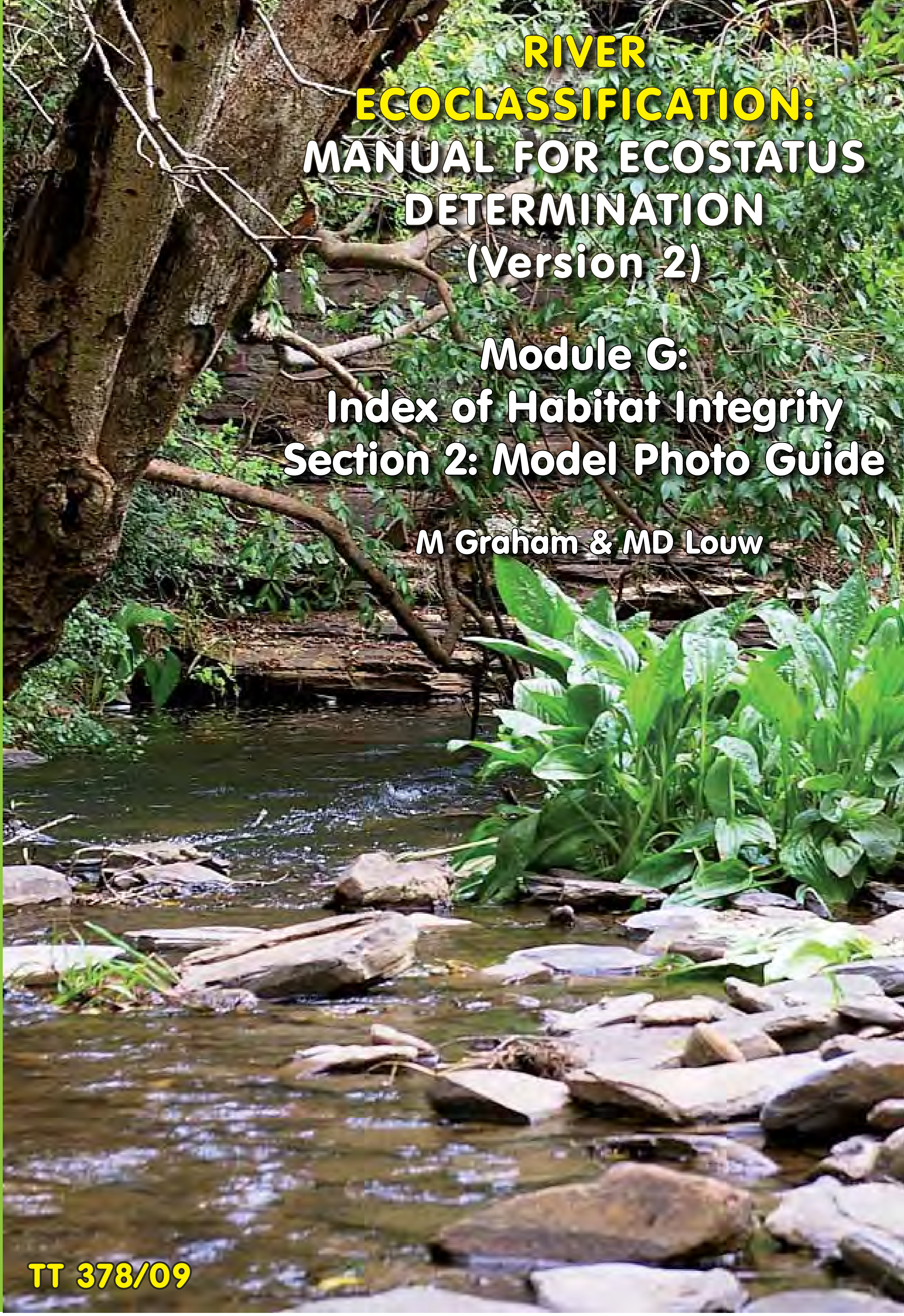
ECOCLASSIFICATION



# RIVER ECOCLASSIFICATION: MANUAL FOR ECOSTATUS DETERMINATION (Version 2)

## Module G: Index of Habitat Integrity Section 2: Model Photo Guide

M Graham & MD Louw

TT 378/09

water & forestry

Department:
Water Affairs and Forestry
**REPUBLIC OF SOUTH AFRICA**

Water Research Commission

# RIVER ECOCLASSIFICATION
# MANUAL FOR ECOSTATUS DETERMINATION
# (Version 2)

# MODULE G
# INDEX OF HABITAT INTEGRITY
# SECTION 2: MODEL PHOTO GUIDE

Report to the
**Water Research Commission**

by

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The manuals for ecostatus determination emanate from studies which were initiated within the WRC research consultancy K8/619 titled "*Designing a Riparian Vegetation Response Assessment Index as part of the existing Ecostatus determination process"*.

This report is the ninth of a series. Please refer to Page iii for a list of the other publications.

**DISCLAIMER**

This report has been reviewed by the Water Research Commission (WRC) and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the WRC, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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# STRUCTURE OF THE MANUAL

The manual consists of the following modules:

- MODULE A: ECOCLASSIFICATION AND ECOSTATUS MODELS
- MODULE B: GEOMORPHOLOGICAL DRIVER ASSESSMENT INDEX (GAI)
- MODULE C: PHYSICO-CHEMICAL DRIVER ASSESSMENT INDEX (PAI)
- MODULE D: FISH RESPONSE ASSESSMENT INDEX (FRAI) Volume 1 & 2
- MODULE E: MACRO-INVERTEBRATE RESPONSE ASSESSMENT INDEX (MIRAI) (Volume 1)
- MODULE F: RIPARIAN VEGETATION RESPONSE ASSESSMENT INDEX (VEGRAI)
- **MODULE G: INDEX OF HABITAT INTEGRITY**
  - Section 1: Technical Manual
  - **Section 2: Model Photo Guide**

This is module G, section 2, which provides an illustrated guide to accompany the Technical Manual for Index of Habitat Integrity (section 1). Habitat integrity assessment is approached from an instream and riparian zone perspective. These are formulated according to metric groups, each with a number of metrics that enable the assessment of habitat integrity. The photo guide is in two sections. The first section focuses on the **instream zone** and looks at various metrics: hydrological, physico-chemical, bed modification, bank modification, connectivity modification and instream vegetation. The second section focuses on the **riparian zone** and includes the following metrics: hydrological, bank structure and riparian zone connectivity modification.

# USING THIS PHOTO GUIDE

When you are assessing a river, you need to look at the instream and riparian zones. Both need to be assessed according to various metrics. However, the first step is to identify the type of river. For example, is it largely a bedrock dominated, boulder cobble or alluvial system? Having identified this, use the appropriate sections in this guide and make a rating based on the photo examples.

**WARNING**

This photo guide is not a field manual. The primary purpose of the document is to assist in the rating of impacts in different river types. It provides illustrations of different impacts and their severity rating at points or sites in the river. The extent of the impact in the river reach is not addressed. The impact rating for a particular disturbance in a reach needs to be interpreted according to the severity of the impact over the entire length of the reach. For example, if the impact at a site is rated as a 5, but the impact occurs over only 1% of the reach, the reach rating would be correspondingly lower depending on the downstream influence of the particular disturbance.

Note that:

1. Not all possible impact scenarios are covered in the guide.
2. Final ratings must be determined using this guide, the technical manual and indicating the rationale for the rating where interpretive explanation is needed.

If you would like to contribute to expanding a web-based version of this photo guide, please take and keep photos of representative examples.

**PURPOSE OF THIS MODEL PHOTO GUIDE**

- To assist with standardisation and hence quality control in the application of IHI.
- To provide an illustrated guide in rating metric groups within the instream and riparian zones. Not all metric groups could be illustrated, and, where appropriate, some text guidance is provided for assistance with assessment.

**WHO SHOULD APPLY THESE MODELS?**

An experienced river ecologist with experience (in application of the first IHI version) and or training in the application of the IHI.

NOTE: It is strongly recommended that the user participates in training courses and/or contacts the authors of this manual when applying the models.

# DOCUMENT REFERENCE

Graham, M. & Louw, M.D. 2009. Module G: EcoClassification and EcoStatus Determination in River EcoClassification: Manual for Index of Habitat Integrity (Section 2, Model Photo Guide). Water Research Commission. WRC Report No TT 378/09

# ACKNOWLEDGEMENTS

All those that have ever been involved in the process of determining Present Ecological State, Future Desired State, Environmental Management Class, Recommended Ecological Reserve and any other terminology that bears relevance to ecological state, are gratefully acknowledged. The following people are specifically thanked for their direct input to this module: Neels Kleynhans, Chris Dickens, Douglas MacFarlane, Christa Thirion and Colleen Todd.

Photographs have been kindly contributed by Mark Rountree, Allan Batchelor, Delana Louw, Andrew Deacon, Chris Dickens, Mark Graham, Donovan Kotze and Ezemvelo KZN Wildlife.

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INSTREAM

1. Hydrological Modification

# Base (Low) Flows

Base (low) flows refers to the sustained or dry weather flow of streams resulting from the outflow of permanent or perched ground water or from the drainage of large lakes and swamps. A change in seasonality as well as the natural degree of perenniality is used as the basis of the assessment. This will obviously vary depending on whether one is in a summer or winter rainfall area.

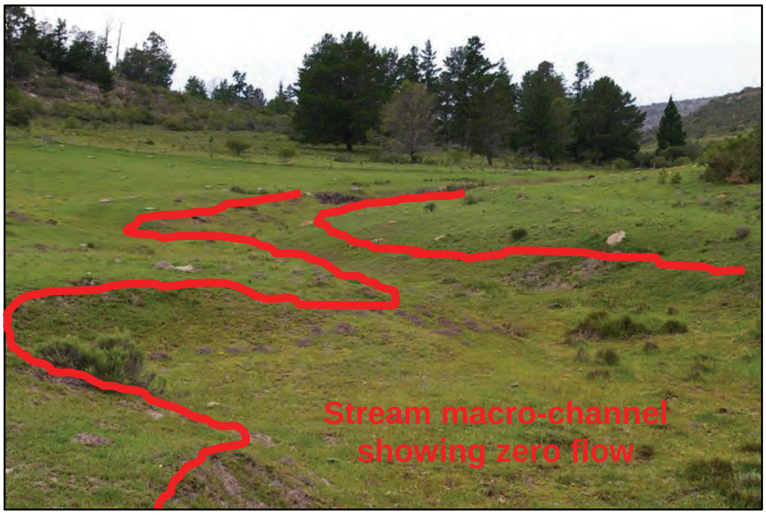
**Assegaai River (Mpumalanga)**

| | |
|---|---|
|  |  |
| Base flow dry season | Base flow wet season |

# Zero (No) Flows

Zero flows refers to <u>no flowing surface water</u>. A decrease or increase in the natural frequency of no flow conditions (i.e. on the continuum: perennial→ephemeral) is the basis of the assessment.

The picture shows a dry river channel due to afforestation and an upstream dam. There is now zero flow and the channel has become vegetated.




**Bushmans River downstream of the Jameson Dam (Eastern Cape)**

# Floods

Floods (also referred to as high flows) are any events having a peak flow with a specific duration of less than a day, to a number of days.

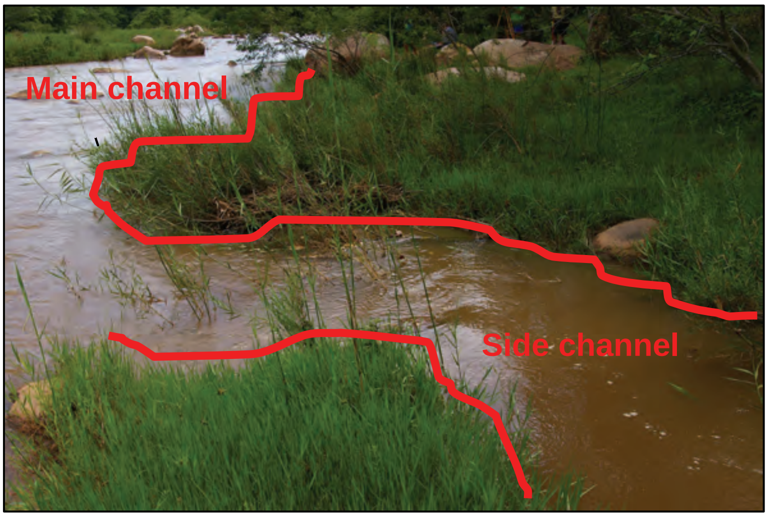
Floods can be divided into three types:

- **Freshes:** These are small events often with duration of less than a day. These floods are often referred to as having a magnitude of double the base flow. They are not important in terms of fluvial geomorphology, but play an important ecological role.
- **Moderate floods:** These are the floods that occur with a frequency of less than 1:1, i.e. they would normally occur every year and usually contained within the active channel. *For purposes of simplification, the above two types of floods have been grouped together.*
- **Large floods:** These are floods that occur with a frequency of more than 1:1, i.e. 1:2 year floods and larger, and often fill or overtop the active channel, inundate flood benches or the flood plain.

## Moderate Flood

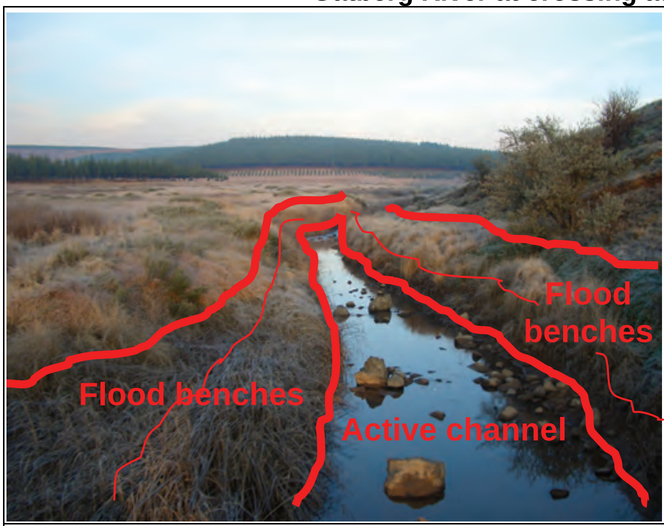
The picture illustrates how side channels are activated during a moderate flood.

**Mkhondvo River (Swaziland)**

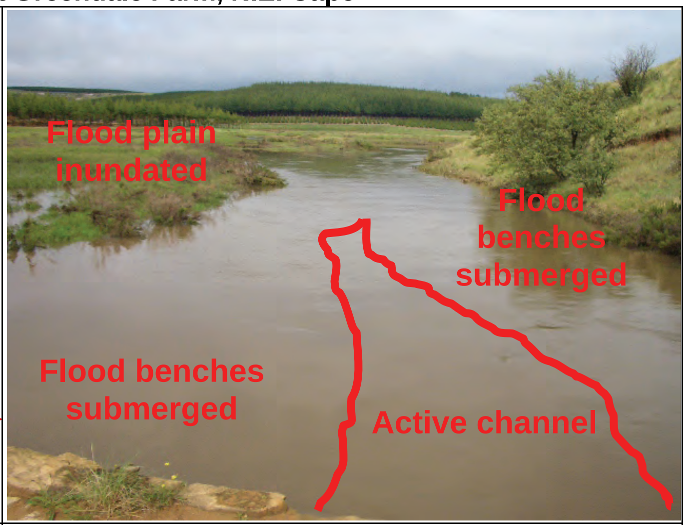



## Large Flood

**Gatberg River at crossing at Greendale Farm, N.E. Cape**




Prior to flooding, only active channel with water




During large flood, showing flood plain inundation

## pH

pH is determined by the concentration of hydrogen ions in water. pH is altered when acid or alkali is added to water. Since pH is a log scale, a change of one unit means a ten-fold change in hydrogen ion concentration. Most fresh waters are relatively well buffered and more or less neutral, with pH ranging from around 6-8.

Some streams are naturally more acidic than others (e.g. the southern and western Cape systems, and some tropical mangrove swamps, with natural organic acids making the water acidic) and their living organisms are adapted to these conditions. There is no one pH or pH range that is suitable for all streams and water quality guidelines have to be site-specific with regard to pH and alkalinity. Thus no single guideline values can be set. In South Africa, water quality guidelines for pH require that the Target Water Quality Range be stated in terms of the background site-specific pH regime.

## Inorganic Salts

One of the major ways to describe the quality of a water sample is the total amount of material dissolved in it. Material dissolved in water is commonly measured as total dissolved salts (TDS), as conductivity or as salinity. This determines the biotic characteristics of aquatic systems and the human uses for the water.

The majority of ions in water derive from weathering of the rocks over which they flow or from which they drain. The other major source of ions is the atmosphere. Maritime air can contain significant quantities of sea salt.

The ions most commonly found in natural waters are calcium, magnesium, sodium and potassium, and the anions bicarbonate, carbonate, chloride and sulphate. Different ions predominate in different areas depending on the atmosphere, and the rocks with which the water has had contact. Highveld water tends to be dominated by calcium, magnesium and bicarbonate ions, whereas those of the coastal regions and the west tend to be dominated by sodium and chloride ions.

Total dissolved salts represents the total quantity of dissolved material, both organic and inorganic, and both ionized and un-ionized, in a sample of water. It is usually measured by weighing the residue from a known volume of filtered water evaporated to dryness at a temperature less than 70°C. Units are usually quoted as mg $l^{-1}$ or g $m^{-3}$ (= parts per million).

Little is known about the salinity tolerances of freshwater organisms. It is often the rate of change rather than the final salinity that is most critical. Many organisms are able to adjust to slow changes. Juvenile stages are often more sensitive to increased levels of salts than adults. In general, there seems to be a critical level of salinity of about 5000-8000 mg $l^{-1}$ which marks the upper limit that most freshwater animals can survive.

## Nutrients

Plant nutrients are any elements required for normal plant growth and reproduction. Nitrogen and phosphorus are most commonly implicated in excessive plant growth resulting from nutrient enrichment of aquatic systems. Nutrient enrichment is called eutrophication and can lead to an imbalance in biological communities, particularly to an increase in plant communities and associated water quality problems.

Factors contributing to the amount of nutrients in a system include:

- Climatic (weathering of rocks and soil, erosion, rainfall, variability of runoff)

[1] This section of the Model Photo Guide is brief and draws heavily on Dallas, H.F. & Day, J.A. *The Effect of Water Quality Variables on Aquatic Ecosystems: A Review.* Report to the Water Research Commission, WRC Report No. TT 224/04, February 2004. For more details refer to Dallas and Day.

- Catchment characteristics (surface geology, land form)
- Anthropogenic:

  Point-source (e.g. sewage treatment works, industry, intensive animal enterprises) – these are relatively simple to measure and regulate, and can be controlled by treatment at the source.

  Non-point-source (e.g. agricultural runoff, urban runoff, atmospheric deposition) – these are diffuse and more difficult to measure and regulate.

## Water Temperature

Rivers can experience both daily and seasonal temperature changes. All organisms survive best at a particular temperature or range of temperatures. Temperature changes can result from thermal pollution (including heated industrial discharge, heated cooling waters from power stations and returning irrigation water), stream regulation (upstream dams can have significant effects on thermal conditions downstream) and changes in riparian vegetation (removal of shade).

An increase in water temperature decreases oxygen solubility and may also increase the toxicity of certain chemicals. This results in increased stress for organisms in the water. Temperature is the cue for many life cycle characteristics of aquatic organisms, e.g. migration, breeding. Temperature changes affect metabolic patterns and life cycle patterns by altering reproductive periods, rates of development and emergence times of water organisms.

Water temperature can also indirectly control local biodiversity and ecosystem health though changes to dissolved oxygen concentrations. High water temperatures reduce the solubility of oxygen (the amount of dissolved oxygen in water) and increase rates of ecosystem respiration which also reduces dissolved oxygen, particularly at night when the combined respiration of plants and animals can often result in dissolved oxygen levels approaching anoxia. Water temperatures can be controlled by adequate riparian shading, and this may have flow-on improvements to lower river systems and estuaries.

In South Africa water quality guidelines specify a target water quality range whereby water temperature should not be allowed to vary from the background daily average water temperature considered to be normal for that specific site and time of day, by more than 2°C or more than 10%, whichever estimate is the more conservative.

## Water Clarity

The immediate visual effect of a change in turbidity is a change in water clarity, and this is the water quality characteristic most obvious to the casual observer. Water clarity affects light penetration, an effect that may have far-reaching ecological consequences. Water clarity is generally considered to be equal to the measure of the concentration of suspended solids. These suspended solids are either washed in during rainfall or brought into suspension from the bottom sediments of rivers. As flow decreases, so the larger suspended solids settle out.

The natural seasonal variations in rivers often result in changes in water clarity, the extent of which is governed by the basic hydrology (e.g. rainfall and flow patterns) and geomorphology (e.g. aspect, weathering) of the particular region.

The main effects of increased turbidity (or reduced water clarity) are on primary production, biotic abundance and diversity. The extent also depends on the type and duration of the input. In turbid waters the amount of light penetration is reduced leading to a decrease in the rate of photosynthesis, decreasing primary production and therefore food availability for aquatic organisms higher up the food chain. Both benthic community diversity and fish are also adversely affected by decreased water clarity.

Turbid rivers are fairly common and it has generally been accepted that water clarity is not a particularly significant water quality variable in this country. More research is needed, however, as some studies have indicated that an increase in suspended solids was accompanied by the loss of or drastic reduction in invertebrate species found in mountain streams and upper river zones. The loss of ephemeropteran (mayfly) nymphs was particularly noticeable.

The recovery of a stream affected by high sediment deposition depends on eliminating the source of the sediment and the ability of the stream water to flush out the deposited material. The importance of riparian buffer strips and livestock fencing have been emphasised.

|  |  |
| --- | --- |
| Clear Drakensberg stream with high turbidity coming in from the left illustrating overgrazed rural sub-catchment with high turbidity. | Confluence of Tangwiza and Mwana rivers showing high turbidity water and sediments from artisanal gold mining. |

## Oxygen Concentration

Most aquatic organisms are dependent on oxygen dissolved in the water. Factors causing an increase in dissolved oxygen include atmospheric re-aeration, increasing atmospheric pressure, decreasing temperature and salinity, and photosynthesis by plants. Factors causing a decrease in dissolved oxygen include increasing temperature and salinity, respiration of aquatic organisms, decomposition of organic material by micro-organisms, chemical breakdown of pollutants, re-suspension of anoxic sediments and release of anoxic bottom water (as, for example, below a large impoundment).

The effect of dissolved oxygen depletion on aquatic organisms depends on the frequency, timing and duration of this depletion. The oxygen requirements of fish and other aquatic organisms vary with type of species, life stages, size and different life processes. Juveniles are generally more sensitive. Many species avoid anoxic or oxygen depleted zones. Super-saturation by oxygen, typically caused by eutrophication, can also have lethal effects.

Dissolved oxygen is measured as milligrams per litre (or mg $l^{-1}$) or as a percentage of the saturation. The former is important as concentration relates to the amount of oxygen that an organism requires, while the latter, percentage saturation gives a useful estimate of biological activity. Results of less than 100% saturation indicate that dissolved oxygen has been depleted while super-saturation (results in excess of saturation) can indicate eutrophication.

## Toxics

Toxics, sometimes referred to as biocides, are chemicals that kill living organisms and that are used in the control of pests, usually associated with agricultural crops and vector-borne diseases. The most common are herbicides, fungicides and insecticides. Potential sources of biocides in aquatic systems include direct application (for pest control), industrial effluents, sewage, leaching and runoff from soil, and deposition of aerosols and particulates. The nature, modes of action and toxicity of biocides vary considerably. Generally, organochloride insecticides (e.g. DDT, dieldrin) are the most hazardous as they persist, concentrating in organisms and thus through food chains (bioaccumulation). It is very difficult, sometimes impossible, to assess the risk posed by biocide contamination to an aquatic system. This is because biocides are difficult and expensive to detect in small quantities, some form a variety of breakdown products of different toxicities, and some interact antagonistically or synergistically with other toxins. Current standards in South Africa are limited. More detailed international toxicity data is available on the ECOTOX (ECOTOXicology) database at www.EPA.Gov/ecotox.

**INSTREAM**

**3. Bed Modification**

**Sedimentation**

## Bedrock

Rating 0-1


**Frikkie-se-Loop**
Geomorph Zone: Lower foothills

No upstream development. Site in excellent condition with no indication of extra sedimentation.


**Umkomaas**
Geomorph Zone: Lower foothills

Bedrock dominated channel with low sediment loads, clear pools and clean bedrock. Few sand or gravel bars, silt drapes or silt in pools.


**uMgeni** (upstream from Nagle Dam)
Geomorph Zone: Upper foothills

Clean bedrock. No sediments.


**Mandleni** (Thukela Valley at Overschot Farm)
Geomorph Zone: Upper foothills

Clean bedrock. Little sediment accumulation.

**INSTREAM**

**3. Bed Modification**

**Sedimentation**

## Bedrock

Rating 2-3


**Ngwempisi** (EFR1)
Geomorph Zone: Lower foothills

Upstream subsistence farming and overgrazing combined with removal of vegetation has led to a moderate increase in sedimentation across the bedrock areas.


**Mkondvo**
Geomorph Zone: Lower foothills

Upstream subsistence farming, irrigated sugar cane and an upstream gauging weir (with its stilling basin full of sediments) has led to a moderate increase in sedimentation across the bedrock areas.


**Lushushwane**
Geomorph Zone: Transitional

Upstream subsistence farming and overgrazing combined with removal of vegetation has led to a moderate increase in sedimentation across the bedrock areas.


**Kao**
Geomorph Zone: Mountain stream

Gravel and cobble sediments accumulating in pools. Upstream alluvial diamond mining, cultivation and localised erosion of steep valley sides has contributed to some sedimentation of pools, particularly by gravels and small cobbles.

**INSTREAM**
**3. Bed Modification**
**Sedimentation**

| **Bedrock** | |
|---|---|
|   |   |
| **Mkhondvo**<br>Geomorph Zone: Lower foothills<br><br>Extreme sedimentation of a largely bedrock type river has caused most of the habitat to be lost in this reach of river. Picture and inset illustrate the sediments accumulating around the large bedrock elements in this river. | **Sibhowe**<br>Geomorph Zone: Upper foothills<br><br>Extreme sedimentation of a largely bedrock type river has caused most of the bedrock habitat to be lost in this reach of river. Picture illustrates the sediments accumulating around the large bedrock elements in this river. |
|   |   |
| **Kao**<br>Geomorph Zone: Mountain stream<br><br>Artisanal diamond mining of kimberlite sediments has led to extensive gravel and small cobble mobilisation and infilling of bedrock pools. High turbidity of water is evident. | **Kudobo**<br>Geomorph Zone: Mountain stream<br><br>Highly sediment enriched water (note clarity tube). Extensive silt drapes and accumulation of sediments in all backwaters and pools. |

Rating 4-5

## Boulder/Cobble

Rating 0-1


**Umkomaas** (at Umko Lodge below Staebras Farm)
Geomorph Zone: Upper foothills

Clean boulder cobble riffle with very little sediment accumulation amongst cobbles.


**Kao**
Geomorph Zone: Mountain stream

Clean boulder cobble riffle with very little sediment accumulation amongst cobbles.


**Kao**
Geomorph Zone: Mountain stream

Clean boulder cobble riffle with very little sediment accumulation amongst cobbles.


**Kaaloog-se-Loop**
Geomorph Zone: Upper foothills

Minimal impacts at this site and therefore little change to catchment and instream zone.

**INSTREAM**

**3. Bed Modification**

**Sedimentation**

## Boulder/Cobble

Rating 2-3


**Komati** (K1 EWR site)
Geomorph Zone: Upper foothills

Fine sediments accumulating on cobbles in backwater areas (see insert). Upstream impacts include some formal agriculture and unseasonal releases for ESKOM power generation.


**Elands**
Geomorph Zone: Upper foothills

Some accumulation of gravels and sediment in pools and around cobbles. Minor impact from upstream agriculture.


**Phongola**
Geomorph Zone: Lower foothills

Upstream weir, abstraction, and agriculture are prevalent although their impact has been moderated by a good riparian buffer zone. The size of the river also makes this reach resilient to impacts and changes.


**Mshushwane**
Geomorph Zone: Lower foothills

Very large plantation fires (see burnt trees in background), reduced riparian zone integrity and associated overland runoff resulting in bed modification due to sedimentation (insert shows sediments mobilised during SASS sampling).

**INSTREAM**

**3. Bed Modification**

**Sedimentation**

## Boulder/Cobble

Rating 4-5


**Mkhondvo**
Geomorph Zone: Lower foothills

Extensive upstream sugar cane farming and subsistence agriculture as well as decreased sediment transport capacity are the cause for this rating. Boulder and cobble habitat occluded by sandy sediments. Considerable loss of cobble and boulder habitat.


**Kao**
Geomorph Zone: Mountain stream

Extensive gravel sediments filling pools and spaces between cobbles and boulders. Loss of boulder habitat and infilling of pools.


**Sikelekehleni** (upstream from uMgeni confluence)
Geomorph Zone: Lower foothills

Insert shows how sediment has covered the boulder cobbles resulting in loss of habitat. The entire boulder/cobble nature of the river has been transformed to a sediment dominated system. Destabilisation of riparian and instream zones due to sand mining is the primary cause of this decline.


**Umbilo**
Geomorph Zone: Lower foothills

Extensive sediment accumulation on boulder cobble bed from poorly functioning waste water works upstream. Insert shows filamentous algae and bacterial growth covering boulder cobbles. Habitat availability is limited for benthic macro invertebrates.

**Alluvial**

Rating 0-1


**Crocodile**
Geomorph Zone: Lower foothills

Extensive upstream abstraction and agricultural activities are evident, but because this is an alluvial bed, it is resilient to changes. There is also a good riparian buffer moderating the upstream impacts.


**Sterkspruit** (at Shongweni inflow)
Geomorph Zone: Lower foothills

Braided alluvial stream in good condition with vegetation in channel bars. Good recovery from 1987 floods.


**Phongola**
Geomorph Zone: Lowland river

Broad alluvial flood plain in good condition with natural sedimentation.


**Lovu**
Geomorph Zone: Lowland river

Lower Lovu river with riparian zone relatively intact despite roads and development on the flood plain.

**INSTREAM**

**3. Bed Modification**

**Sedimentation**

**Alluvial**

Rating 2-3

| | |
|---|---|
| <br> | <br> |
| **Maputo** (EFR 4)<br>Geomorph Zone: Lowland river<br><br>This river has been affected by the Phongolapoort dam, sugar irrigation from the Usuthu River and fairly extensive flood plain utilisation. Decreased flooding within this reach and the above-mentioned activities have had an impact on sediment accumulation and sediment mobility. However, this is a very large river, well buffered by good riparian zone integrity and hence is still in reasonable condition. | **Ngwempisi**<br>Geomorph Zone: Lowland river<br><br>Excessive sedimentation due to overgrazing within the catchment, numerous dams on the system, and the associated low flows have caused increased reed growth. |
| <br> | <br> |
| **Lovu**<br>Geomorph Zone: Lowland river<br><br>Localised illegal sand mining is affecting sediment balance within the river. | **Thukela** (IFR 16)<br>Geomorph Zone: Lowland river<br><br>Moderately increased sediment load resulting from poor catchment management due to cultivation to the edge of riparian bank and poor catchment management (subsistence agriculture, overgrazing, etc.) upstream. |

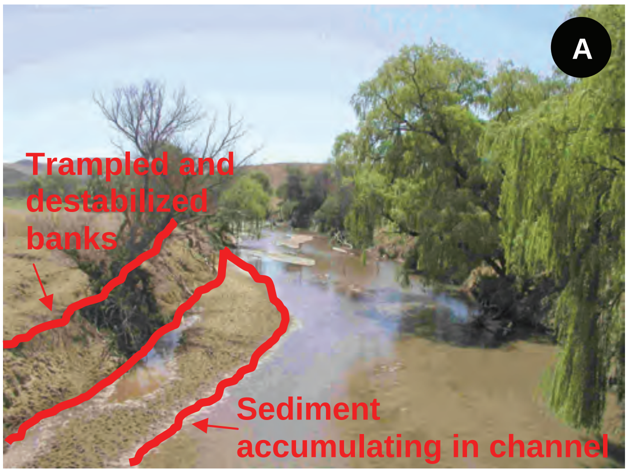
**INSTREAM**

**3. Bed Modification**

**Sedimentation**

**Alluvial**

Rating 4-5




**Mzimvubu** (at Jones Bridge)
Geomorph Zone: Lower foothills

Extensive alien willows along bank resulting in bank destabilisation combined with chronic trampling of banks by livestock. Lack of bank stability and increased sedimentation negatively impact on the instream channel.


**Umkomaas** (at Sappi Saicor barrage)
Geomorph Zone: Lowland river

Construction of barrage and sand mining by dredging is interfering with the movement and distribution of natural alluvial sediments.


**Ohlanga** (downstream from N2 road bridge)
Geomorph Zone: Lowland river

Canalisation of river for bridge has resulted in a change of flow regime. High nutrient content from sewage return flows results in extensive instream hydrophytic growth. Filamentous algal growth is also evident in the stream bed resulting in changed instream habitat.


**Mshwati** (upstream from confluence with Duzi)
Geomorph Zone: Lower foothills

Extensive livestock utilisation of riparian zone and trampling of banks and channel. Loss of natural riparian vegetation. Unstable instream sediments and loss of diversity of instream habitats.

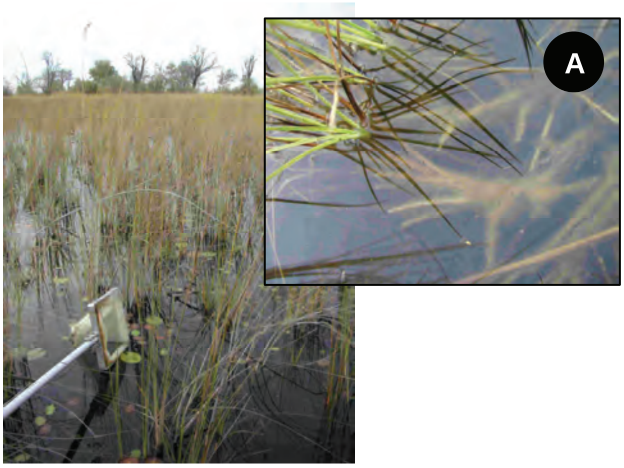
**INSTREAM**

**3. Bed Modification**

**Sedimentation**

## Organic/Peat/Wetlands

Rating 0-1




**Khwai** (Botswana)
Geomorph Zone: Upland flood plain

Broad flood plain draining the Okavango swamps. No impacts on natural sediment movement or distribution.


**uMgeni** headwaters (uMgeni Sponge)
Geomorph Zone: Source

Broad flood plain adjacent to main river channel. No impacts on natural sediment movement or distribution.


**Unnamed stream**
Geomorph Zone: Source

Stream emerging from high altitude wetland seep above Sani Pass. No change to natural instream sediments.


**Franklin Vlei**
Geomorph Zone: Lower foothills

Broad flood plain adjacent to main river channel. No impacts on natural sediment movement or distribution. Some limited grazing is evident on flood plain but impacts are negligible.

## Organic/Peat/Wetlands

Rating 2-3


**Unnamed stream** (Bergville)
Geomorph Zone: Upland flood plain

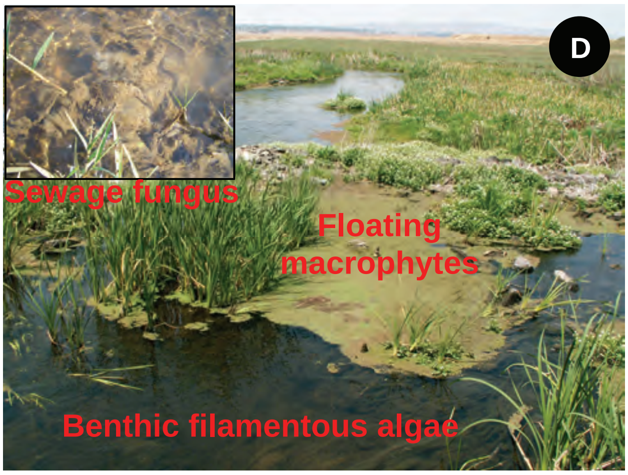
Extensive mats of algal growth on bottom sediments, otherwise in good condition.


**Unnamed stream** (Blair Atholl, Mooi River)
Geomorph Zone: Upland flood plain

Wetland seep area with trampling and incision of channel through wetland. Some bank collapse increasing instream sediments.


**Unnamed stream** (swamp forest, KwaZulu-Natal South Coast)
Geomorph Zone: Lowland river

Light channel incision and physical litter accumulation from stormwater runoff.




**Unnamed stream** (Gauteng)
Geomorph Zone: Upland flood plain

Floating macrophytes and benthic filamentous algae in channel indicating nutrient enrichment. Insert shows sewage fungus (Piesang, KwaMashu), growing over aquatic vegetation resulting in a loss of available instream habitat.

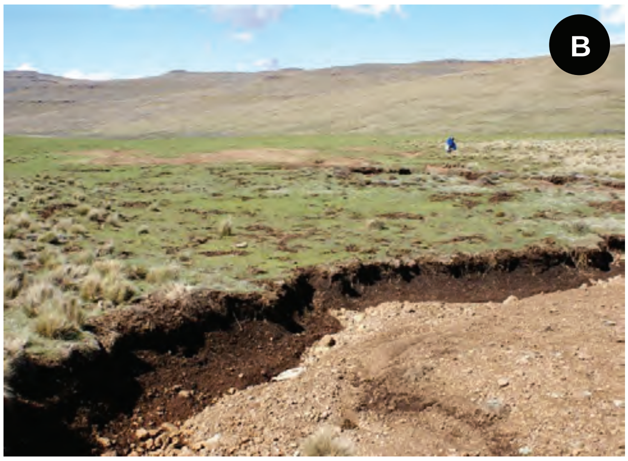
**INSTREAM**
**3. Bed Modification**
**Sedimentation**

## Organic/Peat/Wetlands

Rating 4-5


**Unknown**
Geomorph Zone: Upland flood plain

Deep organic wetland soils on either side of river channel are being severely eroded with slumping of the river bank into the channel. Insert illustrates erosion of organic-rich wetland type soils.




**Unknown** (Lesotho)
Geomorph Zone: Source

Erosion due to overgrazing has removed organic wetland soils down to subsoil and bedrock. There is also a localised lowering of the water table due to channel incision.


**Unknown** Gauteng
Geomorph Zone: Lower foothills

Wetland soils have been removed by erosion. Alluvial sediments have been deposited onto wetland soils (labeled above) from upstream agriculture and poor land use. Insert illustrates the larger catchment context.


**Unknown** (Gauteng)
Geomorph Zone: Upland flood plain

Accelerated urban runoff and increased flood peaks cause erosion through the wetland. Picture also illustrates bank slumping, channel incision and bed modification and sedimentation.

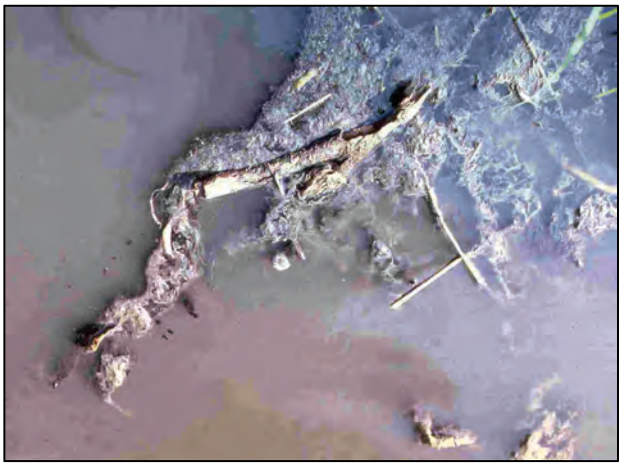
# Microphytes

Mats of benthic algal growth covering stream bed and reducing available habitat.

Instream filamentous algae visible in the foreground of the above photo.


**Nqutu** (at Kranskloof Nature Reserve)
Extensive benthic algal and bacterial growth covering surface of bedrock and cobble biotopes (see insert) in response to nutrient enriched water.

**Mlazi**
Intensive market gardening and crop production upstream with nutrient runoff into the streams causing extensive filamentous algal growth.



**Sphaerotyllus (sewage fungus)**

Fongozi - sewage fungus coating instream vegetation substrate in the river.

Sewage fungus coating the instream stones habitat of the Baynespruit, Pietermaritzburg.

**INSTREAM**

## 4. Bank Modification: Marginal and Non-Marginal Zones

**Bedrock**

Rating 0-1


**Tsitsa** (at Niagra Falls)
Geomorph Zone: Transitional

Bedrock intact with healthy riparian vegetation.


**uMgeni**
Geomorph Zone: Upper foothills

Bedrock and large boulder banks intact with healthy riparian vegetation.


**Mandleni** (at Overschot Farm)
Geomorph Zone:  Mountain stream

Bedrock intact with healthy riparian vegetation. Bedrock dominated riparian zone which is very stable and intact.


**uMgeni** (downstream from Nagle Dam)
Geomorph Zone:  Lower foothills

Bedrock dominated riparian zone which is very stable and intact, although there has been some armouring of this river.

**INSTREAM**

**4. Bank Modification: Marginal and Non-Marginal Zones**

**Bedrock**

Rating 2-3


**Mkhondvo**
Geomorph Zone: Lower foothills

Large boulder/bedrock bank with slightly elevated gravels and sand. Marginal vegetation is in moderate condition.


**Lushushwane**
Geomorph Zone: Transitional

Relatively stable bedrock banks with localised overgrazing of grassy riparian vegetation. River banks still in moderate condition.


**Ngwempisi** (EFR 1)
Geomorph Zone: Lower foothills

The far bank is relatively undisturbed (rating probably 1). The near bank is highly disturbed with localised vegetation removal and trampling by livestock. Hence the overall rating is moderate (2-3).


**Mkhondvo**
Geomorph Zone: Lower foothills

Modified sediment transport dynamics have resulted in undercutting and erosion of the exposed bank. As the river attempts to widen, vegetation root structure is exposed.

**INSTREAM**

## 4. Bank Modification: Marginal and Non-Marginal Zones

**Bedrock**

Rating 4-5


**Sikelekehleni**
Geomorph Zone: Lower foothills

Massively impacted riparian zone due to removal of gravel sediments for sand mining. Destruction of riparian zone is virtually complete.


**Town Bush Stream**
Geomorph Zone: Lower foothills

Channel re-alignment and complete bank modification in both marginal and non-marginal zones. Complete loss of riparian zone functioning.


**Sabie River** (at Aan-de-Vliet Lodge)
Geomorph Zone: Lower foothills

Marginal zone has been highly modified to cater for recreational areas on the banks (including the lodge).


**Mwana** (Kivu province, Congo)
Geomorph Zone: Upper foothills

Complete destruction of entire riparian zone due to artisanal mining of alluvial sediments for gold. Paleo channel and flood plain also extensively mined.

**INSTREAM**

**4. Bank Modification: Marginal and Non-Marginal Zones**

## Boulder/Cobble

Rating 0-1


**Umkomaas** (at Umko Lodge)
Geomorph Zone: Lower foothills

Good boulder/cobble substrate and vegetation along bank.


**Tongaati** (at Ngedleni Village)
Geomorph Zone: Lower foothills

Intact riparian vegetation (reeds) in both marginal and non-marginal zones.


**Kaaloog-se-Loop**
Geomorph Zone: Upper foothills

Intact riparian vegetation with little change to bank structure and integrity. Overhanging and good marginal vegetation provide excellent refugia for fish and invertebrates and hence good habitat integrity. The intact state prevents any erosion, sedimentation, bed modification and bank erosion.


**Eerste** (Western Cape)
Geomorph Zone: Upper foothills

Intact riparian vegetation with little change to bank structure. Overhanging and good marginal vegetation provides excellent refugia for fish and invertebrates and hence good habitat integrity. The intact state prevents any erosion, sedimentation, bed modification and bank erosion. There is also a clear lack of alien vegetation which adds to the integrity.

INSTREAM

4. Bank Modification: Marginal and Non-Marginal Zones

**Boulder/Cobble**

Rating 2-3


**Thukela** (at Tugela Ferry, IFR 9)
Geomorph Zone: Transitional

Marginal vegetation on banks cropped short and or removed by livestock grazing pressure. This provides very little marginal, instream and overhanging vegetation for this system. However this is localised and due to flooding, vegetation is removed and any regeneration of vegetation is repeatedly removed by grazing. Easy access amplifies this problem.


**Kao** (Lesotho)
Geomorph Zone: Mountain stream

Gravels and sediments accumulating in marginal zone. Reduction in integrity of marginal vegetation.


**Assegaai**
Geomorph Zone: Lower foothills

Overgrazing and associated pressures causing localised bank erosion and collapse.


**Buffalo** (IFR 14)
Geomorph Zone: Lower foothills

The presence of alien vegetation and localised erosion on the far bank, due to overgrazing, upstream abstraction and lack of flooding, have reduced the integrity of the riparian zone.

## 4. Bank Modification: Marginal and Non-Marginal Zones

**Boulder/Cobble**

Rating 4-5


**Sikelekehleni**
Geomorph Zone: Lower foothills

Extensive sand mining operations have completely modified the marginal and non-marginal zones of this reach of river with significant loss of available riparian habitats.


**Umlazi** (upstream from Umlazi township)
Geomorph Zone: Lower foothills

Extensive building rubble dumping into riparian zone and into stream channel. There is also nearly 100% exotic macrophyte cover (water hyacinth). These combined impacts have a major effect on the marginal and non-marginal zones of the bank.


**Piesang** (at Corobrik)
Geomorph Zone: Lower foothills

Extensive reed and hydrophytic growth along banks as well as solid waste disposed (see insert showing top of bank) have modified marginal and non-marginal components of the bank, and resulted in instream bed modification.


**Likasi** (Katanga, Congo)
Geomorph Zone: Transitional

Virtual complete destruction of riparian zone due to human activity, specifically mining of river and flood plain sediments (see insert).

**INSTREAM**

**4. Bank Modification: Marginal and Non-Marginal Zones**

**Alluvial**

Rating 0-1


**Crocodile**
Geomorph Zone: Lower foothills

The encroachment by the agricultural lands within the upper riparian zones will have minor impacts on the bank integrity. Even though at present there does not appear to be a problem there is long term potential for impacts within this reach.


**Luangwa**
Geomorph Zone: Lower foothills

Broad alluvial banks, within a nature reserve (Southern Luangwa National Park), showing limited modification.


**Maputo**
Geomorph Zone: Lowland river

There is some flood plain subsistence agriculture and due to limited human pressures, there is limited impact on the instream habitat. The flood plains in the lower reaches are regularly inundated and sand is deposited on the banks.


**Phongola**
Geomorph Zone: Lowland river

Broad alluvial flood plain in good condition with natural sedimentation. Also illustrated are natural open patches within the riparian zone.

**INSTREAM**

**4. Bank Modification: Marginal and Non-Marginal Zones**

**Alluvial**

Rating 2-3


**Tongaati** (upstream from estuary)
Geomorph Zone: Lowland river

Nutrient enriched water (from sewage effluent return flows) is leading to extensive coverage of channel by macrophytes and modification of the natural riparian flora.


**Msimbazi**
Geomorph Zone: Lowland river

Marginal vegetation is intact with trees and shrubs except where informal and artisanal sandmining (see insert) is evident resulting in loss of marginal and non-marginal vegetation structure.


**Mdloti** (upstream from estuary at N2 bridge)
Geomorph Zone: Lowland river

Sewage effluent return flows are increasing available nutrients for instream and riparian plant species. There is corresponding marginal vegetation growth and occlusion of channel.


**Umkomaas** (at Sappi Saicor barrage)
Geomorph Zone: Lowland river

Extensive sand mining operations along left bank. Almost complete destruction of marginal and non-marginal vegetation on one bank. Opposite bank is still in reasonable condition.

## 4. Bank Modification: Marginal and Non-Marginal Zones

**Alluvial**

Rating 4-5


**Lovu** (at Illovo Sugar Mill)
Geomorph Zone: Lowland river

Total bank modification due to indiscriminate sand mining. Virtually 100% loss of marginal and non-marginal elements.


**uMlaas canal** (at N2 road bridge)
Geomorph Zone: Lowland river

Canalised section of river with 100% modification of natural marginal and non-marginal elements.


**Mhlatuzane**
Geomorph Zone: Lower foothills

Massive overgrazing and trampling by livestock with large-scale destruction of marginal and non-marginal elements.


**Piesang** (at kwaMashu canal)
Geomorph Zone: Lowland river

Middle to lower reaches of the Piesang River canalised with extensive loss of functional riparian wetlands along marginal and non-marginal areas of the bank. Artisanal sand mining of non-marginal areas is now possible and is taking place (see lower insert).

INSTREAM

4. Bank Modification: Marginal and Non-Marginal Zones

## Organic/Peat/Wetlands

Rating 0-1


**uMgeni headwaters** (uMgeni Sponge)
Geomorph Zone: Source

Typical palustrine wetland/stream with intact marginal vegetation.


**Top of Sani Pass** (Lesotho)
Geomorph Zone: Source

Typical palustrine wetland/stream with intact marginal vegetation.


**Gat**
Geomorph Zone: Upland flood plain

Banks in very good condition with little or no impact.


**Polela side channel wetland**
Geomorph Zone: Upland flood plain

Banks in very good condition with little or no impact.

## 4. Bank Modification: Marginal and Non-Marginal Zones

# Organic/Peat/Wetlands

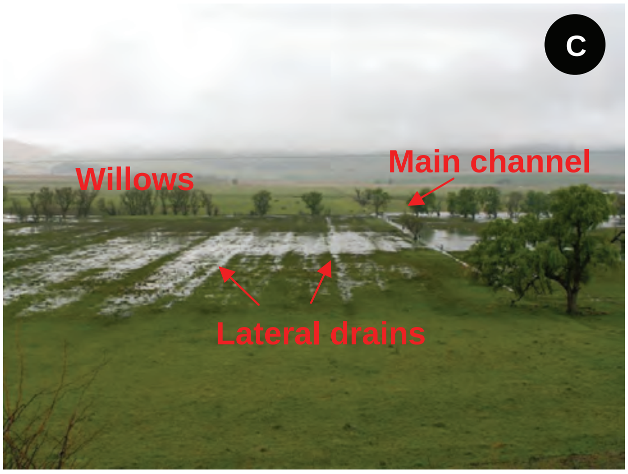
Rating 2-3


**Tributary feeding into Kosi Bay Lake**
Geomorph Zone: Lowland river

Moderate cultivation of coastal swamp forest/wetland stream, but low impact on marginal and non-marginal zones.

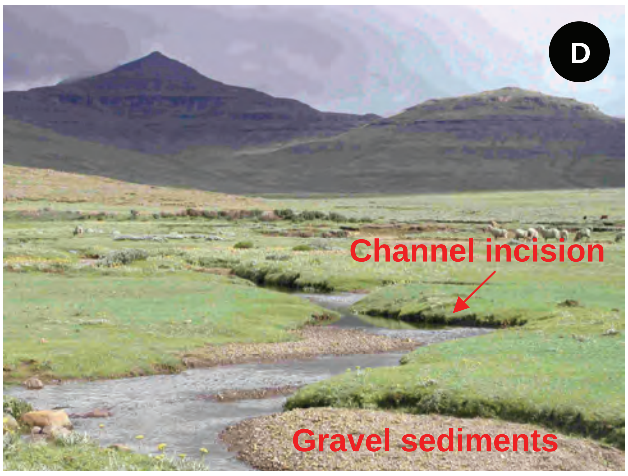

**Incised stream** (Blair Atholl wetland)
Geomorph Zone: Upland flood plain

Localised lowering of water table and subsequent draining of wetland. Banks modified through drying out of marginal and non-marginal zones.




**Franklin Vlei** (during high flows)
Geomorph Zone: Upland flood plain

Moderate impact from some lateral drainage of marginal wetlands on the flood plain and infestation of exotic willows along the main channel.

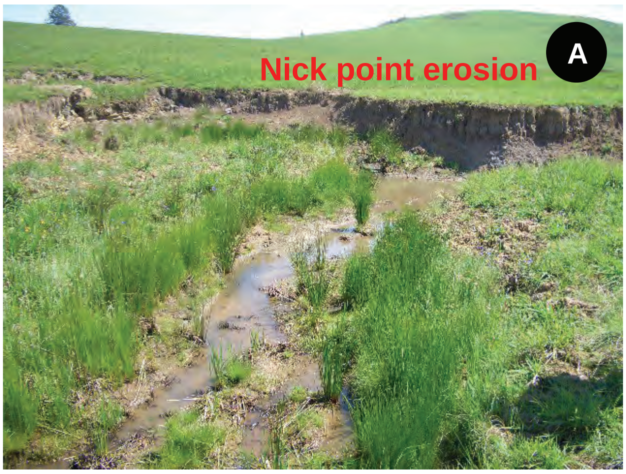



**Top of Sani Pass**
Geomorph Zone: Source

High altitude seep/source zone. Extensive impact from livestock (hoof action and overgrazing). Incision of channel through seep/source. Loss of organic matter and gravel sediments accumulating.

## Organic/Peat/Wetlands

Rating 4-5




**Blair Atholl wetland**
Geomorph Zone: Upland flood plain

Nick point erosion in wetland with lowering of water table and draining of wetland. Immediate marginal vegetation lost to sediments. Non-marginal vegetation is limited.


**Umhlangane / Piesang**
Geomorph Zone: Lowland river

Naturally meandering river through coastal wetland has been straightened and canalised. There is significant loss of riparian wetland function.


**Unknown**
Geomorph Zone: Upland flood plain

Canalised and modified riparian wetland through urban setting – channel straightening, infill and hard engineered weirs have removed most wetland functioning. Increased flood peaks and accelerated stream flows also cause bank erosion and channel incision.


**Unknown**
Geomorph Zone: Upland flood plain

Overgrazing, bank slumping and erosion have reduced most of wetland functionality on this site. Channel incision and lowering of the water table are also evident.

# Longitudinal

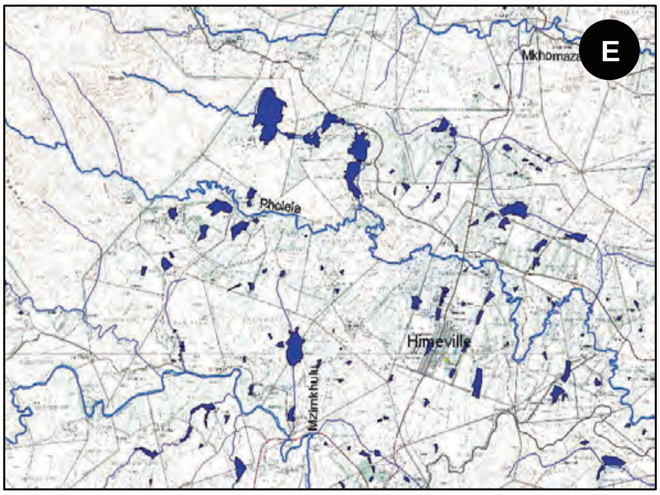

**Duzi** at Edendale Weir
The illustrated Krump weir is slightly more fish-friendly (as compared with photos C and D) but nonetheless interferes with connectivity.


**Ingwavuma**
Extreme case of connectivity modification. The downstream section of this river hardly ever flows due to upstream abstractions.

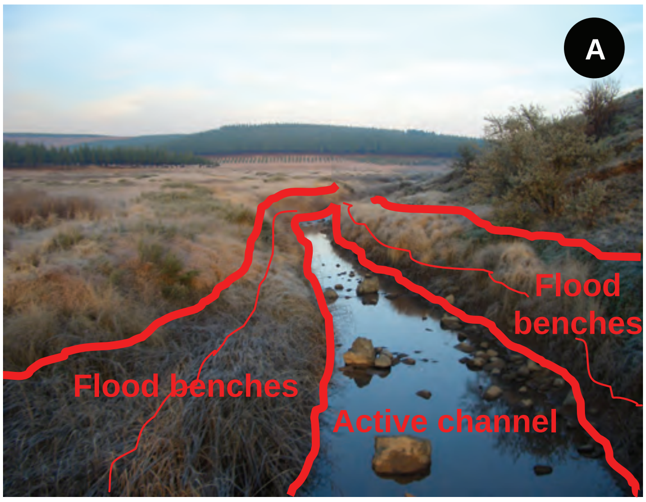

**Assegaai**
Typical gauging weir forming a natural migration barrier and interfering with lateral connectivity.


**Phongolapoort Dam**
Large dam wall forms a complete barrier to migration even during high flows.

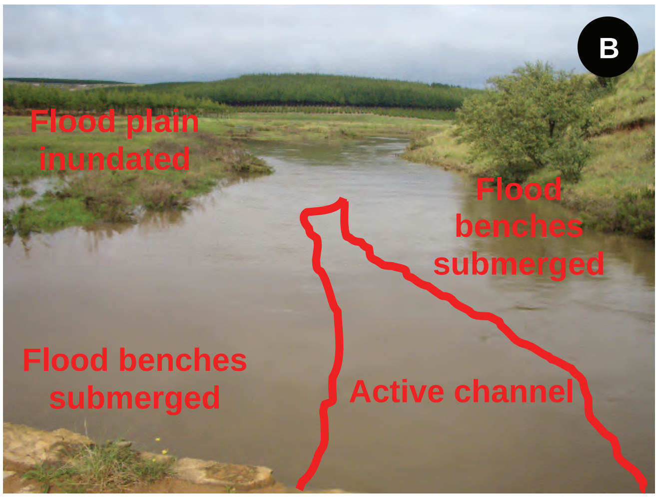
**Himeville**
The dam sequence to the right illustrates a fairly extreme case of connectivity modification along the main tributary of the Pholela River because of multiple farm dams. Dams also affect connectivity along smaller tributaries in this section of the map of Himeville and surrounding farmlands. Note the number of small farm dams on almost every available tributary. The cumulative effect interferes with natural hydrological flow patterns and longitudinal connectivity.



## Lateral

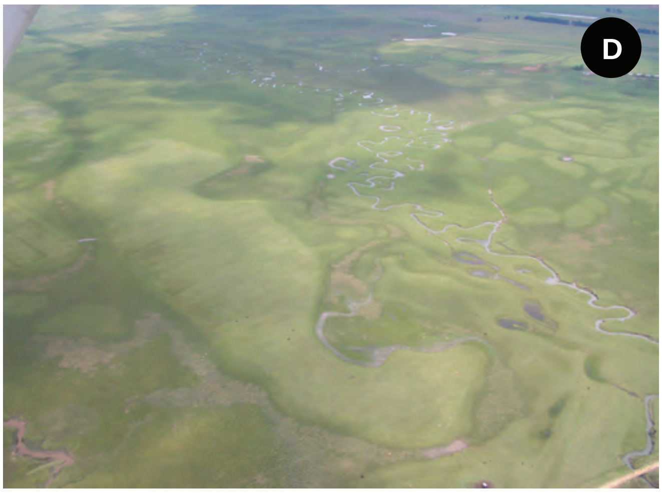



**Gatberg** (Crossing at Greendale Farm, N.E. Cape) **Prior to flooding.** If levees or weirs were used to reduce flooding the lateral connectivity illustrated above would be lost.




**Gatberg** (Crossing at Greendale Farm, N.E. Cape) **During flooding.** Flood benches are submerged and flood plain is inundated.


**Gatberg**
Flood terraces and flood plains recharged and connected to the main channel during flooding.




**NECF Sephton wetland**
Backwaters are recharged if connected to the main stream channel during flooding.


**Duzi -** Canalisation and dredging through Pietermaritzburg has reduced lateral connectivity with adjoining flood plains.

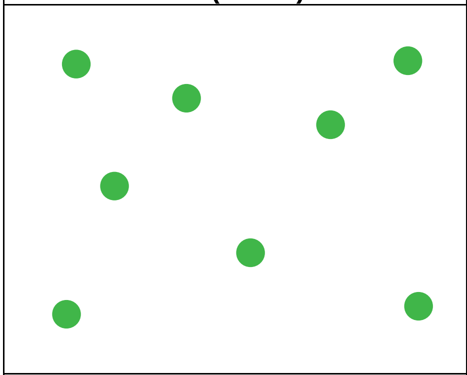
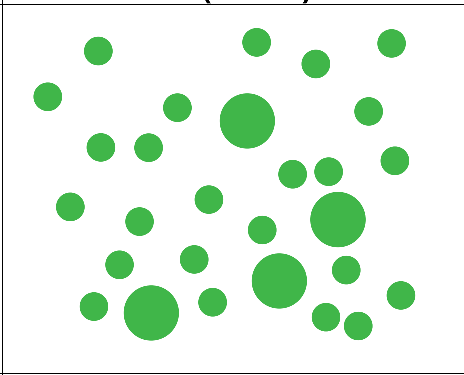
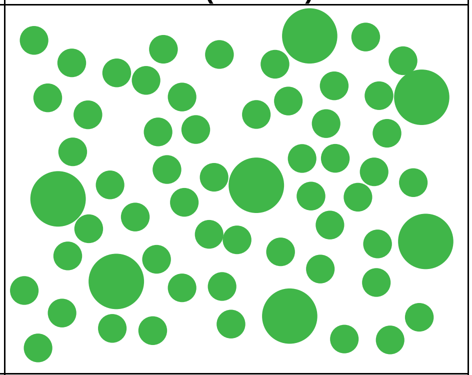

**Lower Piesang / Umhlangane** in KwaMashu showing extensive canalisation severely reducing lateral connectivity with adjacent riparian wetlands.

**INSTREAM**

**6. Instream Vegetation**

# Instream Vegetation

**Rating is determined by the percentage coverage of water surface by macrophytes**

| 0-1 (0-30%) | 2-3 (30-60%) | 4-5 (60-90%) |
|---|---|---|
|  |  |  |
|  |  |  |

Instream vegetation affects the following Metric Groups (and their metrics):

- Hydrology
- Physico-Chemical (Nutrients, Water Clarity, pH, Temperature, Oxygen, Toxics)
- Bed Modification (Sediment) – fines settling out
- Connectivity Modification (Longitudinal, Lateral)

Excessive or unnatural instream vegetation affects hydrology in that flows may be disrupted and/or decreased. For example, instream aquatic vegetation (weeds) can increase water loss from a water body by transpiration by up to six times that of normal conditions. Instream vegetation may also act as a “plug” at culverts/bridges or other narrow sections of river that can result in an increase in the water level and localised flooding during high flow conditions.

Physico chemical effects of instream vegetation includes changes in pH (more acidic, due to humic acids from decomposing vegetation), temperature (reduced and/or with a reduced daily variations), increased nutrient levels and depleted instream dissolved oxygen levels. For example where excessive instream vegetation accumulates, dead plant material within the water column can increase the nutrient loads and bacterial decomposition. The increased biological oxygen demand depletes the instream dissolved oxygen, thereby dramatically affecting stream biota.

Instream vegetation can also alter or modify stream beds due to the increased sedimentation from the slower moving water. The decomposition of dead plant material can also increase the organic composition of the stream beds which may change the entire biotype from a sandy/gravel bed to organic rich mud. The associated instream biota may also change in response to these changes in substrate and nutrient and energy modifications.

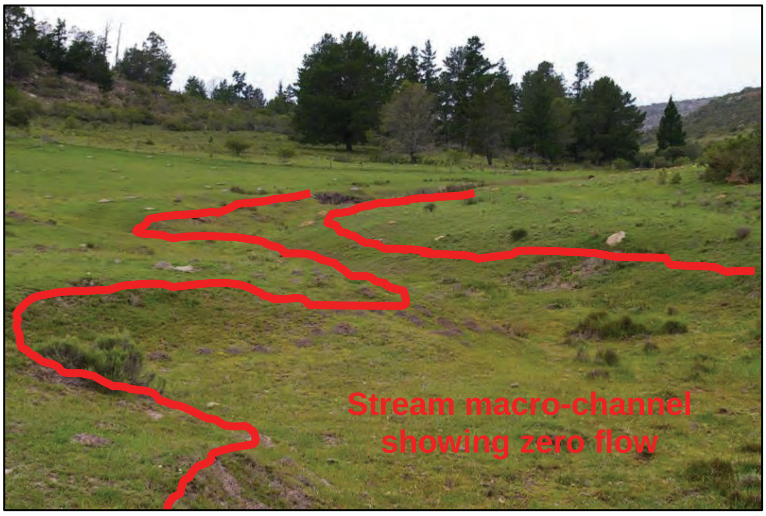
Connectivity may be modified by instream vegetation by the creation of barriers to the movement of fish and invertebrate communities. This can be through the change in pH, temperature or light that eliminates or modifies food sources (phytoplankton and zooplankton) or by the vegetation becoming so dense that fish or invertebrates are physically unable to penetrate through the vegetation. Where instream vegetation blocks flowing water bodies it can create a build-up of water levels. This can result in moderate flood events acting as large flood events by causing banks to overflow. In some instances this may be a beneficial aspect.

**RIPARIAN**

1. **Hydrological Modification**

# Base (Low) and Zero (No) Flows

**Ingwavuma**
Photo shows complete encroachment and terrestrialisation. Older trees are surviving but there is little replacement of vegetation by younger riparian species.




**Bushmans River downstream of the Jameson Dam**
Due to zero flows typical riparian species have largely disappeared. Terrestrial grassland species now dominate the entire riparian and instream zones.

**NECF Funeray Plantation**
Afforestation in upper catchment and trees within the riparian zone have dramatically reduced base flows. Photo inset shows normally perennial river reduced to seasonal pools.

## RIPARIAN

### 1. Hydrological Modification

# Floods (Moderate and Large) and Freshes

Prior to moderate flooding and freshes, the riparian vegetation in the Vaal and Mzintlava rivers in the photographs below, is clearly obvious. During flooding this riparian vegetation is inundated temporarily.

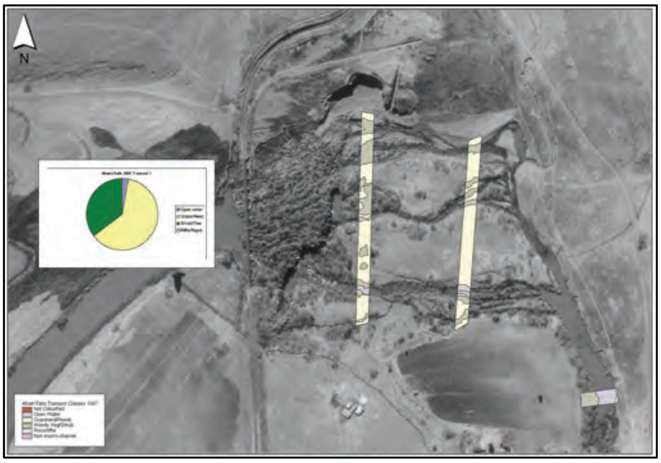
**Vaal River** Prior to flooding

During flood

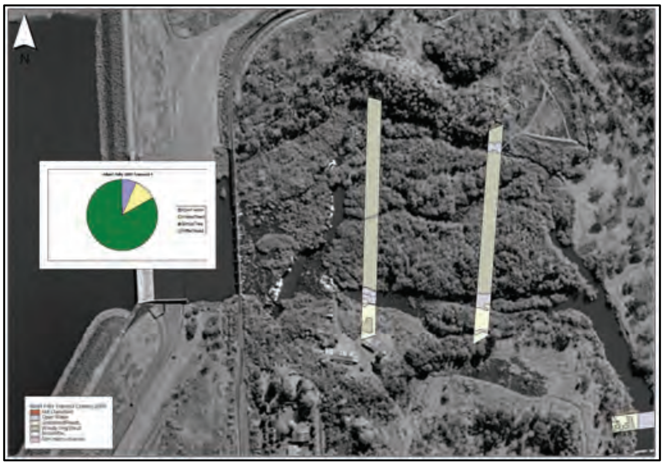
**Mzintlava River** Prior to flooding

During flood

The 1937 aerial photograph below shows the uMgeni river before the construction of Albert Falls dam. Note the lack of encroachment of vegetation within the riparian zone. Compare this with the same area in 2003. Vegetation has progressively thickened, due to a reduction in large and moderate floods and their frequency.



**uMgeni – 1937**



**uMgeni – 2003**

**RIPARIAN**

**2. Bank Structure Modification**

## Substrate Exposure

Rating 0-1


**Usuthu**
Geomorph Zone: Upper foothills

Left and right banks are well covered by a combination of grass, trees and shrubs. Very little substrate is exposed.


**Mzimkhulwana** (at Oribi Gorge)
Geomorph Zone: Upper foothills

Stable bedrock and boulder riparian zone with very little natural modification.


**Pholela**
Geomorph Zone: Upland flood plain

Meandering river with dense sedge and grass riparian zone. No exposed substrate.


**Mdlotane**
Geomorph Zone: Lowland river

Healthy and intact riparian zone with well-established riparian zone tree species. Insert shows how roots are holding bank structure together resulting in minimal substrate exposure.

**RIPARIAN**

**2. Bank Structure Modification**

## Substrate Exposure

Rating 2-3

**Snake**
Geomorph Zone: Upper foothills

Forestry harvest debris in channel with localised bank erosion and exposure. Also evidence of cattle grazing within the riparian zone. Cattle hoof action is destabilising riparian zone banks.

**Ngwempisi**
Geomorph Zone: Lower foothills

Riparian vegetation removal by livestock grazing and trampling particularly on near bank. Insert shows sparse cover in areas. Far bank is well covered.

**Unknown**
Geomorph Zone: Upland flood plain

Overgrazing in the catchment and slumping of riparian banks combine to produce moderate substrate exposure.

**Mhlatuzi** (Swaziland)
Geomorph Zone: Lower foothills

Mauritius thorn and wattles can be seen on both banks. Loss of typical marginal vegetation has exposed underlying substrate and destabilised the banks in places.

# Substrate Exposure

Rating 4-5


**Lion**
Geomorph Zone: Upper foothills

Alien weed control, removal, stacking and burning of aliens has led to severe substrate exposure along banks.


**Umkomaas** (downstream from Sappi Saicor barrage)
Geomorph Zone: Lowland river

Flow modification and sand mining upstream of estuary has exposed large areas of sandy bank.


**Town Bush Stream**
Geomorph Zone: Lower foothills

Channel re-alignment and exposure of new bank is evident. There is complete loss of riparian zone vegetation and total modification of the bank.


**Mhlatuzi** (Swaziland)
Geomorph Zone: Lower foothills

Overgrazing and trampling by livestock on both banks leading to virtually 100% bank exposure.

## Invasive Vegetation

Rating 0-1


**Kaaloog-se-Loop**
Geomorph Zone: Upper foothills

Minimal alien invasion along riparian bank – one willow tree can be seen but few other aliens are evident. There is also minimal upstream impact that can affect vegetation.


**Coleford Stream**
Geomorph Zone: Mountain stream

No aliens along riparian zone. Healthy and intact banks.


**Karkloof River** (at Game Valley)
Geomorph Zone: Upper foothills

No alien infestation of riparian zone. Healthy and intact banks.


**Pholela**
Geomorph Zone: Upland flood plain

Natural grassland with no alien invasion.

**RIPARIAN**

**2. Bank Structure Modification**

# Invasive Vegetation

Rating 2-3


**Ngwempisi**
Geomorph Zone: Lower foothills

Approximately 50% of bank is covered with alien weeds (bugweed). Marginal vegetation only supplying limited instream habitat.


**NECF Funeray plantation**
Geomorph Zone: Mountain stream

Kloof on river with localised 100% cover of wattles. Along riparian zone virtually complete loss of natural vegetation. Localised transformation of riparian zone. Had this been more widespread, the rating would have increased.


**Unnamed**
Geomorph Zone: Upland flood plain

Bugweed and bramble in foreground within gum and pine plantations. Photo also shows moderate bank erosion and harvest debris left in the stream.


**Lion**
Geomorph Zone: Upper foothills

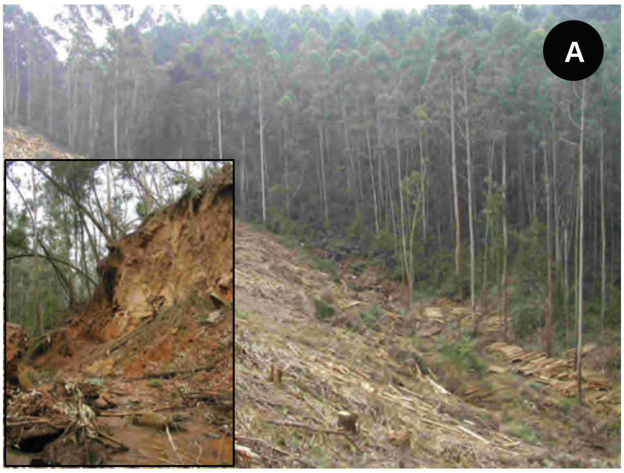
Left hand bank of main photo shows very extensive alien weed infestation. Insert shows this cleared and natural riparian zone buffer re-established. If both banks had been infested this would have increased the rating.

**RIPARIAN**

## 2. Bank Structure Modification

# Invasive Vegetation

Rating 4-5

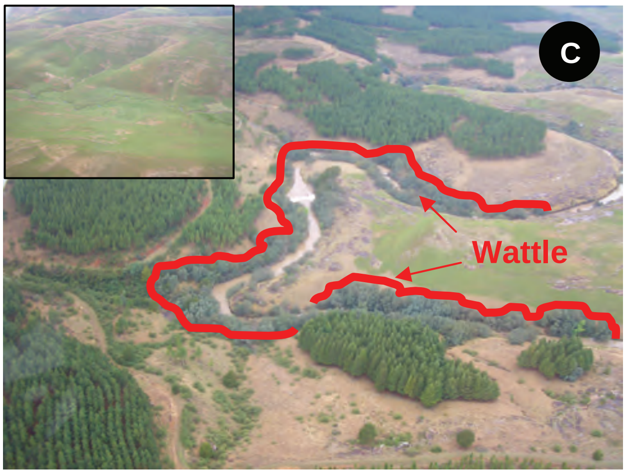



**Town Bush Stream**
Geomorph Zone: Upper foothills

Gums planted through riparian zone. Insert shows destabilisation of bank due to adjacent plantation and shading out of natural riparian zone species. Loss of these riparian zone species results in bank erosion and collapse.


**uMgeni**
Geomorph Zone: Upper foothills

Poplars have totally invaded and modified this bank. Natural riparian zone species have been outcompeted and bank structure has been significantly modified.




**Wildebees**
Geomorph Zone: Upper foothills

Extensive infestation of wattles along riparian zone is severely modifying the bank. Compare this to the same area (primarily grassland) with no weeds (see insert).


**Unnamed**
Geomorph Zone: Mountain stream

Commercial afforestation and poor weed control management have negatively impacted on the banks of this stream in the KwaZulu-Natal Midlands. Harvest debris in the stream further exacerbates bank instability.

# Physico-Chemical Changes


**Sikelekehleni**
Photo illustrates diesel and oil spillage in riparian zone associated with illegal sand mining operations.


**Little Amanzimtoti**
Tent washing is a common sight in riparian zones following weekend funerals and weddings.


**Mbokodweni**
Hippo grass infested riparian and instream zones due to nutrient enriched water.


**Umbilo**
Sewage works discharge has resulted in abundant nutrients and a flourishing alien weed community.


**Likasi**
Acid mine drainage and excessive sedimentation have killed riparian tree species.


**Likasi**
Artisanal mining and working of riparian sediments have changed the physical structure of the bank.

**RIPARIAN**

**2. Bank Structure Modification**

## Erosion

Rating 0-1


**Wildebees**
Geomorph Zone: Upper foothills

Bedrock and boulder dominated riparian zone with very little erosion. Forestry is not in the riparian zone and does not impact on the instream habitat.


**Drakensberg stream**
Geomorph Zone: Source

Source zone/seep wetland with extensive wetland vegetation along riparian zone and no erosion.


**Unknown**
Geomorph Zone: Upland flood plain

Unmodified meandering stream.


**Eerste**
Geomorph Zone: Mountain stream

Healthy riparian vegetation stabilising riparian banks and no signs of erosion.

**RIPARIAN**

**2. Bank Structure Modification**

## Erosion

Rating 2-3


**Mhlatuzi**
Geomorph Zone: Lower foothills

Extensive erosion of both left and right bank along long reaches of river. Livestock pressure has caused instream and riparian modification.


**Pot**
Geomorph Zone: Upper foothills

Moderate erosion of banks with sedges stabilising areas.


**Usutu**
Geomorph Zone: Lower foothills

Localised erosion at river crossing due to artisanal sand mining. Banks outside of impact zone in fair condition.


**Wildebees**
Geomorph Zone: Upper foothills

Moderate bank erosion due to human settlement activities and artisanal small-scale sand mining along the far bank.

RIPARIAN

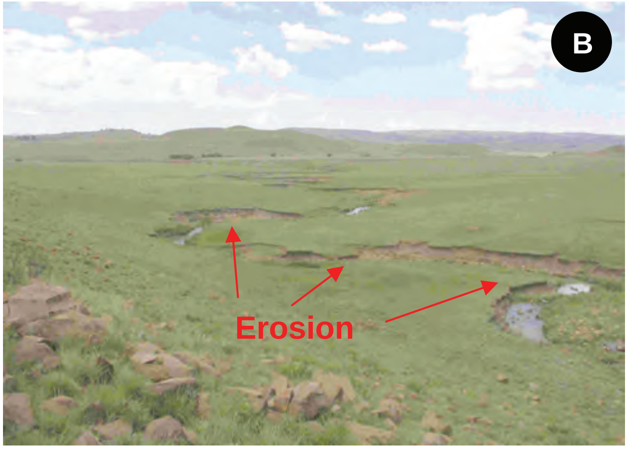
## 2. Bank Structure Modification

**Erosion**

Rating 4-5


**Unknown**
Geomorph Zone: Lower foothills

Alien trees and livestock hoof impact have caused large-scale bank erosion and sedimentation of channel.




**Unnamed stream** (in Bergville area)
Geomorph Zone: Upland flood plain

Extensive erosion of both left and right banks.


**Ingwavuma**
Geomorph Zone: Lower foothills

Livestock pressure has contributed to extensive slumping and bank erosion.


**Mzimvubu**
Geomorph Zone: Lower foothills

Both banks severely compromised by livestock hoof action and overgrazing. Exotic willows exacerbate this impact through shading out of natural riparian zone species.

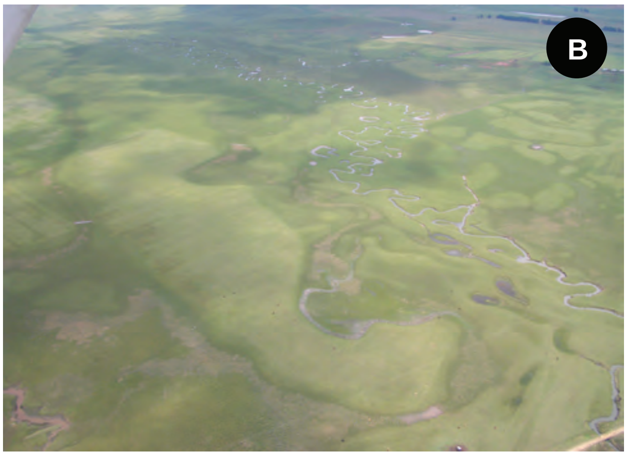
## Channel Straightening

Rating 0-1

A

**Unknown**
Geomorph Zone: Upland flood plain

Naturally meandering section of river with no channel modification.



B

**NECF Sephton Wetland**
Geomorph Zone: Upland flood plain

Naturally meandering stream through Sephton wetland showing little channel modification.


C

**Berg**
Geomorph Zone: Lower foothills

Natural sinuosity of this river has been modified to accommodate cultivation along river flood plains. Encroachment by orchards is evident.

D

**Tributary of Mooi River** (N.E. Cape)
Geomorph Zone: Upper foothills

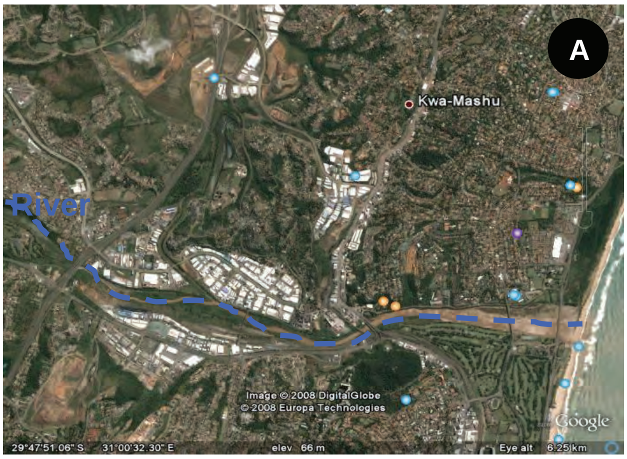
Road works contribute to very localised channel modification, hence a low rating.

**RIPARIAN**

**2. Bank Structure Modification**

# Channel Straightening

Rating 2-3




**Lower uMgeni**
Geomorph Zone: Lowland river

Previously a broadly meandering river, the uMgeni is now confined and straightened by development on the Springfield Flats (previously the flood plain).


**uMhlangane**
Geomorph Zone: Lowland river

Canalisation of this river has reduced natural sinuosity of this river. This is localised to accommodate local industrial development, hence the moderate rating.


**Mkhondvo**
Geomorph Zone: Lower foothills

High sediment loads and deposition interfere with natural braiding and sinuosity of this river.


**Isipingo Canal**
Geomorph Zone: Lowland river

Canalisation to drain lowland floodplain for industrial development, alien weeds and mechanical clearance of canal has interfered with natural channel sinuosity.

# Channel Straightening

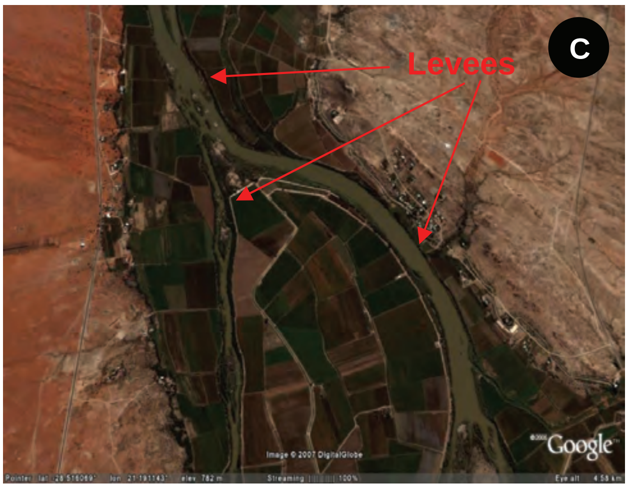
Rating 4-5


**Town Bush Stream**
Geomorph Zone: Lower foothills

Extensive channel realignment to accommodate new shopping complex.


**Umlaas Canal**
Geomorph Zone: Lowland river

Meandering flood plain transformed by concrete canal diverting entire river flow away from natural coastal flood plain wetlands into the sea.




**Lower Orange**
Geomorph Zone: Lowland river

Levees and agriculture within the riparian zone have confined the natural channel significantly, modifying the banks and reducing channel sinuosity.

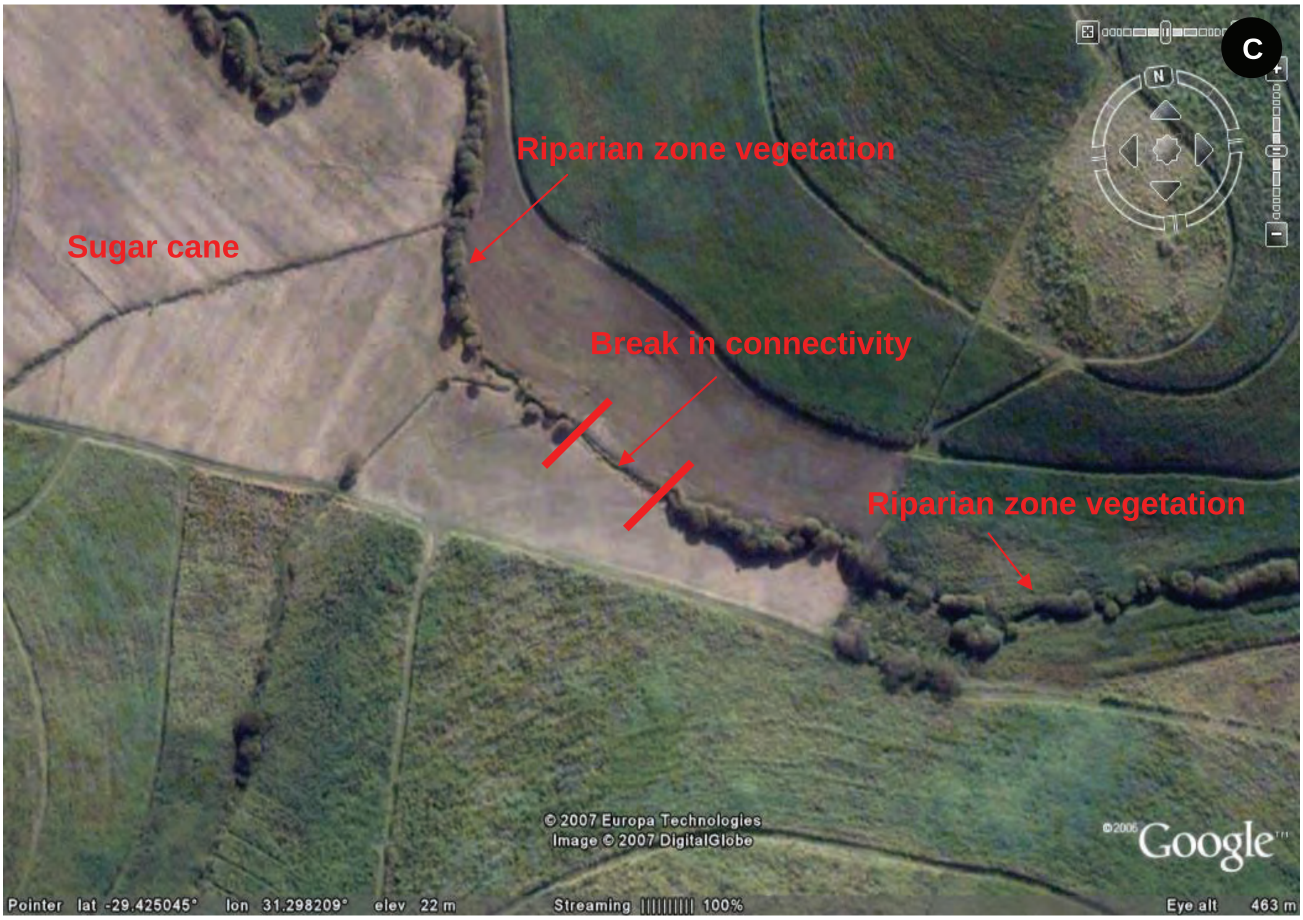

**Duzi**
Geomorph Zone: Lower foothills

Urban development has significantly modified the riparian bank and channel sinuosity as the river passes through the city. This is particularly visible in the canalised central section.

# Longitudinal

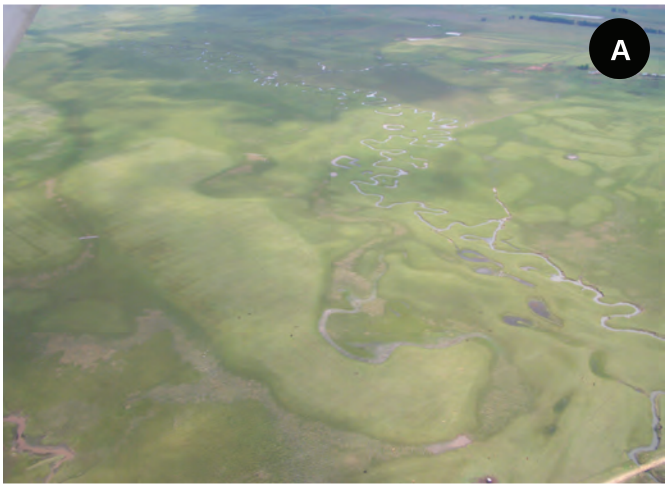
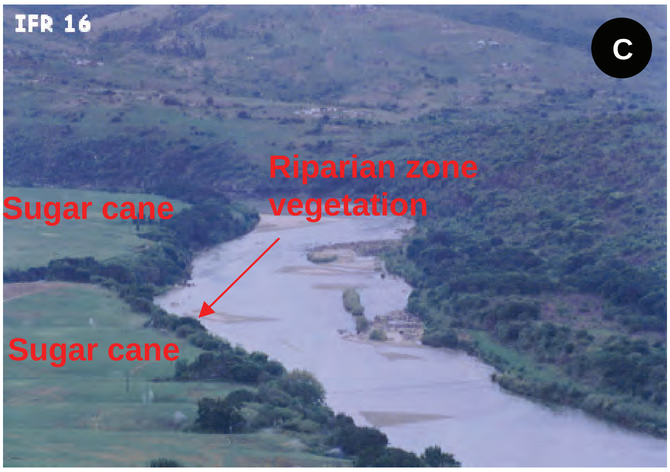

**Berg**
Cultivation in riparian zone has interfered with longitudinal connectivity.


**Tongaat**
South bank shows good connectivity of the riparian zone. The north bank connectivity has been broken by agriculture in the riparian zone.




KwaZulu-Natal coastal river through sugar cane fields showing breaks in riparian zone connectivity due to cultivation to the edge of the stream.

# Lateral

| | |
|---|---|
|  |  |
| **NECF Sephton wetland**<br>Natural grasslands and no alien weeds and lack of cultivation allowing for flux of all riparian zone elements enabling full lateral connectivity in the riparian zone. | **NECF Sephton wetland**<br>Extensive connectivity modification by wattle invasion in this lower area of the NECF Sephton wetland. |
| <br> | <br> |
| **Thukela**<br>Cultivation along the riparian zone has significantly altered the lateral connectivity between the river and the riparian zone. Sugar cane on the flood plains and left bank have reduced the width of this riparian zone and isolated it from the natural flood plains. | **Berg**<br>Parklands have been established on the west bank with grass planted to the water's edge, as opposed to the more natural riparian zone vegetation on the east bank. |