoring
Fish 	Fish comprise one of the main biological components of aquatic ecosystems. Because they are relatively long-lived and mobile they can indicate long-term influences (years) and general habitat conditions in a river reach. They represent a variety of trophic levels and hence integrate effects of environmental changes.
Invertebrates 	Invertebrate communities respond relatively quickly to localised conditions in a river, especially water quality though their existence also depends on habitat diversity. They are common, have a wide range of sensitivities and have a suitable life-cycle duration that indicates short- to medium-term impacts on water quality.
Riparian Vegetation 	Healthy riparian zones maintain channel form and serve as important filters for light, nutrients and sediment. Riparian vegetation regulates river flow, improves water quality, provides habitats for faunal species and corridors for their movement, controls river temperatures, provides nutrients and maintains bank stability. Changes in riparian vegetation structure or function are commonly associated with changes in river flow, exploitation for fire wood or changing use of the riparian zone (for example for grazing or ploughing).

Table 2.2. Non-biological ecosystem components associated with biomonitoring.

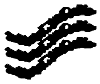
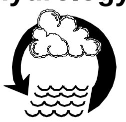
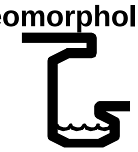
Ecosystem Component	Relevance to biomonitoring
Habitat 	Habitat availability and diversity determine aquatic community structure. Habitat degradation adversely affects biological communities.
Hydrology 	Flow conditions in a river affect the distribution and abundance of biota by creating dynamic habitats characterised by current speed, water depth, and (in the longer term) substratum characteristics.
Water Quality 	Aquatic ecosystems and their biota are affected by turbidity, suspended solids, temperature, pH, salinity, concentrations of dissolved ions, nutrients, oxygen, biocides and trace metals. Changes in these due to pollution, geomorphological or hydrological factors can have detrimental or even lethal effects on aquatic organisms.
Geomorphology 	Geomorphological processes determine river channel morphology which provides the physical environment within which stream biota live. Changes to channel form occurs both naturally and as a result of man-made changes to rivers or their catchments (*e.g.* impoundments, water importation, agriculture and so on).

Table 2.3. Summary of the main indices, associated ecosystem components and typical spatial scale.

Index	Component	Spatial Scale
Biological		
SASS4	Invertebrates	up to 20 m
FAII	Fish	Homogeneous fish segment, typically kms
RVI	Riparian Vegetation	10s of metres
Non-biological		
IHI	Habitat	5 km
IHAS	Habitat (Invertebrates)	up to 20 m
GI	Geomorphology	10s of metres

There are many biomonitoring indices receiving research attention in South Africa. However, they are not only focussed on riverine ecosystems. For example, algae and zooplankton are more appropriate for lakes and estuaries. These will not be discussed further.

A water quality index has been developed for South African conditions. However, it contains indicators not necessarily directly relevant to a biomonitoring programme. It may therefore not be the most appropriate water quality index to aid interpretation of the main biological indicators of the RHP.

For more details ...

Moore, 1990
Uys *et al.*, 1996

There are a number of indices in early stages of development that are likely to be applicable to the RHP. However, these are simply mentioned here and not discussed in any detail.

The Hydraulic Biotope Diversity Index (HBDI) is based on the fact that various geomorphological features have distinct hydraulic characteristics which can be described using numbers like the Froude number and Reynolds number. However, these features are also ecological habitats. An objective way of recognising these habitat features has been developed. It is the intention that this become part of the Geomorphology Index (GI).

For more details ...

Wadeson and Rowntree, 1999
Rowntree and Wadeson, 1996

A site-base Riparian Vegetation Index (RVI) is also being developed. This involves observations from the ground at the relevant site. This has been developed from an approach involving an aerial survey using a helicopter. A description of this can be found below under Index of Habitat Integrity (IHI). Data collected on-site will be on river channel, riparian zone (including invasion), ground and vegetation cover, main species present and disturbances. The formula will reflect the extent to which the natural vegetation is present and its inherent resilience to impacts.

The following figure is a rough (subjective) guide to the relative maturity of the various indices in more common use in the RHP. An index could take more than five years to reach maturity.

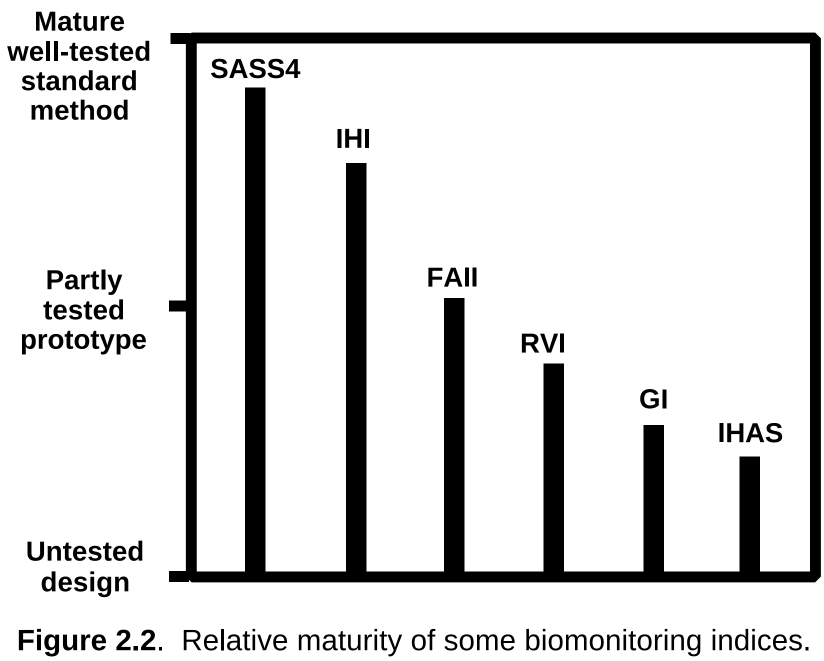


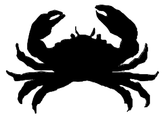
Figure 2.2. Relative maturity of some biomonitoring indices.

It can be noted here that some indices that have been or are being developed in South Africa are not appropriate for a national River Health Programme. The criterion that should be used to assess relevance to the RHP is whether the index permits ecological integrity to be quantified and assessed as a function of time. (Interestingly, SASS4 as presently defined, does not strictly allow this. However, it is so widely used and user friendly that it is accepted as a very valuable index.)

Those indices that are appropriate to the RHP and that have reached a stage at which they can be applied (though more testing and development are required for some), are described briefly in the following sections.

Definitive methods are outside the scope of this document.
Latest details should be obtained in training courses
or the technical expert responsible for the index.

2.3.1 South African Scoring System Index (SASS)



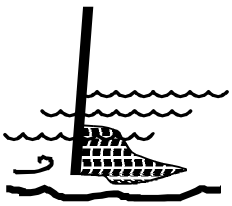
It has long been known that some components of the aquatic flora and fauna of streams and rivers respond in a predictable way to changes in the physical and chemical nature of water. The South African Scoring System version 4 (SASS4) is an index of one such component, namely aquatic invertebrates. This is the backbone of biomonitoring in South Africa [Dickens, 1998]. It has been suggested that the effects of polluted water on invertebrates may last as long as six weeks before noticeable recovery is observed.

***In Situ* observations of the presence of invertebrate taxa ...**

For more details ...

Chutter, 1998
McMillan, 1998
Thirion *et al.*, 1995

In the field, the procedure involves the following. Invertebrates are collected from the watercourse using a standard net by a number of well-defined methods in various habitats (stones in current, stones out of current, sand, gravel, mud, marginal vegetation, aquatic vegetation and bedrock). These collections are placed in a large tray. The types of invertebrates present are recorded on score sheets. Checking for taxa is limited to a maximum of 15 minutes or five minutes since the last taxon was found. The final result is obtained in the field - no laboratory work is required. The invertebrates are typically returned to the water. However, it is noted here that this prevents the assessment from being verified.



... and weighting their respective tolerances to polluted waters ...

Each taxon, typically a family, has been weighted on a scale of 1 to 15 according to its estimated tolerance of polluted conditions. (Formal tolerances have only been measured for a few.) Those least tolerant (*i.e.* most sensitive) are weighted (scored) higher.

... provides two indices, SASS4 and ASPT, ...

The SASS4 index is a function only of the tolerance scores for those taxa found to be present.

$$\text{SASS4} = \sum(\text{tolerance scores})$$

where the sum is over all taxa present in the sample.

The Average Score Per Taxon (ASPT) is also calculated:

$$\text{ASPT} = \text{SASS4}/(\text{Number of Taxa})$$

... that give a broad assessment of water quality changes.

The interpretation of SASS4 and ASPT has been divided into two classes, depending on the natural acidity of the water. The most widespread class includes waters not naturally acid, having a pH greater than six. The second class includes naturally acid waters (pH<6) typically occurring in parts of the southern and western Cape.

Table 2.4. Guidelines for interpretation of SASS4 and ASPT scores [Chutter, 1998].

Waters not Naturally Acid (pH>6)		**Waters Naturally Acid (pH<6)**		**Interpretation**
SASS4	**ASPT**	**SASS4**	**ASPT**	
>100	>6	>125	>7	Water quality natural, habitat diversity high
<100		<125		Water quality natural, habitat diversity reduced
>100	<6	>125	<7	Borderline between natural water quality and some deterioration in water quality.*
50-100		60-125		Some deterioration in water quality
<50	variable	<60	variable	Major deterioration in water quality

*Interpret on basis of extent by which SASS4 exceeds 100 and ASPT is <6 (or 125 and <7 respectively for naturally acid waters).

ASPT & SASS4 indices are fairly constant over significant sections of a river when in its natural condition.

The method should be used to assess water quality changes in broad terms and is therefore useful in water quality monitoring. It is claimed to be sensitive to all types of water quality change, though less so for changes in Total Dissolved Solids than for others.

Polluted parts of rivers are unambiguously identified as such. Since deteriorating water quality and habitat degradation affect both the SASS4 value and the number of taxa, ASPT (being the quotient of these two) is not greatly affected by the sample size. However, this is obviously less so the fewer the number of taxa. All scores should be used in a final interpretation. The fewer the number of taxa found the less appropriate it is to use the ASPT score.

Furthermore, recording the habitats sampled is also necessary for a more detailed interpretation. In particular, a comparison of SASS4 scores between different locations needs to take account of the respective habitats. A habitat index (IHAS) has been developed specifically for SASS4 and is described elsewhere.

The method has been widely tested in South Africa.

The taxa used in the index have been carefully chosen to include a range of sensitive and hardy taxa. As water quality deteriorates, the number of taxa are selectively decreased. Those most sensitive disappear first. Once the water is significantly polluted, only the most hardy taxa remain. Under these conditions the habitat diversity is no longer an important factor since

Factors Affecting Invertebrate Diversity as Measured by SASS4

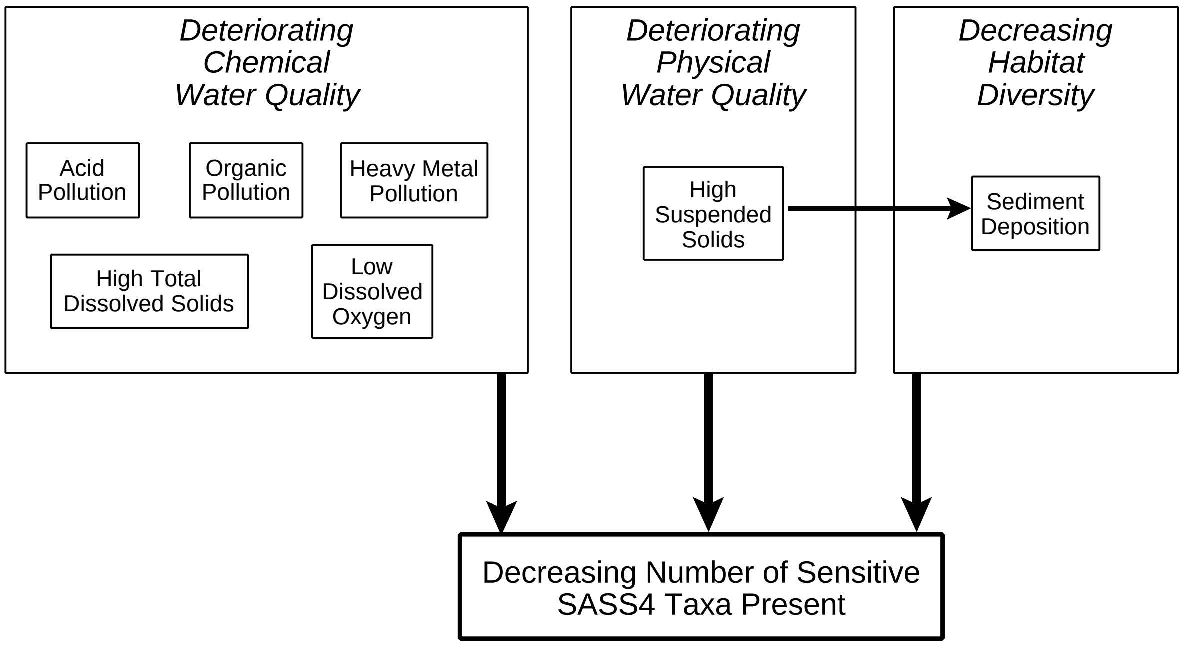


Figure 2.3. Illustration of some factors affecting the invertebrate diversity as measured by the SASS4 index.

the hardy taxa are somewhat evenly distributed among the various habitats. High levels of suspended solids impact on invertebrate communities in two ways. First, the solids clog gills making breathing difficult or impossible. Secondly, if significant quantities of these solids settle on the bottom, habitats become smothered (especially those associated with stones out of the current) and are therefore not available. Some of these relationships between water quality, habitat diversity and the two indices are illustrated in the adjacent figure.

simple and inexpensive resources are required on-site for sampling. These include data sheets, a standard net, and a large
sampling and checking for taxa.

There
invertebrates. A User Manual does exist [Thirion *al.*, 1995] but a more comprehensive
of identification guides is currently being produced [Dickens, 1998]. However, it has been
specific guide should be developed [Palmer, 1999].

Data
project is underway to deal with this problem that is discussed elsewhere in this document.

A
or equivalent, is required. Furthermore, at least seven days training in the field is necessary

It has been noted that a problem that may be encountered is that samplers lose their
skills unless they practice them regularly [Chutter M, Afridev, personal communication].

Invertebrate Habitat Assessment System (IHAS)

This habitat index (IHAS) is specifically associated with the SASS4
originally from the Habitat Assessment Matrix (HAM) through

For more details ...

As noted elsewhere, a SASS4 score depends on two main

IHAS is to provide an overall assessment of habitat at the site at the time of sampling that is
countrywide and easy to determine. Another use of IHAS is to adjust a SASS4 score
dependent on water quality). Therefore, if a SASS4 score is obtained at a site in which there
little habitat diversity, the SASS4 score is adjusted upwards. Equivalently, in a pristine site, the SASS4 score is adjusted (slightly) downwards. This aspect is still being tested.

Table 2.5. Summary of Invertebrate Habitat Assessment Index indicators.

Indicator	Maximum Allowed Score
Sampling Habitat	
Stones in Current (SIC)	20
Vegetation	15
Other Habitat / General	20
Stream Condition	
Physical	45

A single page data sheet is available that permits each indicator to be quantified. Each attribute contributing to each indicator is assigned a value on a scale of zero to five. The sum of these for each indicator gives the actual value. If this exceeds the maximum allowed (for the sampled habitats only) then the score is reduced to this maximum. The adjustment required to make it equal to the maximum (either positive or negative) equals the adjustment required to the SASS4 index. An IHAS value of >75% is suggested to indicate good habitat conditions. More than 65% indicates “adequate” habitat conditions.

Application does not require extensive specialist experience. It has only recently been proposed though has been received enthusiastically.

2.3.1 Fish Assemblage Integrity Index (FAII)

For more details ...

Kleynhans, 1999

An index has been proposed recently for fish based on biological river segments. The Fish Assemblage Integrity Index (FAII) for a particular segment is defined as follows:

$$\mathbf{FAII = 100 \times FAII_{Obs} / FAII_{Exp}}$$

where observed index = $\mathbf{FAII_{Obs}} = \sum(\mathbf{I_{Exp} \times (F_{Obs} \times H_{Obs})/2})$

and expected index = $\mathbf{FAII_{Exp}} = \sum(\mathbf{I_{Exp} \times (F_{Exp} \times H_{Exp})/2})$

where each sum extends over all species expected to be present in the segment. I, F and H are defined in the adjacent table. (The above recommended formulae are slightly different from those that occur in the original publication [Kleynhans N, DWAF, personal communication].)

The indicators are summarised in the following table.

Table 2.6. Summary of indicator ratings and criteria used for the Fish Assemblage Integrity Index.

	Indicator		
	I_{Exp}	**F_{Obs} and F_{Exp}**	**H_{Obs} and H_{Exp}**
	Intolerance to changes in conditions	Frequency of occurrence (% of sites at which species occurs)	Health (% of affected fish)
Indicator rating	**Criteria**		
1	Low (least sensitive)	< 34% (infrequent)	> 5%
3	Moderate	34 - 67% (frequent)	2 - 5%
5	High (most sensitive)	> 67% (widespread)	< 2%

Brief descriptions of the final calculated FAII classes are given in the following table.

Table 2.7. Fish Assemblage Integrity Index assessment classes.

FAII Score	**Class**	**Brief description**
90-100	**A**	Unmodified or approximates natural conditions closely
80-89	**B**	Largely natural with few modifications
60-79	**C**	Moderately modified
40-59	**D**	Largely modified
20-39	**E**	Seriously modified
0-19	**F**	Critically modified

The FAII gives a broad description of biological integrity.

This index has been tested on a part of the Crocodile River, Incomati System, Mpumalanga Province. It was found that the index reflected several aspects of the modifications that have occurred in that river. These included water quality and flow changes and the introduction of alien fish.

The following limitations were noted:

6. It was suggested that the index in the above form underestimates the biological integrity. This is because the expected list of species is based on a whole segment not on those expected in the specific habitats that were sampled. Basing the expected indicators on segment as well as habitat will improve the interpretation of the FAII.
7. Fish abundance (as an indicator) is not included in the FAII at present.
8. The FAII is heavily dependent on the intolerance indicator. A more objective approach

to quantifying this needs to be investigated.

9. The FAII is not considered suitable for the assessment of streams with a naturally low fish species richness.
10. The FAII is largely dependent on narrative biological criteria. Numerical criteria will require more research.
11. It is not possible to develop a fish index that can be applied directly without any modification to all South African rivers. Fish indices will need to be developed for specific river types.

It was further suggested that a combination of fish and instream macro-invertebrate indicators be investigated. An index such as FAII should be regarded as part of a system that will lead to more questions being asked in an attempt to solve a particular problem. It should not be regarded as able to determine cause and effect relationships unless considerably more intensive sampling and alternative approaches are used.

Unlike the determination of the SASS index, a considerable amount of work is required before the on-site sampling is done. This involves a calibration exercise that determines the expected occurrence of species. This involves considerable professional judgement and local knowledge of the area.

Resources required to determine an FAII for a river segment depends on the extent of sampling required. However, the simplest involves electroshocking equipment and a small seine net. The type of electroshocking equipment will also dictate the number of people required. The older type ideally requires four people. However, a newer backpack version requires only two. Time on-site for sampling and fish identification may require 2-3 hours.

Considerable expertise is required. Adult fish need to be identified to species level. A local knowledge of the rivers being sampled is also important. Someone with a basic diploma in zoology can probably be trained within a year. This will include considerable work in the field.

2.3.1 Index of Habitat Integrity (IHI)

For more details ...

Kleynhans, 1996

The habitat integrity of a river provides the template for a certain level of biotic integrity to be realised. Ecological integrity can be regarded as a combination of habitat and biotic integrity.

The Index of Habitat Integrity (IHI) assesses the impact of disturbances on a river on the capacity of that river to provide suitable habitats for organisms. Information is collected primarily by continuous video recording taken from a helicopter down the length of the river. Each 5km length of the river is examined for specific indicators, each with a previously assigned weight, and the degree of impact quantified. The indicators, weights and impact classes are summarised in the following tables.

Table 2.8. Habitat Integrity indicators and associated weights.

Instream Indicator	**Weight**	**Riparian Indicator**	**Weight**
Water abstraction	14	Indigenous vegetation removal	13
Flow modification	13	Exotic vegetation encroachment	12
Bed modification	13	Bank erosion	14
Channel modification	13	Channel modification	12
Water quality	14	Water abstraction	13
Inundation	10	Inundation	11
Exotic macrophytes	9	Flow modification	12
Exotic fauna	8	Water Quality	13
Solid waste disposal	6		
TOTAL:	100		100

Table 2.9. Summary of Habitat Integrity impact classes and scores.

Modifications	**Impact on habitat quality, diversity, size and variability**	**Impact Class**	**Score**
Not discernable	None	None	0
Few localities only	Very small	Small	1-5
Small number of localities	Limited	Moderate	6-10
Generally present	Clearly detrimental	Large	11-15
Frequently present	Almost whole of area affected	Serious	16-20
Present overall, high intensity	Almost whole of area detrimentally affected	Critical	21-25

The overall Index is calculated as follows:

$$\mathbf{IHI(instream) = 100 - \sum[(Indicator\ Score/25) \times (Indicator\ Weight)]}$$

where the sum extends over all instream indicators. A similar index, IHI(riparian) is calculated with the sum extending over all riparian indicators.

The final value for each is converted to a narrative description of the overall integrity of the associated river reach.

Preparation includes obtaining a helicopter and a suitably qualified pilot and preparing flight plans. It also includes familiarisation with the area (using maps), identifying the part of the river to be surveyed and dividing this into 5km sectors.

Other resources required include a video camera and GPS. Preferably both the navigator and the videographer should be experienced aquatic ecologists though at least one must be. Comments on observations during flight can be recorded directly using the video's microphone.

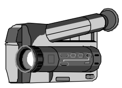


Table 2.10. Brief narrative description of Habitat Integrity assessment classes.

IHI as %	Class	Description
100	A	Unmodified, natural
80-99	B	Largely natural with few modifications
60-79	C	Moderately modified
40-59	D	Largely modified
20-39	E	Extensive modification
0-19	F	Critical, almost complete loss of natural habitat and biota

Time on-site should be restricted to a maximum of five hours per day actual recording time to avoid fatigue. A few days on-site may be required. Subsequent analysis of the video and estimation of the final index may require up to ten days.

2.3.1 Geomorphology Index (GI)

Geomorphological processes (like flooding, erosion, silt deposition, etc.) determine the form and structure (the morphology) of river channels. This morphology provides the various physical habitats for stream biota (such as pools, under cobbles and rocks, etc.). Attempts to explain changes in biota may therefore benefit from an examination of changes in geomorphology.

For more details ...

Rowntree and Ziervogel, 1999

The proposed prototype geomorphological index comprises five individual indicators (summarised in **Table 2.11**). (It has also been suggested that an index for degree of channel modification be added in future [Rowntree K, Rhodes Univ., personal communication].)

The overall index is represented as a string of five digits. The index should be interpreted digit by digit and not as a single overall numerical value. For example:

43402 means a **foothills cobble bed**, **alluvial channel** with **extreme bank erosion**, **no bed degradation** and **moderate bed aggradation**.

Full descriptions of each indicator can be found in the original report.

Table 2.11. Summary of indicators contributing to the geomorphological index.

Indicator	Numerical Range	Typical diagnostic features
Zone	1-9	Varies from source through foothills to lowlands; based on gradient and channel features
Channel Type	1-4	Includes bedrock, fixed boulder, alluvial and mixed channels
Bank Stability	0-4	Erosion evidence; degree of vegetation cover; stability of bank toe; root exposure
Bed Degradation	0-4	Absence of fine alluvial material; degree of deepening
Bed Aggradation	0-4	Material accumulation at obstructions; channel blocking by sand and gravel; degree to which cobbles are embedded, degree of silt in pools

The index is based on field work on 14 rivers in the eastern Cape, Western Cape and Kwa-Zulu Natal. Field observations, for which data sheets have been developed, included the following:

1. A photographic record.
2. Condition of local catchment.
3. Sketch of channel morphology (including measured dimensions).
4. Riparian and in-channel vegetation.
5. General site geomorphology (including valley form, channel pattern, perimeter material, morphological units, bar type, channel type, reach type, bed material size distribution and bed packing).

A comprehensive (countrywide) baseline assessment is still required. Routine monitoring, for which data sheets have also been developed, include observations of the following:

1. Sketch of site indicating differences from the reference photographs.
2. A photographic record.
3. Water flow and turbidity.
4. Bank vegetation density in the active channel and impact of alien woody debris.
5. In-channel modifications (weirs, etc.) and bank impacts (*e.g.* by animals, paths, vegetation removal, etc.).
6. Channel condition (bank, bar and bed).
7. A specific rating of bank condition, bed degradation and bed aggradation indicators (providing the final three digits of the overall index).

A short document “Guidelines for Site Assessment” has also been developed which formally defines the many terms used [Rowntree and Ziervogel, 1999]. Some difficulties have been experienced with the terminology by nonspecialists. A project is in the pipeline for producing an illustrated guide to address this problem.

A baseline assessment should be performed when biomonitoring sites (reference or monitoring) sites are chosen. They should also be done after major hydrological events (for example, a 10-year flood) or following any significant upstream disturbance such as a forest fire or major change in land use. This assessment must be carried out by an experienced geomorphologist. Typically one to two hours at the site is required (assuming the help of a field assistant). Resources include data sheets, camera, 50 or 100 m measuring tape and a standard template for particle size measurements.

Routine monitoring should be done by a trained technician on an annual basis during a low flow period to facilitate access to the channel. Each site requires about half an hour to assess. Resources include data sheets and camera. All data sheets are archived. A computer database has still to be developed.

Extensive testing is still required. This is likely to result in changes to the estimation of the overall geomorphological index. Training methods and improved training resources (manuals, videos, CD ROMs, etc.) still need to be developed.

2.4 SITE SELECTION

The issue of “where to monitor” is of fundamental importance to any monitoring programme. This issue has been, and is still being given considerable attention. It is outside the scope of this document to give all relevant detail so further information should be obtained from the original works.

For more details ...

Eekhout *et al.*, 1996

The number of reference and monitoring sites is a function of a number of factors including the distance from the source, natural habitat variability and anthropogenic impacts. This is depicted in the following diagram.

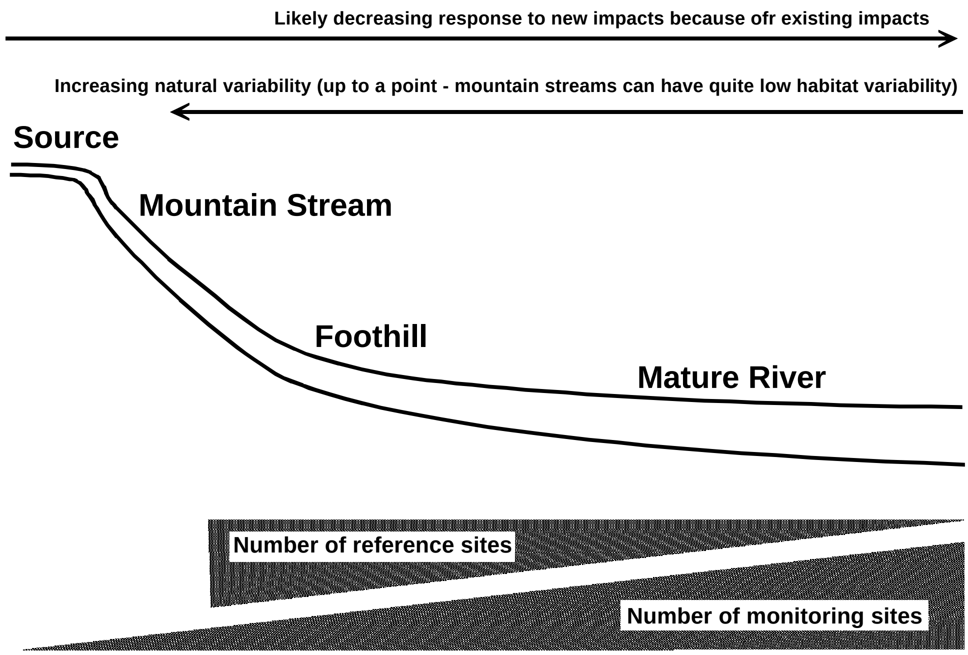


Figure 2.4. Number of reference and monitoring sites as a function of distance from the source [Eekhout, *et al.*, 1996.]

2.4.1 Reference Conditions

Notwithstanding built-in reference states
(*i.e.* unimpacted) in the definition of most currently-used indices ...

The basis of biomonitoring in South Africa is ecological integrity. That is, a comparison of current state with natural (unimpacted) state is implied. Many of the indices have built-in reference conditions (defined as the natural state). For example, the Index of Habitat Integrity (IHI) is defined to have a value of 100 (the maximum value) if there is no anthropogenic modification or impact on river segment being assessed. Similarly, the Fish Assemblage Integrity Index (FAII) is defined to have a value of 100 (again a maximum) if the fish segment contains the assemblage of fish expected to exist in such a segment if it was in its natural state. Establishing the "reference condition" under these circumstances is currently largely based on historical records, knowledge of similar sites and expert opinion. Even the SASS4 index has a scale though the maximum is above 100. A SASS4 value greater than 100 with an ASPT value above six is described as having "natural water quality and high habitat diversity". However, the latter have not been based on a formal method for identifying reference conditions.

... work is underway to characterise all rivers
to the level of "type" ...

A project is underway to classify all rivers in South Africa in a three-tier system down to the level of "river type" (focussing at present on Mpumalanga). Because of the varied climate, geology and geomorphology in South Africa, classification needs to be established within a spatial framework. Variation in these factors, both between and within rivers, together with natural biogeographic differences in the distribution of riverine biota, may potentially lead to biotic differences.

... that takes account of natural variations in
climate, geology and geomorphology.

Having classified all rivers to the level of "type", reference conditions for each type can be defined as those that exist at unimpacted places where a particular type occurs. A number of individual reference sites may be necessary to establish the reference condition.

Reference conditions for a river type
will be defined as those typical of the least
impacted places where that type occurs.

Because totally unimpacted sites are nonexistent for many river types, an ecological reference condition will be the condition that is representative of a group of "least-impacted" or minimally disturbed habitats. In some instances this reference condition may represent the natural or intrinsic conditions of the water body whilst in others it may represent the "best available", for example in lowland rivers which have been subjected to extensive anthropogenic modification.

(This project will also play an important role in the classifying of South African rivers for the purpose of determining the reserve. The reference condition is likely to be a management class A.)

These will be benchmarks against which monitoring information can be compared. At present this is primarily aimed at the SASS4 index although it will also contribute to the Fish Index (FAII). Defining reference conditions in this way is an objective means of establishing the expected invertebrate and fish assemblages for particular river types.

A report that outlines the development and application of a spatial framework designed to assist with the identification of river types and selection of reference sites has been produced. This report focuses on the rivers of Mpumalanga. A report on the result of ground-truthing of the spatial framework is pending.

For more details ...

Dallas and Fowler, 1999

2.4.2 Monitoring Sites

Characterisation of all rivers into types will also ensure that all types are represented in a random sample for SoE reporting.

Some suggestions have been put forward in respect of choice of monitoring sites for State of Environment (SoE) reporting (the primary national perspective). They should be randomly selected and there should be a sufficient number to cover all river types. There are also pragmatic considerations: They should be suitable for the various monitoring methods; they should be accessible; they should be selected to maximise information content.

For more details ...

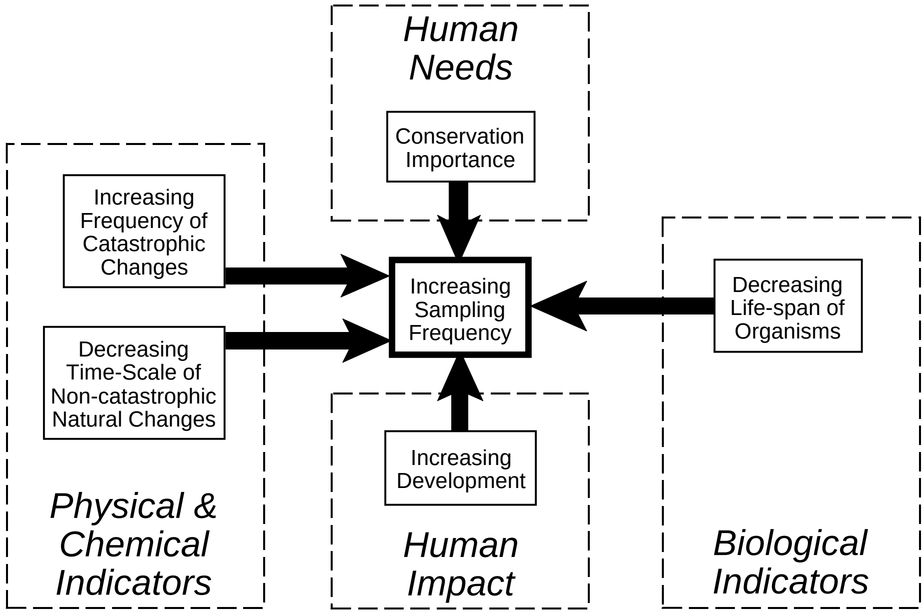
Eekhout *et al.*, 1996

If the purpose of the monitoring is the assessment of impacts (a more regional or local perspective), then sites should be chosen that will adequately reflect changes due to those impacts.

2.5 SAMPLING FREQUENCY

From a purely ecological viewpoint, the frequency of sampling should be related to the time-scales typically associated with change in the ecological component being monitored. This change can be either natural or anthropogenic. However, other factors such as conservation status also play a role. This is illustrated in the following figure.

Generic Factors Determining Sampling Frequency

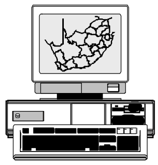


The following table proposes appropriate sampling frequencies.

Table 2.12. Typical sampling frequencies for various biomonitoring indices.

Index	Frequency	Comments
SASS4 & IHAS	2-3 times per year	Preferably during dry season, at end of dry season and at end of wet season
FAII	every 3 years	
RVI	every 3 years	To coincide with fish monitoring
IHI	every 3-5 years	Depending on development rate
GI	Annually during low flow period	Baseline assessment done initially for all rivers; then after major hydrological events or major upstream disturbances such as a forest fire or major change in land use

2.6 DATABASE MANAGEMENT

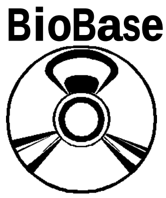


2.6.1 Current Mechanisms

Current data storage mechanisms are not at all standardised. This is one of the most pressing problems in the RHP.

Umgeni Water stores their biomonitoring data on a Laboratory Information Management System (LIMS). They store the following: All family data contributing to each SASS score, with biotopes sampled and automatic calculation of the SASS score, Taxa, ASPT, number of airbreathers and the final result of HQI and IHAS. Umgeni also collects the data of a number of local organisations doing biomonitoring. However, data storage has become a problem.

Fish data from the Northern Province are currently being stored in spreadsheets [Angliss M, Dept. Agric., personal communication]. Other indices are not yet determined.



Southern Waters has developed a database comprising biological (SASS-related) and chemical data from more than 40 studies over a 40 year period [Dallas and Janssens, 1998]. It is available on CD ROM though allows viewing and querying only (not input of data). It uses a three-level hierarchical framework within which the data are accessed and queried. The primary level is the regional or geographic framework (including water quality management regions, bioregions and political regions). The secondary level differentiates longitudinal components or subregions. The tertiary level is the site.

2.6.2 The Proposed "Rivers Database"

A Rivers Database for Mpumalanga was one of the products to be delivered as part of the Ecological Reference Condition project undertaken by Southern Waters in August 1997 for the Institute for Water Quality Studies (IWQS). Initially, the Rivers Database was a comparatively small component of that project. However, during the course of the first year of the project (1998) it became apparent that the potential existed to greatly expand this component to incorporate aspects of general importance to the River Health Programme (RHP) [Dallas H, Southern Waters, personal communication].

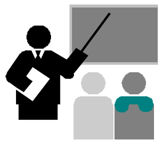
The development of the Rivers Database is divided into three phases. They are focussed only on the rivers of Mpumalanga with expansion to include the whole of DWAF primary drainage regions B and X.

Phase 1 (target date April 1999) involves design, testing and inclusion of site, river and catchment information. The IWQS SASS4 and HAM/HQI data for Sabie, Crocodile, Komati and Olifants River catchments will also be captured and verified.

Phase 2 (November 1999) involves data capture and verification of Fish Assemblage Integrity Index (FAII), Riparian Vegetation Index (RVI) and water chemistry data.

Phase 3 (November 1999) includes development of querying frameworks, a user guide and an import/export facility.

2.7 TRAINING CAPABILITIES



A training protocol is being developed at present by Dr Mitchell (WRC) who holds the training portfolio on the NCC. He is developing an inventory of biomonitoring training throughout South Africa. It is also his task to set up courses and identify institutions and people who can set the necessary standards.

A number of organisations countrywide have biomonitoring training capabilities. The following is a preliminary list: Umgeni Water, Rand Water, University of Cape Town, Rhodes University, Free State University, Potchefstroom University, University of the Witwatersrand, Rand Afrikaans University, Environmentek (CSIR) and Mpumalanga Parks Board.