A SURVEY OF MACROINVERTEBRATE DIVERSITY OF ELEVEN RIVERS IN AND AROUND THE TSITSIKAMMA NATIONAL PARK, EASTERN CAPE, SOUTH AFRICA

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EXECUTIVE SUMMARY

In August and December 2000 researchers from the Albany Museum undertook surveys of the aquatic macroinvertebrates of the Salt River, Nature's Valley (Barber-James 2000, de Moor and Barber-James 2001). The aim of these surveys was to investigate whether special conservation measures were needed to protect any rare or endemic species, following a request to introduce trout (for recreational fishing) into this river. Although the Salt River naturally has no freshwater fish (Bok 2000, 2001) the macroinvertebrate fauna collected proved to be so special, recording 13 undescribed species as well as three possibly undescribed genera, that a permit for introducing this alien fish into the Salt River was denied.

In April 2004 Nature's Valley Trust requested a follow-up survey of the macroinvertebrates of the Salt River to obtain a more complete coverage of species throughout the annual cycle. A second reason was to assess whether changes in the macroinvertebrate communities had occurred since the 2000 surveys, because of several developments that had taken place in the catchment and along the riparian zone during the interim period. Of particular concern was the possible impact of a devastating silt discharge down the river that occurred late in 2002, following land clearing operations for the development of a polo-field.

The findings of that study revealed a further three undescribed species. The sediment discharge was found to have had no discernable long-term impact on the macroinvertebrate community structure and it was concluded that the fauna of the Salt River can, in time, recover from very infrequent massive sedimentation events (de Moor et al 2004, de Moor 2007). Continuous and regular inputs of sediment would, however, result in significant deterioration of the conservation status of the Salt River. Further concerns regarding water quality deterioration were however raised during this study. The most serious threat to the continued existence of the rich macroinvertebrate communities was excessive water abstraction. Reduced flow volumes can result in a multitude of detrimental impacts (such as pH changes, eutrophication, and temperature increases) due to reduced dilution effects. The high number of unidentifiable species and the diversity and abundance of certain rare species, led to recommendations that the Salt River should be given special conservation status. The following recommendations were also made: that no introduction(s) of fish (of any species) should be allowed in the system; that alien fish in surrounding farm dams in the catchment be eradicated, and that surveys of all the rivers in the southern Cape should be carried out to assess the status of indigenous and endemic fish and invertebrate fauna in these rivers in order to evaluate their conservation importance. It was also suggested that special measures be taken to preserve the Salt River, and its tributary the Wit River, as an aquatic insect sanctuary

or nature reserve. Educational posters depicting some of the research findings were produced and are on display along the main Garden Route Road, and along the beach, at Nature's Valley.

As an outcome of the above reports and their recommendations, a two-year study of eleven selected rivers in the Tsitsikamma Mountains was proposed. This was undertaken by a team of researchers from the Albany Museum, Rhodes University, Stellenbosch University and the Department of Water Affairs and Forestry (DWAF = DWAE). These researchers were also assisted by rangers from SANParks in the field between January 2008 and February 2010.

The selection of 20 sampling sites, covering upper and lower reaches of river in each catchment, on eleven selected rivers was undertaken during two visits between 7-18 January and 10-13 February 2008. Assessing the accessibility of these sites was an important aspect, in order to determine future easy access for DWAF teams that will be involved in continued monitoring of water quality. The aim of the surveys was also to collect macroinvertebrates from as wide a variety of aquatic biotopes as possible, in order to cover the greatest possible diversity of species at each river site.

During four routine seasonal surveys March-April, July and October 2008 and January 2009 all sites were visited and surveyed for aquatic invertebrates. An upper catchment collecting survey along several rivers was also conducted in March 2009 as well as a survey in February 2010, when data loggers were retrieved.

The physicochemical data gathered at each site encompassed the following parameters: temperature, pH, electrical conductivity (EC), Dissolved Oxygen, Turbidity and Total Dissolved Solids (TDS). Thermocron i-button data loggers were set to record water temperatures at two-hourly intervals for a year. Water samples for nutrients and heavy metals were also collected for laboratory analysis. Data on detailed river conditions — encompassing slope, flow, surrounding marginal vegetation, and other aspects — were acquired or recorded as digital photographs. Aquatic macroinvertebrates were collected from rivers using a number of different techniques and collecting methods, and adult flying insects were collected with hand nets or light traps set overnight. All collected material has been stored and curated in the Albany Museum, Grahamstown or Stellenbosch University Insect collection. Material is stored under the Tsitsikamma Rivers catalogue (TSR).

Water quality assessment conducted by the DWAF team, using SASS5 and water chemistry results, revealed that the Upper and Lower Buffels, Matjies, Lower Elands and Lower Groot Rivers were all impacted and showed consistent deterioration in water quality. The quality of the Lower Salt River ranged between 'natural' and 'borderline deterioration'. Water chemistry analysis also revealed that the Buffels/Matjies River system was different to all the other rivers and that the Salt River had one occurrence of very elevated nutrient levels, most likely due to anthropogenic disturbance. The pH of the Buffels/Matjies River system was consistently above 7.0, indicating a higher concentration of OH^- ions when compared to other rivers in the study area in which pH was consistently <7.0. Elevated levels of pH >6.0 were also notable for the Lower Salt River, Lower Groot River East and Lower Elands River on all sampling occasions and the Lower Groot River West on one occasion in winter. This is an issue of concern and indicates changes beyond the natural pH ranges in these rivers.

From 616 samples collected during the survey of 20 river sites, the following taxa (from five orders of aquatic insects and the dipteran family, Simuliidae) were recorded:

- Ephemeroptera: 8,683 individuals; 20 species
- Odonata: 1,221 individuals; 31 species
- Plecoptera: 1,968 individuals; 5 species
- Megaloptera: 219 individuals; 2 species
- Trichoptera: 42,683 adults; 6,741 larvae; 48 species
- Simuliidae 9,886 larvae & pupae; 10 species.

Further analysis revealed that this collection incorporated four undescribed genera and 33 undescribed species. There were clear distinctions (characterized by species composition) between certain rivers as well as between upper and lower zones of rivers. The rivers were characterized by high numbers of taxa, and large populations of regionally-endemic species.

In summary, of the 20 Ephemeroptera species recorded in the 2008-2009 survey, only *Bugillesia* sp. and *Nigrobaetis* sp. are new undescribed species that can be added to the list of Ephemeroptera previously recorded from the Salt River. During earlier Salt River surveys, 21 species of Ephemeroptera were recorded, which included four species (*Afronurus barnardi*, *Adenophlebia peringueyella*, *Aprionyx pellucidus* and *Barnardara* sp.) that were not recorded from any of the other rivers flowing off the Tsitsikamma mountains. Following the 2008-2009 survey, the total number of new undescribed species of Ephemeroptera for the region now stands at one or two new genera and nine species.

During the 2008-2009 surveys, all the species of Notonemouridae, that had been recorded during the 2000-2004 surveys, were again recorded and only the differentiation of the forms ‘S’ and ‘P’ of *Aphanicerca capensis* were recognised as different species. All these Plecoptera, except for the one form of *Aphanicerca capensis,* have been recorded from the Salt River.

Two species of Megaloptera in the genus *Platychauliodes* were recognised during the 2008-2009 survey. *Chloroniella peringueyi* was previously recorded from the Salt River but not in the recent survey.

In the Trichoptera, 29 species (from 18 genera in 11 families) were previously recorded in the Salt River of which 17 species were recognized as SW Cape endemic species (de Moor 2007). Of these species, one genus and 11 species were recognized as undescribed after the 2004 survey of the Salt River. The recent 2008-2009 surveys produced a further 19 species not previously recorded from the Salt River. Of these, seven are new undescribed species and an additional two species of *Oecetis* (in which only females were collected) could also be undescribed species. In summary: of the 48 species of Trichoptera recorded during the 2008-2009 survey, 20 species were not recorded from the Salt River. In addition, one genus and 11 undescribed species have not been recorded in the Salt River but have (so far) been found in some other rivers of the Tsitsikamma region. There is also one new genus and species in the family Dipseudopsidae that has only been recorded in the Salt River. Numbers of new, unique and undescribed Trichoptera species within the surveyed Tsitsikamma Rivers (i.e. the Salt River and 10 other rivers) can be summarized as follows:

- Upper Salt River: compared to the other 10 rivers, this river produced the highest number (i.e. nine) of undescribed Trichoptera species.
- The Upper Bobbejaans and Lower Storms River each produced seven of the undescribed new species and each of these rivers also recorded one unique new species.
- The Lottering River produced six of the new species but none of these was unique.
- The Elandsbos River produced six of the undescribed species of which one was unique.
- The Lower Buffels, Lower Groot West, Upper Bloukrans, Upper Storms, Upper Elands and Upper Groot East Rivers each produced four of the undescribed species.
- In addition, the Lower Buffels, Upper Storms and Lower Groot East Rivers each contributed a unique new species.

To sum up: the total number of new undescribed species of Trichoptera for the region surveyed now stands at two new genera and 20 species.

For the Diptera (Simuliidae) the surveys between 2000-2004 recorded five species for the Salt River, which comprised five known species and one unknown species for which larvae and pupae could not be placed. In the survey of the 11 rivers carried out in 2008-2009 ten species were collected, including the larvae of what appears to be a second undescribed species. All species collected previously, except for *Simulium dentulosum* and the one considered to be a new species, were again recorded from the Salt River in 2008-2009. In addition *Simulium rutherfoordi* and *S. impukane* were also recorded. It is thus possible that there are now two undescribed species of *Simulium* from the region: one from the Salt River, and one from the Upper Groot River West and Lower Bloukrans River.

Taking the Trichoptera as an example to illustrate the regional and National diversity of aquatic macroinvertebrates in southern Africa, the following figures can be calculated. Out of an estimated 222 species of Trichoptera in southern Africa, 85 species were listed (de Moor and Scott, 2004) from the SW and southern Cape hydrobiological region (which is designated as 'Region A' by Harrison, 1959). With the addition of data from this and other surveys, this has now been increased to an estimated 123 species of Trichoptera from Region A.

The rivers flowing into the sea off the Tsitsikamma mountains form a small subregion within Harrison's hydrobiological Region A (Figure 8) and this is designated as the southern Cape 'Region K' (as classified by DWAF). There are currently 51 species of Trichoptera recorded in this region, indicating that 41.5% of Harrisons Region A Trichoptera species are represented here. When examined from a South African perspective, this clearly shows that Region A contributes the largest diversity of Trichoptera in South Africa with 73.2% of the species being endemic to the region.

When selecting rivers for special conservation attention it should be noted that the upper river sites group together in the majority of the ordination analysis and therefore can be considered as a separate group in terms of conservation selection. The rivers in which primary fish species have not been recorded (neither indigenous nor exotic aliens) are also unique and it is no coincidence that that all three of these rivers (Salt, Bobbejaans and Lottering Rivers) have been identified as being of high conservation importance. The Bobbejaans River recorded the highest diversity of species and the Upper Salt River contains the highest number of new undescribed species. The Lottering River recorded high numbers of some of the new undescribed species. It is during times of stress, such as droughts, that such rivers can maintain sufficiently large populations of these endemic species in small areas without the additional pressure of predation by fish. Via the adult phases of the life cycles, these species can then recolonise adjacent streams along the upper catchments and via forest corridors.

The Bobbejaans River is the single river that stands out as producing the greatest diversity of Trichoptera (25 species), including one unique new species and seven of the undescribed species recorded. With previous survey records included, the Salt River records two unique species and is the river with the highest number (totaling nine) of the undescribed species. The most recent surveys on the Salt River record 16 Trichoptera species. The Lottering and Elandsbos Rivers record 19 and 17 species of Trichoptera, respectively, including one unique species and each of these rivers also recorded five undescribed species. Ephemeroptera also attained their highest number — 11 species, including one unique species and six undescribed species — from the Salt River. The Elandsbos River also produced 11 species with four of these belonging to undescribed species that had also been recorded from the Salt River. The Salt River also records all species of Teloganodidae found in the region. Thus, in terms of the conservation of Ephemeroptera, this is the most important river.

The major threats to the conservation and health of all these rivers are:

a. Reduction in flow due to water abstraction for various purposes. Reduced runoff yield — as a result of increased biomass of alien vegetation that has invaded the riparian zone — will also cause a reduction in flow volume.

b. Increase in water temperature due to reduced flow volume and global warming. (The indigenous biota is adapted to cool summer water temperatures).

c. Decline of water quality (increase in pH and nutrient loads in rivers), resulting from discharge of treated sewerage and industrial wastes as point sources of pollution and diffuse runoff of waste matter from various developments along the riparian zone of the rivers.

d. Invasion of alien fish into the rivers and the introduction of either alien or 'indigenous' fish into the fishless rivers. (Note: even though fish from the Tsitsikamma region may be colloquially termed 'indigenous', such species would not be indigenous to the fishless rivers described here).

e. Sedimentation in rivers due to clear felling of plantation forests, land clearing, road building and other anthropogenic developments.

f. Possible poisoning of the rivers by pesticides, herbicides and cattle dips.

RECCOMMENDATIONS FOR CONSERVATION AND MANAGEMENT

- To conserve CFK functional ecosystems, there is a need to focus on conservation of important keystone species, not only rare or new species. These need to be identified and evaluated.

- The status of all the new undescribed species needs to be ascertained, and until known their environment needs to be protected.

- A detailed conservation planning exercise needs to be undertaken: to ensure that representation and persistence of biodiversity are addressed (Nel et al. 2010 in press) and to identify rivers that would fulfill such requirements. This would involve a workshop with various researchers and affected parties. GIS planning would form a fundamental component of this exercise.

- For developing a conservation plan for the Tsitsikamma Mountain's rivers a combination of the Biodiversity Act, National Environmental Management Act, Spatial Development Framework and Water Act should be invoked to motivate a request for higher flow levels in the selected rivers. For the Salt

River, a water management plan for the whole catchment and a full reserve determination and biodiversity provisions should be considered.

- Conservation of the lower zones of rivers to remain ecologically functional as complete representatives of CFK Rivers is important.

- To allow connectivity of the upper, middle and lower reaches of rivers a 30-50m wide protected corridor of indigenous riparian vegetation should be established along all rivers, where possible.

- To allow connectivity between the upper catchments of rivers, indigenous forest and fynbos should be preserved so that natural intercatchment migration of flying insects is enhanced.

- Annual routine surveys should be undertaken to monitor the diversity of aquatic insects and to assess changes. This is important if remedial action needs to be taken in order to maintain viable populations of indigenous and CFK endemic species in all reaches of rivers selected for conservation.

- Monitoring of water quality and flow using SASS5 and water chemistry parameters such as pH and nutrients as well as flow gauges where they are installed. This will be addressed by DWAE but information needs to be requested so that action can be taken if things go wrong.

- Limit the amount of water abstraction to ensure maintenance of cool temperature, low pH and low nutrient levels in the rivers.

- Monitor land management to prevent increased siltation and pollution of the rivers. . Investigations into irrigation methods that can be used to minimise nutrient runoff (for example, that proposed by Schuman 2004 in de Moor et al. 2004 should also be considered).

- Ensure that the rivers with no freshwater fish are maintained as fishless rivers as they serve as sources of indigenous CFK macroinvertebrates.

- Prohibition of 'clear felling' of vegetation. If land must be cleared then this should be done in an ecologically sensitive manner and mitigating actions, such as the construction of berms, as recommended in Allanson (2002), be taken to ensure against excessive runoff of sediments into rivers.

- Select a number of species that can be used as indicators of conditions favourable to CFK freshwater endemics. These species should be fairly common.

- Test the tolerance of selected species to increased levels of sediments, nutrients, pH and water temperature both in the laboratory and in the field under natural conditions. Some of this research is already being undertaken by Dr M Picker and students from UCT.

- Determine the habitat requirements of all life-cycle stages of selected keystone species to ensure informed conservation management of the riverine ecosystem.

A possible list of suitable species to use for further studies to ascertain the tolerance limits of the adapted CFK macroinvertebrates has been drawn up in the report.

The research is written up for an MSc thesis by Mr Terence Bellingan and is also drafted as a number of scientific papers. It is presented here as a special report for SANParks, WWF, Nature’s Valley Trust and Cape Nature who are the funding bodies of this research.

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1. GENERAL INTRODUCTION

1.1 Introduction

Between August 2000 and April 2004 three surveys on the diversity and uniqueness of the macroinvertebrates of the Salt (Sout) River and its tributaries in the southern Cape were undertaken by staff from the Department of Freshwater Invertebrates, Makana Biodiversity Centre of the Albany Museum, Grahamstown. Initially, surveys were undertaken to assess the potential impacts that a proposed introduction of brown Trout (S*almo trutta*) would have on the river's invertebrate community, and also to determine whether the invertebrates to be found were of any particular conservation value. The Department of Nature Conservation, Western Cape, required this information, along with other studies such as a survey for indigenous fish species (Bok 2000), to determine whether to grant a permit for stocking non-breeding trout into the Salt River.

The findings of the first two surveys (Barber-James 2000, de Moor & Barber-James 2001) indicated that the Salt River contains a rich diversity of aquatic insect species. In the four orders of insects that were examined in detail (Plecoptera, Ephemeroptera, Trichoptera and Diptera (Chironomidae and Simuliidae) there were 13 undescribed species as well as three potentially new genera, and some remarkable range extensions of certain species. The river also produced the richest recorded diversity of species in the mayfly family Teloganodidae for Africa.

Surveys of fish of the Salt River (Bok 2000, 2001) indicated that there were no primary freshwater species in this river or its major tributary, the Wit River. It was considered that the absence of any primary freshwater fish in the Salt River and its tributaries plays a major role in this river having such a unique and diverse aquatic insect fauna. It was also notable that species composition upstream and downstream of the interbasin diversion canal-weir was different. The density of invertebrates was considerably higher but diversity was lower in reaches of the Salt River downstream of the canal weir, indicating that nutrient concentrations and productivity were higher. Upper reaches of the river had a greater diversity of invertebrate species, but their density was observed to be considerably lower.

A permit to stock non-breeding brown trout into the Salt River was denied, largely because of the potential impact of fish on the unique assemblage of aquatic macroinvertebrates in the river.

In 2004 the Natures Valley Trust (NVT) requested an autumn survey of the macroinvertebrates of the Salt River. The purpose of this survey was two-fold:

- To obtain a more complete coverage of macroinvertebrates species throughout the annual cycle.

- To assess whether any changes in the macroinvertebrate communities had occurred since the surveys conducted in 2000 as a result of several developments that had taken place in the catchment and along the riparian zone during the interim period. Of particular concern was the possible impact of a devastating silt discharge into the river late in 2002 that occurred following land clearing operations in the catchment.

The third report produced (de Moor et al 2004) also included an assessment of previous threats and newly-identified threats to the conservation status of this river.

The April 2004 survey collected further undescribed species and revealed that the reported sediment discharge of December 2002, while probably causing devastating immediate impacts, had no discernable long-term impact on the macroinvertebrate community structure and it was found that sediment-sensitive species were present in large numbers throughout the river. It is important to note that while the Salt River can in time recover from infrequent 'massive sedimentation events', a continuous increase in sedimentation or more frequent 'massive sedimentation events' could result in a significant deterioration in the conservation status of the river.

Of concern, however, was a slight increase in the pH of the river downstream of the diversion canal. The endemic invertebrate species are acidobiontic and require strong acid conditions to maintain healthy viable population levels. For this reason, the pH has been regularly monitored since the 2004 survey. Preventative measures also need to be taken to ensure against a further increase in nutrient loading as this could lead to eutrophication of this oligotrophic river, which would also detrimentally influence the endemic freshwater invertebrates. Water abstraction is probably the most serious threat to the status of the macroinvertebrate communities, as reduced flow volumes can result in a multitude of detrimental impacts and an exacerbation of many of the impacts (such as pH changes, eutrophication and temperature increases) mentioned above, due to reduced dilution effects. For this reason, data gathered in the 2004 study were geared towards providing information that could be used for determining the ecological reserve of the Salt River, information needed to properly evaluate appropriate protection measures required for a river of such high conservation importance. The National Environmental Management Act (NEMA) and the Biodiversity Act can be invoked to ensure that the conservation of endangered and vulnerable rivers and rare or endangered biota must be considered for any intended development or conservation action.

The aquatic invertebrate fauna of the southern and south-western Cape is unique when compared to the rest of Africa, being adapted to the cool, low nutrient, fast-flowing acidic waters typical of this region. The distribution of many of the species and genera found in these rivers is restricted to the southern and south-western Cape and such species are considered to be endemic to that region. The rivers of the southern Cape along the Tsitsikamma Mountains are all headwater streams, plunging straight from mountainous catchments to the sea without any of the slow, meandering lowland river and floodplain attributes characteristic of most other South African rivers. The high aquatic insect diversity of the Salt River, with many of the species belonging to families or genera endemic to the southern and western Cape Floristic region, can be partially attributed to the fact that there has been no major catastrophic event — such as glaciation, complete flooding by epicontinental seas, or total aridity — since the mid Cretaceous (over 100 million years ago). These cold, acidic waters house the remnant of the cold-adapted, temperate Gondwana fauna that was common to the southern land-mass during the Permian to the Jurassic periods, before the break up of Gondwana in the Cretaceous. The nearest extant relatives of these species are found in South America, Australia, Madagascar and India rather than in the rest of Africa. Climatic events and geological formations have resulted in a high degree of endemism in species, genera and families of invertebrates found in this region.

The aquatic invertebrates of the Salt River show a high degree of ecological specialisation due to the low nutrient concentration and absence of fish, as evidenced by the active behaviour of larvae and nymphs moving around on top of boulders and bedrock in the river. These assemblages of macroinvertebrate species would be highly susceptible to predation by introduced alien or indigenous fish. The complete absence of primary freshwater fish therefore adds to the conservation importance of the Salt River. Where undisturbed communities of rare and unique invertebrates are found, they require protection from aquatic alien species and habitat degradation.

Clearly these studies identified the Salt River as a river worthy of special conservation attention and action and it was suggested that special measures should be taken to preserve the Salt and Wit Rivers as an aquatic insect sanctuary or nature reserve.

The question then arose as to how unique the invertebrate fauna of this small river was and whether other rivers within the southern Cape quaternary sub-catchment 'Region K' (as designated by DWAF) contained a similar invertebrate fauna. If this proved to be the case this would allow for a broader-based conservation plan to preserve the biota and ecological conditions in a selection of these rivers. Alternatively, if the rivers were to show sufficiently different components of invertebrate biota — and, in particular, limited distributions of populations of endemic species — then a more targeted form of conservation for individual rivers would be required.

One of the recommendations made in the 2004 report was that surveys of more rivers in the southern Cape should be carried out to evaluate the status of the indigenous and endemic invertebrates and also any fish fauna found or recorded in these rivers. The aquatic invertebrate biota found there should then also be compared with what is known about the fauna in the rest of the Cape Floral Kingdom. This would allow for informed conservation planning prioritising conservation efforts of rivers in order to ensure protection of the natural heritage and ecological processes needed to maintain the endemic biota in the rivers of this region.

The aquatic macroinvertebrates present in most of the rivers in the Tsitsikamma region have not previously been comprehensively surveyed. Hence there was a need to compare macroinvertebrate assemblages in rivers that contain indigenous freshwater fish and those that do not contain fish with such assemblages recorded from the Salt River (that does not contain fish). Furthermore, little is known about the environmental requirements of the macroinvertebrates in this region, particularly the large numbers of Cape endemic species recorded, and hence their potential vulnerability to current, proposed, or potential man-induced, environmental changes

A three-phased research programme has been proposed as follows:

Phase 1: Surveys of aquatic macroinvertebrates in 11 rivers comprising nine adjacent short coastal systems in the Tsitsikamma region, to enable spatial comparison of species assemblages to identify and prioritize rivers in terms of local, regional, and national conservation importance.

Phase 2: Environmental requirements of aquatic macroinvertebrates in a selected river or rivers, with particular emphasis on endemic biota.

Phase 3: Facilitate and promote effective conservation and wise management of rivers in the Tsitsikamma region by promoting stewardship and private ownership conservation initiatives, with particular emphasis on rivers of high conservation importance by virtue of their aquatic macroinvertebrate assemblages.

This report pertains only to Phase 1 of the project.

1.2 Aims of the present study

The principal aim of this study was to obtain a representative sample of aquatic macroinvertebrates from the 11 selected rivers during all four seasons of an annual cycle. This is of importance since many insects are seasonal and the adults of different species of aquatic insects emerge at different times of the year. The adult phase of the life cycle is needed for species identification in most instances. Since species assemblages of macroinvertebrates, and Trichoptera in particular, provide an indication of the conservation status of rivers (de Moor 1988, 1998, 1999, 2002; Dohet 2002), a study of aquatic macroinvertebrates, in conjunction with measurements of key physicochemical parameters, will give an indication of the impacts that developments in the catchments of the various rivers may have had on the river ecology.

1.3 Terms of Reference

The terms of reference, as outlined in the accepted project proposal of 20 February 2008 (submitted to the *Nature's Valley Trust* after taking comments from SAN Parks into account), are reproduced below:

1. Undertake field surveys to collect and identify representative samples of all macroinvertebrate groups in eleven rivers in the Tsitsikamma region (Matjies, Buffels, Salt, Bobbejaans, Groot (West), Bloukrans, Lottering, Elandsbos, Storms, Elands, Groot (East)) by means of sampling diverse aquatic biotopes as well as various forms of sampling (light trapping and netting) for flying insects to collect the aerial adult stages of the life cycle.

2. Surveys are to be carried out at a minimum of two sites per river (representative of the upper and lower reaches) incorporating all recognised biotopes characteristic of the river reach (for example, stones-in-current in both shaded canopy forested- and in open- reaches in runs and pools, emergent aquatic vegetation, backwater leaf-litter, course and fine sediments, wood snags, stones covered with moss or algae, small hygropetric seeps, and splash zones below waterfalls), with sampling undertaken quarterly in each biotope per site over a minimum period of one calendar year (i.e. four sample periods per annum, with all sites sampled per quarter), starting no later than Jan 2008. In the case of the Salt River, sampling sites should correspond as closely as possible to those of previous surveys. In the two cases where identified rivers are tributaries of a system (i.e. Matjies River and Buffels River in the "Matjies system"; Bobbejaans River and Groot River in the "Groot (West) system") there must be separate sites in the upper reaches of each tributary, though if appropriate, there need be only one site in (and representative of) the lower reaches which is common to both rivers provided that this is situated below the confluence of the two tributaries.

3. Collect aquatic physiochemical data (minimum = pH, dissolved oxygen, temperature, salinity, conductivity, suspended solids, turbidity) for each site during each sample period. Each sample site is also to be geo-referenced, photographed, and the aquatic and surrounding environment described (geophysical, land use etc.) in line with the SASS 5 methodology as described by Dickens & Graham (2002), for each visit. Standard meteorological conditions at the time of sampling also to be recorded. Water chemistry samples must be collected according to the standard DWAF national inorganic water chemical monitoring programme protocol, and submitted for analysis to Roodeplaat Dam.

4. Preserve and have accessioned in a recognized South African national museum or museums representative samples of all biota collected, in such a manner that the collection is available to specialists and other researchers for inspection.

5. Identify macroinvertebrates to lowest possible taxonomic level (species level where possible) depending on the availability of keys, descriptions and available expertise, with particular emphasis on the orders Ephemeroptera, Megaloptera, Trichoptera, Plecoptera, Diptera (Simuliidae) and Odonata. Informally describe (written description, including figured illustrations and photographs) any new taxa that are collected during this project, for use by other scientists and/or the Steering Committee for future communications and awareness-raising of the conservation importance of Tsitsikamma rivers. Record, identify and retain any fishes that may be collected during sampling.

6. In addition to the taxonomic descriptions described above in 5, score aquatic macroinvertebrates as per the SASS5 methodology as described by Dickens & Graham (2002), and make these results available to the national River Health Programme database.

7. Compare and discuss species assemblages of aquatic macroinvertebrates between the rivers surveyed as well as in a broader regional and national context, with particular reference to the taxa previously described only in the Salt River (cf. de Moor *et al.* 2004 - electronic copy available on request).

8. Present the final results at a South African hosted conference (for example, Fynbos Forum) during 2009.

9. Publish the final results, in coordination with the project Steering Committee, during 2009 in at least two popular weekly or daily media of wide readership and distribution in the region. Submission of paper/s to the peer reviewed literature is encouraged (including species descriptions), as is submission of any theses for higher degrees.

10. Submit a final report, which is to include at least: detailed description of methods and collection protocols; comprehensive lists of taxa collected per river; relative abundance data where appropriate; SASS evaluations; site descriptions; comparison of the physical conditions and water chemistry conditions at sampling sites across all sample sites (inter- and intra-river); comparison of the biota across all sample sites (inter- and intra-river) paying particular attention to new species previously described from the Salt River and endemic species; assessment of the significance of the rivers in relation to bio-

regional and national conservation targets and plans, with levels of endemism and species richness contrasted with other comparable rivers from the Cape Floristic Region; all of which is discussed in relation to relevant literature and knowledge.

11. Deliver all physical and electronic artefacts and final reports including raw data in hardcopy and electronic format to both Nature's Valley Trust and duplicates to SANParks Scientific Services (Rondevlei Office). Ownership of the data and any artefacts from the project remains vested jointly with all institutions represented on the project Steering Committee, known as the "Tsitsikamma Macroinvertebrate Steering Committee". Whenever referencing data or information from this project, people should acknowledge the funders and the programme partners. Should any co-financing be secured, the executants are obliged to inform the Steering Committee immediately.

12. Submit all reports in MS Word format, all databases in MS Access format, all spreadsheets and point spatial data in MS Excel format, and all other spatial data in shape file format which is ArcView compatible as well as in standards acceptable to SANBI B-GIS and the C.A.P.E. Freshwater Conservation Planning Group (if different from standards already described), unless otherwise agreed by the project Steering Committee. All of the above are to be submitted in digital form on CD / DVD and in hard copy. One bound and one unbound copy of the final report will be required.

13. Meet with and provide written report back to the Steering Committee on progress every six months, including a Project Inception Meeting. Meetings will be held in the area of study.

14. Avail themselves within reason to the Steering Committee or any executants of future phases of this program of research, who may need to use the knowledge or information from this consultancy in order to align, interpret or otherwise improve the outputs of that phase of work.

2. MATERIALS AND METHODS

2.1 Site descriptions

2.1.1 *Site selection*

Site selection was primarily based on accessibility and characteristics of the site. Accessibility was important for the following reasons: the SASS5 protocol, carried out by DWAF colleagues at each site for each sampling trip, involves the use of cumbersome equipment that does not permit long hikes or rugged terrain; it is the intention of DWAF to use the sites sampled during this study for continual assessment of river health and routine monitoring of water quality so convenience of access is imperative. In some instances safety was a concern, in which case an overnight stay at a site may be necessary, in order to reach the site as well as to carry out all of the required sampling methods. During the fire season this presents a tangible safety issue.

Characteristics of the sites relate to the terms of reference for this study, i.e. the sites should be 'representative of the river course'. For this reason, sites that were diverse and heterogeneous (in terms of biotopes) were chosen. In some instances compromises need to be made in order to include unique sites that pertain to particular conditions in the river. For example, in the Lower Groot River (East) a site was selected at a reach where the upstream river was impounded and the flow was highly modified (as described in 2.1.3 of this chapter). This kind of compromise had to be made despite the need to optimize the chances of collecting as many species of macroinvertebrate along a selected reach of the river as possible.

The process of site selection took place from the 7th to the 18th of January 2008 with a second trip being undertaken from the 10th to the 13th February. The first trip included visiting all but two of the sites that were included in the terms of reference, namely the upper reaches of the Groot and Bobbejaans Rivers. After a day hike, on 17th of January, into the mountains that included the catchment of the Upper Groot River, a decision was taken by the steering committee that it was not feasible to hike to these sites but rather that they should be reached by helicopter. The second visit during early February provided this opportunity and the sites to be sampled along these upper rivers were selected and deemed suitable, based on availability of safe and reusable landing sites.

2.1.2 ***Upper Groot River (East)*** (33º57'21"S, 23º38'19"E)

Introductory notes: This site is situated in the foothills of the Eastern Tsitsikamma Mountains, approximately 1.6 kilometers from their base where the river leaves the mountains, at an altitude 275m above sea level. Access is via an MTO forestry road that is used to service a water abstraction pipeline running parallel to the stream, approximately fifteen meters above the western bank.

River channel: The sampling site was approximately 18 meters in length. A chute of about a meter in height, at the upstream end, flows into a waist-deep pool (where the data logger was placed). This is followed by another chute leading to a wider, shallower riffle of approximately 5 meters in length and 3 meters wide that flows over bedrock into another waist-deep pool densely lined with Palmiet (Plates 1 & 2 respectively). Further downstream, conditions remained the same, with slow-flowing deep pools lined with homogenous Palmiet (*Prionum serratum*: Juncaceae). The bottom substrate consists of bedrock, small boulders, cobbles, stones and gravel (Plate 3). Flow rate at this site remained low throughout sampling; however, when site selection was taking place in January 2008, the river was higher than that measured at any other time when we visited the site (Plate 1).

Riparian vegetation: The river course at this site has very little canopy and the riparian vegetation primarily consists of Palmiet and other indigenous plant species. Twenty to thirty meters further up the banks, alien trees such as Eucalypts and Black Wattle are the dominant vegetation type. The Eastern bank, up to approximately 3 meters from the rivers' edge, is devoid of vegetation with the exception of moss, and is best described as a root bank (Plate 4). Palmiet was scoured from this area as a result of the flooding that occurred at the end of 2007, which left bedrock and root-bound soil exposed. The western bank at the site is covered with indigenous vegetation, consisting mostly of woody bush and a few ferns (Plate 5).

Plate 1: Upstream view of upper Groot River (East) sampling site showing the two chutes and the sampling area. Water flow is high and water colour humic. Photo: F. C. de Moor, 11 January 2008

Plate 2: Downstream view of the upper Groot River (East) sampling site. The stream narrows and is nearly overgrown by Palmiet before opening into a wider, pool that has isolated outcrops of bedrock breaking the surface. Photo: T. A. Bellingan, 2 July 2008

Plate 3: Upstream view of the upper Groot River (East) sampling site, showing the heterogeneous nature of substrate found in this section of the stream. The water colour was clearer when the water level was lower, with the converse occurring during increased water volumes; c.f. Plate 1. Photo: T. A. Bellingan, 16 January 2009

Plate 4: Eastern bank of upper Groot River (East) site, showing part of the exposed root bank where Palmiet was uprooted after the Dec 2007 floods. Photo: F. C. de Moor, 11 January 2008

Plate 5: A section of the western bank of the upper Groot (East) site; the vegetation is fairly dense but only shades the stream in the late afternoon. Photo: T. A. Bellingan, 16 January 2009

2.1.3 ***Lower Groot River (East)*** (34º02'05.1''S, 24º12'27.2''E)

Introductory notes: The site sampled on the Lower section of the Groot River lies approximately 6.5 kilometers from the river mouth, at an altitude of 14 meters above sea level, making it one of the lowest sites sampled during this study. This site is reached by MTO forestry roads, through several pine plantations. It is situated immediately downstream of a causeway crossing the river that is approximately 66 meters long and 6 meters wide. The length of river sampled lay along this causeway, as it provided the best biotopes for sampling.

River channel: At this point the river channel is approximately 60 meters wide and is almost entirely choked with Palmiet and exotic vegetation, leaving only relatively small sections flowing between, and underneath, the plants. The main flow is along the left side of the riverbed (Plate 6) and, after flowing under the causeway, flows parallel along it, across the river bed, and then downstream along the right hand bank (Plate 7). Some of the water escapes this route and flows underneath the Palmiet. This pattern is obviously dependant on the amount of water flowing in the river at the time, but was the case for each of the sampling surveys, with the exception of the survey in January 2009 when no water was flowing at all, leaving the data logger — that was placed under one of the pipes — exposed. As is characteristic of the lower reaches of these rivers, large pools are common, broken up by weirs and shallow riffles over cobbles, stones, gravel and sand. At times, a filamentous alga was also common at this site (Plate 8). The water colour was darkly stained by tannins and humic acid during each sampling event.

Riparian vegetation: Both upper banks of the Groot River at this site are characterized by pine forest. A short distance upstream and downstream of the causeway on the left hand bank there is a patch of indigenous forest that reaches down to the river's edge. This extends along the bank for approximately 200m before meeting another pine plantation. Associated with the pine forest, and vegetation choking the river bed itself, are alien invasive species such as black wattle, bugweed and kikuyu grass (Plate 6, 7).

Plate 6: An upstream view of the "main channel" of water flowing along the left bank of the lower Groot River (East). Note the abundant alien vegetation within the river course, resulting in the diversion of the water flow. Photo: T. A. Bellingan, 7 April 2008

Plate 7: Downstream view of the lower Groot River (East) flowing along the length of the causeway. Photo: F. C. de Moor, 10 January 2008

Plate 8: Filamentous algae is sometimes prevalent at the lower Groot River (East) site, and bottom substrate is clearly illustrated. A fair amount of wood debris is also present, and this provided an additional biotope that was sampled. Photo: T. A. Bellingan, 4 October 2009

2.1.4 ***Upper Elands River*** (33°58'17.60"S; 24° 3'51.10"E)

Introductory notes: After assessing the main course of the Elands River, it was decided that the area with reasonable access was too homogeneous and lacked the necessary biotopes to meet the requirements of this study. Instead, a tributary of the Elands River was sampled. As with the other sites, access is via MTO forestry roads through plantations and into the mountains over a poorly-maintained, and what appeared to be a rarely-used, upper catchment access road. The altitude of this site was recorded as 313 meters above sea level, making it the second highest site sampled. The tributary drains underneath the access road, through a makeshift causeway, making it very convenient for sampling.

River channel: The area sampled began upstream of a deep pool below a waterfall of roughly 3 meters in height; biotopes included splash and hygropetric zones as well as "potholes" in the bedrock filled with stones. The pool, of approximately 8 meters in length and 5 metres in breadth, provided small amounts of marginal vegetation and stones out of current (Plate 9). Below the pool the stream forms a run over some bedrock that weaves between boulders, and over cobbles and stones, with small amounts of gravel and some coarse sand (Plate 10). The total length of the sampling site along the river was approximately 21 meters.

Riparian vegetation: This site was unique in that the left bank was completely overgrown with alien *Eucalyptus* trees while the right bank seemed to be pristine indigenous forest. Both vegetation "types" extended down to the banks of the stream (Plate 11). The site is shaded for most of the day with only patches of sunlight reaching the stream bed. This is due to the canopy formed by mature gum trees. Furthermore, the exotic vegetation has a negative effect on the system due to plant debris falling into the river. This material is not broken down naturally and thus chokes river flow and possibly alters water chemistry as well.

Plate 9: Upstream view of the pool below the waterfall along the upper tributary of the upper Elands River, which was sampled. Photo: T. A. Bellingan, 4 October 2008

Plate 10: Downstream view of the upper Elands River site showing the pool below the waterfall. Photo: T. A. Bellingan, 16 January 2009

Plate 11: Upstream view of the riparian vegetation, with emphasis on the left bank (on right of picture). Note the lack of undergrowth and the amount of dead plant matter accumulating on the soil compared to that of the right bank. Photo: T. A. Bellingan, 16 January 2009

2.1.5 *Lower Elands River* (34° 1'2.80"S; 24° 3'39.10"E)

Introductory notes: The Elands River is reached via the Robbehoek MTO forestry road, through a large tract of indigenous forest followed by immature pine plantation. This site is situated within a comparatively deep valley at the end of a forestry cul-de-sac. Care must be taken in getting to this site as the steep slopes can prove treacherous, especially when wet. The altitude at this site is 56 meters above sea level and approximately 6 kilometers from the river mouth.

River channel: We were fortunate to be able to sample from a riffle flowing over some bedrock, small boulders, cobbles and stones that provided “in current” biotopes (Plate 12). The Elands River along this section is characterized by large, deep pools (8-12 meters wide and in excess of 30 meters long) alongside steep cliffs (Plate 13). These pools were lined with marginal vegetation, due to Palmiet being plentiful, and “out of current” biotopes (Plate 14). Beyond this, the site was almost devoid of useful riverine sampling biotopes. The sampling site incorporated a stretch of river of approximately 12 meters long.

Riparian vegetation: The steep banks along this reach of the Elands River are lined with indigenous forest, up until the tops of the steep valley. Along the left bank, the natural vegetation only extends up to the edge of the river valley, after which pine forest plantation ensues. The river valley is wide enough to prevent complete shading by the forest canopy; however, due to its deep incision, only few hours of direct sunlight reach the river below.

Plate 12: The riffle sampled along the lower reaches of the Elands River. Photo: T. A. Bellingan, 4 October 2008

Plate 13: Downstream view of the lower Elands River showing the large slow-flowing pool, steep banks and forest along the river margin. Photo: F. C.de Moor, 14 January 2008

Plate 14: Upstream view of the Elands River (lower site) showing a small chute below a large forest- and Palmiet-lined pool. Water colour can also be seen to be comparatively clear, for a lower site. Photo: T. A. Bellingan, 4 October 2008

2.1.6 *Upper Storms River* (33°56'57.20"S; 23°54'55.00"E)

Introductory notes: This site lies on a tributary of the main river, as was the case for the Elands River site. The site is situated within a tract of indigenous forest, called Sleepkloof, along the Tsitsikamma Hiking trail, not far from an overnight rest hut. It is reached via a SANParks road that is used to service the hiking trail hut. It lies at an altitude of 285 meters above sea level. The main river is less than 1 kilometer along the tributary's course from the area that we sampled. Although the main river appears to be accessible from this point, sampling was not possible due to the presence of waterfalls and other steep areas, which blocked access (Plate 15).

River channel: The tributary is a small stream that was reduced to little more than a trickle during the dry period that coincided with summer sampling in January of 2009. The stream weaves in between boulders and over bedrock, which makes up a large proportion of the stream bed; small riffles over sand and stones are also present (Plate 16). Because of the rocky nature of the stream bed, very little true marginal vegetation biotope was present at this site. A large, three-tiered waterfall is found at the lower end of the sampling site, providing hygropetric and splash zones as well a pool at its base with "out of current" biotope (Plate 17). The pool was approximately 3 meters long, 5 meters wide and 1.5 meters deep. This site is complex in nature, as the stream is slow flowing, with much vegetation and small seeps, providing good, stable habitat for insects. The entire sampling site, including the waterfall, was roughly 25 meters in length.

Riparian vegetation: As mentioned above, the site lies within indigenous forest and is completely surrounded by dense natural vegetation with no alien plant species recorded. A canopy completely covers this site, shading it throughout the day. The stream banks are made up of root mats, moss and leaf litter: ideal forest aquatic biotopes.

Plate 15: Upper Storms River site: pools below the waterfall, which is approximately 10 meters in height.The dense vegetation surrounding the the stream, and sometmes growing from within the river bed, can be seen. Photo: T. A.Bellingan, 19 January 2008

Plate 16: Upstream view of part of the area sampled along the upper Storms River; the water is clear at this site as with most of the other upper sites. Photo: F. C. de Moor, 14 January 2008

Plate 17: Upper Storms River: upstream view above the waterfall showing the bedrock and moss in current biotopes. Photo: F. C. de Moor, 14 January 2008

2.1.7 *Lower Storms River* (33°59'19.20"S; 23°55'8.60"E)

Introductory notes: This site lies at an altitude of 65 meters above sea level and, as it winds, is situated approximately 4.8 kilometers from the river mouth. It is conveniently placed in the vicinity of the low water bridge that crosses the Storms River. Sampling took place both below the bridge and a few hundred meters above it.

River channel: The river bed at this site is approximately 27 meters wide, making it the widest of rivers sampled in this study. The river winds through vegetation growing in the riverbed, until it is dammed up by the bridge (Plate 18). As sampling was carried out during the year, it was noted that this area became inundated with filamentous algae. The concrete structure of the bridge added several advantages to the site: a place to conceal the data logger safely; a place for the collection of adult insects as they seek refuge under its shaded parts; "bedrock in current biotope" is provided by the concrete foundation, with moss anchored to it. Further below the bridge, deeper riffles over large stones are found as well as marginal vegetation biotopes, due to the abundance of Palmiet (Plate 19). Upstream of the bridge is a deep, large pool, of roughly 30 meters long and 12 meters wide (Plate 19) and beyond this is a shallow riffle over rounded cobbles, perfect for sampling the stones- in-current biotope (Plate 20). From the riffle, sampled upstream of the bridge to downstream of the bridge, the overall length of the sampling site is approximately 80 meters

Plate 18: An upstream view from the bridge along the lower Storms River showing the damming effect of the bridge and the "islands of vegetation". Photo: T. A. Bellingan, 3 October 2008

Riparian vegetation: As mentioned above, there is an abundance of Palmiet lining the streams, as well as other woody vegetation and grasses growing in the riverbed forming "islands" of vegetation (Plate 20). The majority of vegetation surrounding this site is indigenous forest, coming down all the way to the river's edge on the cliff-like left bank, above and below the bridge. On the right bank downstream of the bridge, the same pattern of vegetation is seen, being forested up to the river bank. Upstream of the bridge, the road winds along the river bank up and out of the river valley resulting in a slight modification of the vegetation as a result of the change is soil composition with the construction of the road.

Plate 19: Downstream view from the bridge along the lower Storms River showing the bridge foundation and deeper riffle as well as an abundance of Palmiet along the river's edge. Photo: T. A. Bellingan, 3 October 2008

Plate 20: Lower Storms River site: Upstream view of the shallow riffle sampled, approximately 150 meters upstream of the bridge. Photo: T. A. Bellingan, 3 October 2008

2.1.8 *Upper Elandsbos River* (33°55'56.80"S; 23°46'58.00"E)

Introductory notes: This site is arguably the most difficult in terms of convenience of access. The road follows what is called “Mangold se pad”, which is taken to get to within walking distance of the site; a small tributary of the Elandsbos River is crossed, draining from “Heuningkloof”. In addition to samples taken at the main river site, light traps were set up at this tributary, downstream of the stone causeway, as it was convenient and presented an opportunity for further collection within the catchment. The road forms part of the Tsitsikamma Hiking Trail; however, at a certain point the road must be abandoned and the descent into the valley through fire-devastated pine plantation and thick Fynbos is made. The altitude of the river at this site is 254 meters above sea level.

River channel: The river is not more that 2 meters across at its widest point; at its deepest, it is roughly 2 meters in depth and, for the most part, it meanders between bedrock outcrops over which shallower water flows. The sampling area extends approximately 40 meters along the length of the river. On average, the stream is quite deep with a few shallow riffles (Plates 21 &22). The bottom substrate consists of rounded cobbles, stones and sand. A large clear pool is situated on the left bank, which overflows through Palmiet into the main river, forming an interesting marshy hygropetric seep (Plate23). To here

Riparian vegetation: The stream at the site, as well as above and below the site, is lined with dense Palmiet up to a few meters from the water's edge (Plates 20 &21). Further up the banks, low-growing woody vegetation and ferns are found, providing no shade for the river at all. Some invasive species, particularly Pine trees, are found, but most of these are dead as a result of recent fires; succession is, however, expected and inevitable. Thick *Restio*-dominated Fynbos is found further up the banks, making walking difficult.

Plate 21: Downstream view of the upper Elandsbos River site showing exposed bedrock and riparian Palmiet; the water is fairly darkly stained. Photo: T. A. Bellingan, 6 October 2008

Plate 22: Upstream view of the Upper Elandsbos River site, the only riffle being just visible behind the dense Palmiet. Dead pine trees can be seen in the background. Photo: T. A. Bellingan, 6 October

Plate 23: Upper Elandsbos River site: a large, clear-water pool on the left bank of the river; this proved very useful for sampling Odonata. Photo: F. C. de Moor, 10 January 2008

2.1.9 Lower Elandsbos River (33°58'0.32"S; 23°46'29.87"E)

Introductory notes: Due to the cascading, incised nature of the Elandsbos River valley downstream (South) of the R102, and a lack of biotopes that could be sampled, this site was chosen despite lying at an altitude (215m asl). The site is approximately 850 meters from the R102 along an MTO forestry road, making it easily accessible. Felling of the mature pine plantation along the right bank during autumn resulted in a pine tree falling across the river, modifying flow considerably. A rainfall event later in the year dislodged the tree that had blocked the channel and flow returned to 'normal'. At the lower end of the site, on the right hand bank, a seep draining from the plantation trickled into the river, creating a soggy patch along the bank that resulted in a few stones being covered with filamentous algae. After clear-felling of the pine plantation, however, this increased to a small spring, resulting in a far larger area being covered by the black algae (Plate 24).

River channel: The channel at this site is mostly of an even width of 10 meters, with a section of bedrock protruding from the right bank, providing a refuge for the temperature data logger and a pool nearly 2 meters deep alongside it. The total length of the sampling site was approximately 80 meters. The bottom substrate of this site consists mainly of rounded cobbles and sand, which meant that the depth and shape of the river changed considerably when flooding events caused movement of the substrate material. Nevertheless, for the entire sampling period, shallow riffles over the cobbles were present and provided stones-in-current biotope (Plate 25). A small island of Palmiet, protected by the bedrock outcrop, provided a marginal vegetation biotope (Plate 26).


Plate 24: The lower Elandsbos River site showing the seep staining the white cobbles black, as a result of algal growth and detritus settling between the stones. The indigenous forest is seen on the far (left) bank. Photo: T. A. Bellingan, 20 January 2009

Riparian vegetation: The site lies on the margin between a large tract of indigenous forest and MTO pine plantations. At the upper end of the site, the river bank on the right side is mostly indigenous trees with no aliens present (Plate 27). Further downstream, the transition to pine forest begins. The left bank is made up entirely of forest and approximately 50 meters below the site it also becomes pine plantation. Some Palmiet is present along the water's edge.

Plate 25: View of the shallow riffle at the bottom end of the lower Elandsbos River sampling site, below a large shallow pool. Photo: T. A. Bellingan, 20 January 2009

Plate 26: Lower Elandsbos River: upstream view of a large shallow pool formed due to cobble and stone movements. The island of Palmiet can clearly be seen. Photo: T. A. Bellingan, 20 January 2009

Plate 27: Upstream view from the upper end of the Lower Elandsbos River site. Indigenous forest on both banks and clean white cobbled substrate are illustrated. Photo: T. A. Bellingan, 20 January 2009

2.1.10 Upper Lottering River (33°55'58.60"S; 23°43'45.60"E)

Introductory notes: This site lies at an altitude of 267 meters above sea level and approximately 1.2 kilometers into the foothills of the Tsitsikamma Mountains in an area called "Noorman se bos". It is situated above and below a concrete causeway built across the Lottering River, making it a particularly convenient site to sample.

River channel: The natural, unmodified part of the river is narrow, approximately 1.5 meters in width. Due to the construction of the causeway, however, a large pool of approximately 9 meters width has formed. This is littered with boulders, large stones and cobbles. Upstream of the pool the bottom substrate is mostly bedrock, while the left hand consists of a root bank, of roughly 7 meters long, below the water surface (Plate 28). In the middle of this large pool is an island of vegetation above a large root mat fixed into clay-like soil (Plate 29). Downstream of the causeway, the stream is shallower and forms a riffle over large and small stones, as it leaves the pipes under the causeway. The river then meanders through Palmiet into a shaded run (Plate 30). The entire sampling site, including the width of the causeway, is approximately 40 meters in length.

Plate 28: The Lottering River upstream of the large pool formed upstream of the causeway. The upper end of the large Palmiet formed root bank (referred to in the text) can be seen in the lower right corner of the plate. Photo: F. C. de Moor, 3 April 2008

Riparian vegetation: The vegetation along this site is quite disturbed and invaded by alien trees; this could be due to the immediate presence of the road descending into the valley above the left bank of the river. This area of the Lottering catchment appears to have higher numbers of invasive plant species than in any of the other upper sites selected. Downstream of the causeway, on the right bank, large Black Wattle trees (*Acacia mearnsii*: Fabaceae) grow. Wattle saplings occur in abundance amongst indigenous woody bush on both left and right banks above the causeway. Palmiet lines the river on both banks, occurring in greater abundance than at any other plant (Plates 29 & 30).

Plate 29: Upstream view of the upper Lottering River sampling site, taken from the middle of the causeway. Photo: T. A. Bellingan, 4 July 2008

Plate30: Downstream view from the causeway crossing the upper Lottering River. The DWAF team are preparing to sample the small riffle below the pipes under the road. Photo; T. A. Bellingan, 4 July 2008

2.1.11 Lower Lottering River (33°58'23.90"S; 23°44'50.50"E)

Introductory notes: The geographical situation regarding this site is very similar to that of the lower Elandsbos River site. The Lottering River is also deeply incised to within a few hundred meters of the N2 and R102 roads and no easy access could be gained to the truly lower reaches of this river. The site is reached via a path from the R102 road, approximately 175 meters upstream of the bridge over the Lottering River. It lies at an altitude of 218 meters above sea level and roughly 4 kilometres from the river mouth. The river bends to an east/west orientation when heading upstream of the bridge, so that it is nearly parallel with the road. Sampling took place along this section of river.

River channel: The river channel is approximately 6 meters wide; depth estimates by visual means are difficult because of the tannin colour of the water, but the channel may reach a maximum depth of a few meters. The substrate predominantly consists of large and small stones and cobbles, with the larger stones usually holding tufts of moss. A small chute, overgrown with woody riparian vegetation (Plate 31) marks the top end of the sampled area. The river forms a shallow pool below this chute, broken up by riffles over the stony substrate and ending in a large deep pool. This follows the bend of the river for at least 75 meters onwards (Plate 32). The length of the sampling site, from the chute to the lower end of the pool, is approximately 45 meters.

Riparian vegetation: Possibly due to its proximity to a national road, the banks of the Lottering River are infested with alien vegetation, nearly exclusively Black Wattle. Palmiet also lines the banks of the river and forms small islands of vegetation within the stream bed. Areas that were swept clean of Palmiet during heavy rainfall events had been colonised by grasses (Plate 32).

Plate 31: Upstream view of the lower Lottering River site showing the small chute in the distance, followed by deeper, slower-flowing riffles. The braches of a pine tree can be seen in the left of the photograph. Photo: T. A. Bellingan, 24 January 2009

Plate 32: Downstream view of the lower section of the lower Lottering River sampling site, ending in a large pool that forms a bend in the river that runs towards the R102 Bridge. Photo: T. Bellingan, 24 January 2009

2.1.12 Upper Bloukrans River (33°55'4.00"S; 23°38'20.00"E)

Introductory notes: This site is comparable to the Elandsbos River site in terms of distance and access. At an altitude of 276 meters, it is situated well into the mountains. A key must be obtained from either the Bloukrans or Storms River Village SANParks forestry stations to access the MTO/ SANParks road, turning right into the forest off the R102 at the top of the Bloukrans pass. A fairly large tract of indigenous forest must be passed though (Platbos), followed by MTO pine plantation, before a rest-hut on the Tsitsikamma hiking trail is reached. A small tributary flowing from "Heksekloof" is crossed in the plantation section of the drive to the site; this was sampled as an additional site in the catchment, using light traps only. From the hut a steep section of the hiking trail must be followed to get to the site along the river below. The river sampled was a tributary of the Bloukrans River, as the main river was far too incised and inaccessible to get to safely (Plate33).

River channel: The river channel showed very high levels of natural modification from a recent flooding event, presumably the heavy rains that fell in the summer of 2007. The channel had been scoured clean of any vegetation growing within it, and along the banks, large amounts of debris could be seen (Plate 34). Working upstream from the top of a very high cliff-waterfall, the site starts with a pool approximately 3 meters long and 4 meters wide. Upstream of this is a waterfall of approximately 4 meters in height and above this a pool of 4 meters wide and 7 meters long. Above this, another pool is connected by a chute over bedrock, between large stones. Further upstream of this pool are a series of small pools with shallow riffles between them. The substrate along this site varies from boulders in the pools with sand along their edges, to stones and cobbles in the riffles and bedrock, allowing for the formation of the chutes and waterfalls (Plate 33 & 34).

Riparian vegetation: As mentioned above, the riparian vegetation along the stream has been highly modified by a recent flood event. Upon visiting the site for the first time, what vegetation that remained alive stood at least 2 meters up the banks, and consisted of thick woody Fynbos and Keurboom. As the sampling proceeded, the riparian vegetation was seen to encroach back down the banks and recovery was evident (Plate 35). It should be mentioned that the invasive Australian protea *Hackea sericia* (Proteaceae) has begun to creep in from the surrounding catchment.

Plate 33: Aerial view of the upper Bloukrans River sampling site from the balcony of the hiking trail hut. The image of a researcher, seated left-of-centre above the highest chute, can be used for scale. Photo: F.C. de Moor, 27 March 2009

Plate 34: Upstream view of the upper Bloukrans River site showing stones- in-current biotope. Marginal vegetation biotope was sparse in most of this section of river throughout the year, but the pools downstream contained some aquatic vegetation. Photo: F. C. de Moor, 8 January 2008

Plate 35: Upstream view of the pools at the lower end of the upper Bloukrans River site, taken from above the large waterfall seen in Plate 33. Photo: T. A. Bellingan, 23 January 2009

2.1.13 Lower Bloukrans River (33°57'21.00"S; 23°38'19.00"E)

Introductory notes: This site is the easiest to reach and most convenient to sample. The area sampled was in the region of 100 meters upstream of a gauging weir, very near to where the R102 crosses the Bloukrans River, at the very bottom of the Bloukrans Pass. It lies deep within the river valley at an elevation of 40 meters above sea level, approximately 800 meters upstream of the confluence with the Vark River.

River channel: The riverbed is approximately 15 meters wide and is composed of large, angular, slab-like boulders that divert the river into many smaller channels that flow underneath and around them (Plate 36). The substrate within these channels is composed of small cobbles, stones, and gravel. Upstream of the weir there is a large pool, upstream of which the majority of sampling took place, mostly within the riffles and pools that formed as a result of bedrock intrusions from the right bank. The total length of the sampling site was approximately 75 meters. Some scrap metal debris was also found in the river channel at this site.

Plate 36: Downstream view of the lower Bloukrans River sampling area; the road and large pool leading to the weir can be seen in the background. Photo: F.C. de Moor; 21 January 2009

Riparian vegetation: The Bloukrans pass winds through a section of indigenous forest called the Rugbos, which stretches the entire length of the Bloukrans pass. The riparian vegetation is, thus, completely natural. The R102 road that lies in close proximity to the right bank has caused some modification of the vegetation and surrounding landscape. Nevertheless, no colonisation of the bank by alien plants has occurred. The left bank, for most of the site, is a cliff above which the forest grows.

Closer to the riverbed, Palmiet fringes the river edges, forming good marginal vegetation biotope. This only occurs along the right bank, due to the rocky nature of the left bank (Plate 37).

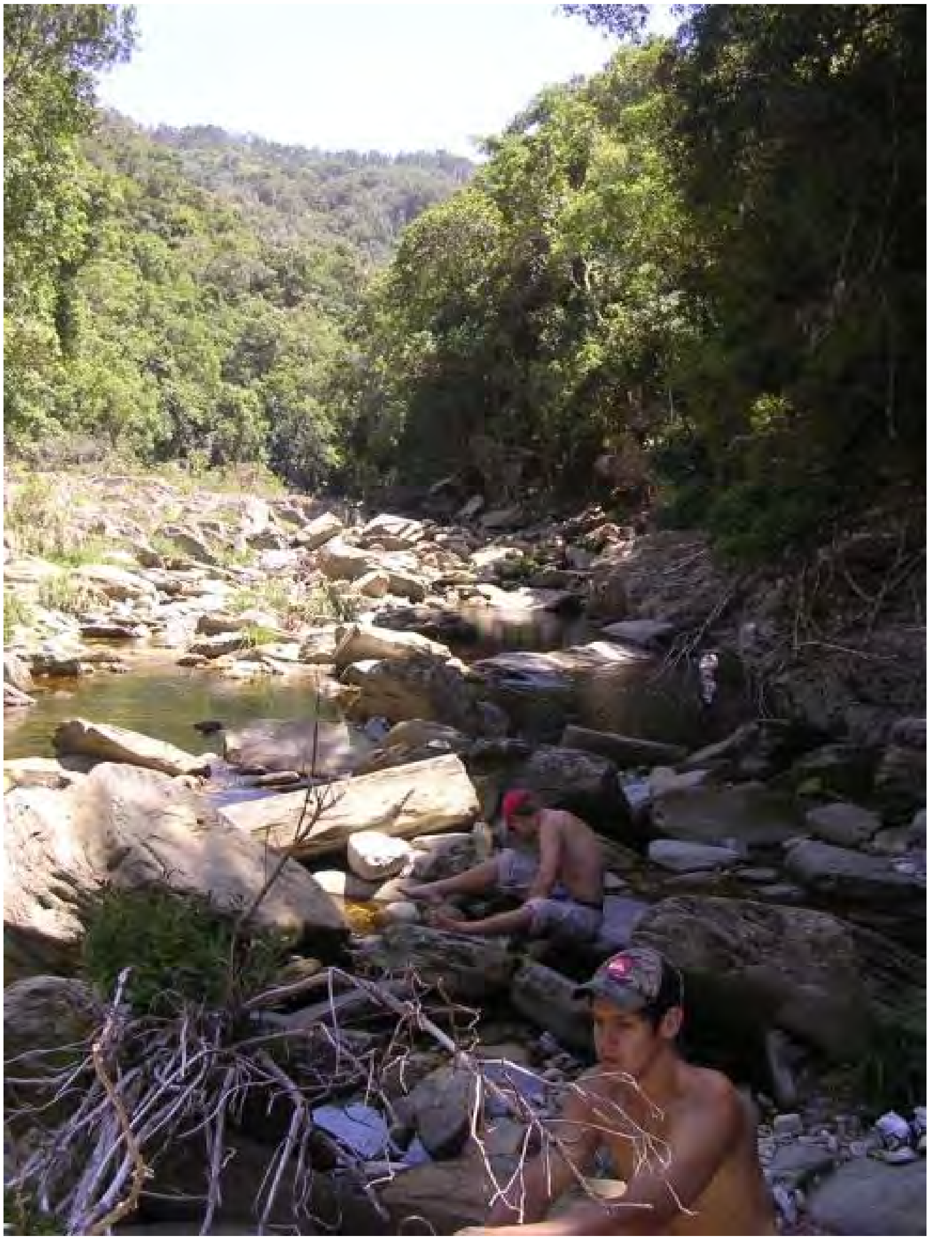


Plate 37: Upstream view of the lower Bloukrans River sampling site. Dense, natural forest lines the riparian zone of the river. Also note the jagged nature of boulders in the riverbed and the very low flow of the river at this time. Photo: F. C. de Moor, 21 January 2009

2.1.14 Upper Groot River (West) (33°54'45.60"S; 23°34'37.10"E)

Introductory notes: This is the first of two sites that were reached by helicopter; no roads or hiking trails existed that would have allowed access to the river at this altitude. Vehicles and excess equipment were left at the Plateau guest house along the R102 between the Bloukrans and Groot River passes. A helipad, owned by the guest house, was used to ferry teams to the site. Obviously, the use of a helicopter made getting into the mountains far easier, thus allowing researchers to get high up into the catchment, provided a suitable place could be found to land the helicopter. The altitude at this site is 313 meters above sea level. The cost of this exercise could, however, be prohibitive.

River channel: The river along this upper section winds considerably as it begins its descent from the mountains, and is already incised into a fairly steep valley, the climb from the helicopter landing site to the riverbed being approximately 75 meters. The riverbed where sampling took place was approximately 9 meters wide with the stream flowing over most of its breadth between boulders and large stones, providing slower-flowing biotopes (Plate 38). A larger, more swift–flowing, channel occurred along the left bank as a reasonably large piece of flat bedrock was exposed, providing little water resistance. Not far upstream of the area that was sampled, a large pool, of roughly 1.5 meters depth, stretched around the bend of the river, providing marginal vegetation biotope (Plate 39). The area sampled stretched approximately 55 meters along the length of the river.

Riparian vegetation: This site is situated within pristine natural forest. Although pine trees have colonized the upper slopes of the mountains and down to the valley edges, no alien vegetation was observed within the river valley or near the river course. The sampling site is almost entirely shaded by forest canopy, with only odd patches of direct sunlight reaching the riverbed. Forest trees and woody understory growth arise from the water’s edge on the right bank while the left bank is lined with large tree ferns, *Cyathea* sp (Cyatheaceae), followed by a steep slope covered with grass, Restionaceae and thick stands of Keurboom (*Virgilia oroboides*: Fabaceae) higher up.

Plate 38: Upstream view of the upper Groot River (West) sampling site. Note the dense woody vegetation lining the river. Photo: T. A. Bellingan, 12 July 2008

Plate 39: Downstream view of the upper Groot River (West) sampling site. The tree ferns, referred to in the text, are visible on the left bank as well as the slab/sheet of bedrock promoting faster flows. Photo: T. A. Bellingan, 12 July 2008

2.1.15 Upper Bobbejaans River (33°53'46.50"S; 23°33'19.50"E)

Introductory notes: This site is the second of the two sites reached by helicopter. At an altitude of 414 meters above sea level, it lies higher than any other site sampled during this study. Despite being so high up in the mountains, the river course is already incised and has begun undulating in its flow. The valley that one has to hike down to get to this site, even though deeper, is not as steep and densely vegetated as that of the Upper Groot (West) (Plate 40).

River channel: The river channel at the site is approximately 4 meters wide and, in places, up to 1.5 meters deep. The upstream part of this site starts with a small chute, above which is a long riffle (roughly 12 meters in length) over large stones and boulders, that flows into a pool (Plate 41). The pool then drains over some smaller cobbles and stones, with the edges of the riffle lined with gravel and sand in places. This riffle continues for approximately 3 meters before the channel of flow is split by a large boulder with a butterfly pattern on it (Plate 42). The riffle then turns to a large chute into another deep pool, where the temperature data logger was positioned under some small boulders. The length of the area sampled at this site was approximately 60 meters

Riparian vegetation: Palmiet lines the stream margins in abundance, serving to stabilize the soil by forming root banks and providing excellent marginal vegetation biotope for sampling. Further up the banks, flood damage from the summer rains of 2007 is visible, with the woody vegetation being broken and “trodden flat” by the flood waters. Succession by smaller proteacous shrubs is taking place on both the left and right banks while the woody vegetation recovers. Further up the banks, burnt pine trees and protea's are common amongst thick superabundant Restio grass.

Plate 40: An aerial view of the upper Bobbejaans River sampling site, taken from the helicopter while descending to land. The area sampled lies between the two pools visible in the centre of the photograph. Photo: T. A. Bellingan, 10 October 2008

Plate 41: Upstream view of the upper Bobbejaans River sampling site from the left bank, illustrating a long riffle leading to the chute (bottom left) and a large pool that is visible on the right. Photo: T. A. Bellingan, 10 October 2008

Plate 42: Downstream view of the upper Bobbejaans River sampling site, taken from the left bank. The boulder with the butterfly shape on it, referred to in text, can be seen to the left of the SANParks ranger, Albert Maarman. Photo: T. A. Bellingan, 10 October 2008

2.1.16 Lower Groot River (West) (33°57'50.50"S; 23°33'30.70"E)

Introductory notes: This site lies only 14 meters above sea level and approximately 2.7 kilometers from the river mouth, making it the lowest site sampled as well as the closest to its mouth and the ocean. Access to the sampling site is via a private road to the Natures Valley pump and water purification station. The area sampled lies approximately 400 meters upstream of the pump house. The river should be crossed and the right bank used to reach the site as the left bank is densely vegetated and steep in places.

River channel: The river channel is typical of the lower reaches of a river. The river bed is wide (up to 18 meters in places) with large slow-flowing pools separated by shallow riffles over cobbles, stones, sand and mud in places (Plate 43). The pools generally contain large amounts of decaying leaf packs, collected on the river bottom, and can be in excess of 2 meters deep. The site that was sampled was approximately 50 meters in length.

Riparian vegetation: The site lies within natural forest that would appear to be particularly old, given the size of the Yellowwood trees growing on the river banks.

The forest canopy extends over the river and, due to with the height of the trees, casts a large shadow early, and late, in the day; however, due to the large breadth of the river, a high quantity of light still penetrates to the riverbed at midday. The immediate banks are covered in grass that overhangs into the water on the edges of the pools (Plates 44 & 45).

Plate 43: An upstream view of the lower Groot River (West) sampling site showing the large pools and shallow riffles found at this site. Photo: T. A. Bellingan, 7 October 2008

Plate 44: Lower Groot River (West): Upstream view from the right bank, showing a researcher 'hand picking' from a 'stones-in-current' sample. Photo: T. A. Bellingan, 7 October 2008

Plate 45: Downstream view of the lower Groot (West). Volunteers are shown next to the large pool, with slow-flowing water, lined with marginal vegetation that stretches around the bend in the river. Photo: T. A. Bellingan, 7 October 2008

2.1.17 Upper Salt River (33°55'36.20"S; 23°29'23.30"E)

Introductory notes: The site along the upper Salt River was chosen as per the terms of reference for this study, viz. in order to match previous studies as closely as possible. Access to the site is via the Kurland Estate, off of the N2 highway. The altitude at this site is 265 meters above sea level.

River channel: The river channel at this site, as with many other sites, has been highly modified by the flooding event of 2007, making it nearly unrecognizable from the descriptions of previous studies. The area sampled stretched for approximately 85 meters above a weir, from where an inter-basin transfer furrow arises. Thus, most of the sampling site lay upstream of the impounded area resulting from the weir; shallow riffles as well as slower-flowing runs were also found in the sampling area. The bottom substrate at this site is comprised of a combination of bedrock, a few large boulders, cobbles, and gravel between the stones. During the sampling period, the water was clear and the larger stones were covered with a moss, *Fissidens plumosus*, and two liverwort species, *Ricardia* sp. and *Frulania* sp. (Plate 46). The river channel is approximately 4 meters wide and, on average, not more than 40 centimeters deep.

Riparian vegetation: Vegetation along the banks of the upper Salt River consists of thick woody bush along the edges with a few ferns making their way to the waters' edge. Further upstream, indigenous forest shades out and replaces much of this vegetation. Small tussocks of Palmiet can be found growing within the river course, although this is not nearly as common as that found at some other sites (Plate 47). Higher up the banks, exotic species — *Eucalyptus*, on the left bank, and pines, on the right — outcompete the majority of indigenous species (Plate 48).

Plate 46: Detail of the slow-flowing riffle shown in Plate 48, at the upper Salt River site; the diverse bottom substrate can be seen, along with liverwort and moss growing on the larger stones in the bottom right corner. Photo: T. Bellingan, 24 January 2009

Plate 47: Upstream view from the sampling area: Upper Salt River. The dense woody marginal vegetation is shown as well as a naturally-formed pool. Photo: T. A. Bellingan, 24 January 2009

Plate 48: A downstream view from the upper Salt River sampling site showing a slow-flowing riffle. The large gum trees that have invaded the left bank are visible in the background. Photo: T. A. Bellingan; 24th January 2009

2.1.18 Lower Salt River (33°58'28.30"S; 23°31'19.70"E)

Introductory notes: This site lies in the de Vasselot section of the Tsitsikamma National Park and is reached via a hiking trail off the R102 between Natures Valley and Kurland. For convenience sake, a large portion through the Fynbos plateau can be crossed by vehicle if a key for the chain “gate” can be obtained from SANParks at the de Vasselot rest camp station. The road, however, only goes to the edge of the valley and the river below must still be reached by foot. The site corresponds to the lower site used in previous studies on the Salt River. The site lies at an elevation of 47 meters and is typical of a lower, depositional, stage of a river.

River channel: Along the section of river sampled (approximately 65 meters), the riverbed is roughly 15 meters at its widest point. At base flow, however, the stream channel only covers approximately half, or less, of this width in the form of slow-flowing pools separated by wide, shallow, riffles. The bottom substrate in the pools consists primarily of sand covered with leaf litter and other detritus while the riffles wind between large stones and over cobbles, pebbles and gravel (Plate 49). Towards the edges of the streambed, the substrate turns to fine sand with large amounts of leaf litter and wood debris.

Plate 49: An upstream view of a shallow riffle within the sampling area along the lower Salt River. The dense forest that lines the river along its lower reaches is evident, casting a significant amount ot shade over the riverbed. Photo: T. Bellingan, 24 January 2009

Riparian vegetation: As mentioned previously, this site lies within the boundaries of the National Park, and thus, within pristine natural forest. The river is lined with tall mature forest trees on both banks that cast a large amount of shade over the stream bed, meaning that sunlight only reaches the river bed for a few hours either side of midday (Plate 50).

Plate 50: A downstream view from the lower Salt River sampling area. A large pool forms beyond the farthest riffle shown. The sandy substrate of the pools is also illustrated. Photo: T. Bellingan, 24 January 2009

2.1.19 Upper Buffels River (33°58'56.80''S; 23°28'43.90''E)

Introductory notes: The site on the upper Buffels River corresponds to the upper reaches of the river in that it is near to the source of the river even though it lies at a relatively low altitude, of 61 meters above sea level. The Buffels River, along with its tributary the Matjies River, does not originate from the Tsitsikamma Mountains as with the other rivers in this study. The upper reaches lie a few kilometers from the foothills of the Tsitsikamma Mountains, on the inland end of the piedmont plain that separates the mountains from the Indian Ocean. The site is reached via the private property of Brenda Bergé, owner of Bracken Fern farm.

River channel: The riverbed at the sampling sites is roughly 4 meters wide, while the stream channel can be reduced to less than a meter wide, depending on flow conditions (Plate 51). Several pools are found downstream of the sampling area, formed by bedrock outcrops. One of these contains a pump for water extraction. Small chutes, formed between these pools are usually lined with moss. A stretch of approximately 35 meters of river was sampled at this site. The geology of the Buffels

River is very different to that of the other rivers in this study; the riverbed is composed of soft, dark-coloured, shale rather that the hard, whitish, table mountain sandstone/quartzite that is found in every other river surveyed. This gives the water a muddy, dirty, appearance (Plate 52).

Riparian vegetation: Grasses and Palmiet grow along the banks of the river forming a thick green carpet of vegetation covering the clay-like soil up to a few meters from the water's edge. From there on, indigenous forest lines the rivers and extends up to the tops of the valleys. This provides a reasonably thick canopy; however, enough light penetrates to allow understory marginal vegetation to flourish (Plate 51).

Plate 51: An upstream view of the sampling site along the upper Buffels River. Flow rate at this time was particulary low, as the photo illustrates; the river was reduced to a trickle along the riffles. Photo: T. Bellingan, 10 March 2008

Plate 52: Downstream view of the upper Buffels River showing the area below the sampling site. The brown water colour is illustrated as well as the pools as a result of bedrock slabs. Many Eastern Cape Redfin Minnows (*Pseudobarbus afer*) could be found here. Photo: T. Bellingan, 10 March 2008

2.1.20 Upper Matjies River (33°58'50.60"S; 23°27'28.10"E)

Introductory notes: The sampling site on the upper Matjies River is situated at an elevation of 51 meters above sea level, i.e. ten meters lower than the sampling site on the upper Buffels River. Access to the Matjies River site was via the property of Mr. Jürgen Schmidt, down a logging path (sleep pad) that follows on from the driveway of his homestead. Caution must be advised when using this path as the combination of a steep gradient and leaf litter makes conditions under foot very slippery, especially when wet.

River channel: The river channel at the this site was very narrow, approximately 2 meters wide at its widest, with the small chutes between and over bedrock narrowing to as little as 30 centimeters at base flow. For most of the sampling period, not more than a trickle was present (Plate 53). Sampling took place between a series of small pools and shallow riffles, roughly 30 meters downstream of the confluence of another tributary of the Matjies. The water was clear, unless the bottom was disturbed, in which case clouds of fine sediment were produced. The bottom substrate consists of bedrock, large stones, pebbles and mud (Plate 54). The bottoms of the pools are layered with leaf debris and a fine, brown alga was present on all available surfaces. The sampling site was approximately 50 meters in length.

Riparian vegetation: As mentioned before, the stream is heavily shaded by natural forest that grows down to the banks, excluding nearly all other understory growth. Where marginal vegetation was found, it was sparse due to the heavily-shaded nature of the stream; some shrubbery was found growing along the upper banks, but this was not nearly as dense as the Palmiet found at some other rivers in this survey (Plate 53).

Plate 53: An upstream view from the middle of the sampling area along the upper Matjies River. Water flow at the time of the photograph was low, as was customary for this site. The sparsely-vegetated banks are also illustrated. Photo: T. Bellingan, 10 April 2008

Plate 54: A downstream view of the upper Matjies River sampling site; the clear water in pools formed by bedrock intrusions can be seen. Some volunteer collectors are included in the foreground. Photo: T. Bellingan, 10 April 2008

2.1.21 Lower Buffels River (33°59'7.90"S; 23°27'48.70"E)

Introductory notes: The area sampled along the lower Buffels River lies approximately 32 meters above sea level and nearly 3.2 kilometers from the river mouth. It is the second of two confluence sites. This site is particularly difficult to reach: to hike directly to the site, it is important to locate the start of the old "sleep pad", or logging path, after which is easy to follow. Alternatively, the site can be accessed via the Upper Matjies site, which may be simpler, but more treacherous, as hiking downstream along the river has resulted in a few injuries from falling during the slippery conditions.

River channel: The river channel is approximately 7 meters wide with the majority of the stream bed surface area being covered by moving or still water. The width varies in places where bedrock breaks the surface of the stream (Plate 55). The sampled area is below a large shallow pool that stretches for some distance upstream. Immediately downstream of the pool, a rocky outcrop forms a riffle, of roughly 4 meters in length, that is littered with large stones and cobbles, making for an excellent “in current” biotope. This is followed by another pool, which is in turn followed by a second riffle (Plate 56). The total length of the sampling site is roughly 85 meters. The margins of the river channel are, for most of their length along the sampling site, made up of clay-like soil held together by marginal vegetation, rather than rock-like margins as seen at most other sites. The water colour was clear except during times of flooding (Plate 57). But, if the stream bed was disturbed, clouds of muddy sediment would result (as was the case when sampling at the Matjies River).

Riparian vegetation: The entire length of the sampling site is lined with indigenous forest that casts a large amount of shade over the site. However, due to the breadth of the stream, enough light still penetrates to allow for good cover of the banks by shrubs and grasses (Plate 55). No alien plant species were observed at this, or any of the other, sites sampled along the Buffels river system.

Plate 55: Upstream view from the upper end of the lower Buffels River sampling site showing a large pool that precedes the riffle where the majority of the in-current sampling took place. Photo: T. A. Bellingan, 26 January 2009

Plate56: Downstream view of the lower Buffels River sampling site with a riffle in the foreground, followed by a pool and a second riffle. Photo: T. A. Bellingan, 10 April 2008

Plate 57: Downstream view of the lower Buffels River sampling site after heavy rainfall that resulted in the river rising nearly half a meter from base flow. Photo: T. A. Bellingan, 9 October 2008

2.1.22 River altitude profiles

River profiles were produced by obtaining data from 1:250,000 digitized topographical maps, provided by the CSIR, and extracting 20m contour data from selected rivers into excel spreadsheets (Lindsey Smith- Adao pers com). From this data sections of 20m contour were mapped and converted to gradient classes ranging from A > 0.1, B = 0.04-0.99, C = 0.02-0.039, D = 0.005-0.019, E = 0.001-0.0049, Z < 0.00001. River profile maps were plotted for all the rivers for data we could obtain and are presented in Appendix 5.

2.2. Physicochemical measurements

The DWAF team undertook the task of gathering water quality parameters: temperature, pH, electrical conductivity, Dissolved Oxygen, Turbidity and Total Dissolved Solids (TDS) were measured and recorded in the field at the time of sampling using a YSI 6 Sonde Multimeter with a variety of probes. Water samples were collected in plastic bottles, preserved and frozen and stored in a deep freeze in the field laboratory (at Petrusville at Storms River Mouth), for later laboratory analysis by Talbot Laboratories Pietermaritzburg, KwaZulu-Natal. Additional chemical parameters recorded included Nitrate/ Nitrite, Ammonia, Total Phosphate, Orthophosphate, Cadmium, Chromium, Copper, Iron, Lead, Magnesium, Mercury, Zinc, Bromide, Chloride, Fluoride, Sodium, Sulphate, Sulphide, Turbidity, suspended solids at 105°C and Total dissolved solids at 180°C.

In addition, Climastats Thermocron i-button temperature data loggers (-40 to 85 °C ± 1 °C accuracy) were installed at each site to record water temperature at 0.5 °C intervals every two hours from January 2008 to January 2009 and every four hours from January 2009 to February 2010. Thermocron i-button data loggers were placed in Ziploc® plastic bags and stored in plastic containers with a sealing screw top. Each sealed logger was placed in a 50mm–diameter, 300mm-long galvanised pipe closed at either end with stainless steel bolts and nuts. The pipe was attached via a stainless steel cable to a river boulder with a rawlbolt. The loggers were placed in the rivers at protected sites in deep pools. They were retrieved for data capture and replaced at three-monthly intervals during the first year of the study.

2.3 Collection of macroinvertebrates

Identification of macroinvertebrate species is necessary in order to obtain an evaluation of differences in composition at different sites and between different rivers. An estimation of species assemblages of aquatic macroinvertebrates at different times of the year is also an important measure of different processes in action at different sites. Patterns of species dominance and the presence/absence of certain key 'indicator' species can be used to assess the status of river health and changes in river conditions over time (while also taking seasonal patterns of presence/absence into account).

Several different types of assessment were made of macroinvertebrates present in the river.

2.3.1 *Collections for detailed identification of invertebrate taxa*

During the study, two site selection surveys (7-19 January and 11-13 February 2008) and four collecting surveys (31 March-13 April, 30 June-13 July, 30 September-12 October 2008; and 16-30 January 2009) were undertaken by the DWAF team, the researchers (from Stellenbosch and Rhodes Universities and the Albany Museum), with support from SANParks rangers. In addition, a special upper-catchment survey (25 March-2 April 2009) was undertaken by Rhodes University and Albany Museum researchers joined by a team from the National Museum, Bloemfontein and Dr A Staniczek (State Museum for Natural Science, Stuttgart, Germany). At each sampling site a photographic record was made of the general aquatic environment giving a visual record of the aquatic biotopes and prevailing conditions at the time of sampling (see site description Plates 1 - 57).

Aquatic invertebrates (for aquatic stages, aquatic juvenile stages and for adult flying stages) were sampled using various water and aerial hand nets ranging in net mesh size from 80 micrometres (0.08 mm) to 1000 micrometres (1 mm).

Sampling of aquatic stages was done using a standard SASS net (mesh size 1000 µm), a hand-net (mesh size 250µm), or a small 'D' hand-net (mesh size 80µm) used for sampling bedrock in swift-flowing cascades and hygropetric splash zones of waterfalls. General hand-picking of stones, lodged branches and removable substrates was also carried out.

Drift nets were left in the water at dusk to collect the nymphal and larval shucks of emerging insects and also to get a measure of organic drift activity. Drift nets were set in the river when it was possible to service these regularly.

Collection of adult phases, which is important for species identification, also took place: Light traps, to collect the adult stages of many aquatic insects were set up at all sites. Where time permitted, Malaise traps were set up, regularly emptied and left for several days at selected sites. Wherever possible, general collecting for flying adult insects with hand-nets was also carried out.

As many aquatic biotopes as possible were sampled at each collecting site. A list of abbreviated descriptions of biotopes is given in the Table 1. The biotopes sampled included 'stones-in-current' and 'stones-out-of-current', marginal vegetation and root stocks, aquatic moss, filamentous and encrusted algae, sediments on substrata, the surface of water bodies, adult flying insects with aquatic nymphal and larval stages, and adult insects attracted to light traps. A light trap using a super-actinic light source over a white tray filled with some water and a few drops of detergent to break water surface tension, was used in all instances and where conditions were suitable. Sheet light traps, which allow selective collecting and rearing of mayfly subimagos to the adult stage, were also used.

Biotopes were sampled in a number of ways. Invertebrates associated with aquatic plants were collected by running a net through aquatic macrophytes and marginal vegetation. Where stony substrata were present, stones were lifted by hand and brushed by hand or washed into a collecting net. Aquatic animals were also picked off these stones with a fine pair of forceps or by hand. Sediments were stirred up and either a coarse, or fine-meshed, net was run through disturbed sediments and substrates. Where running water was found, stones in the flowing current were dislodged and kicked and invertebrates were carried by the current into a net suspended below the disturbed substrates.

Unsorted samples as well as selected collections of animals were given a catalogue number for each site, date and biotope type. Samples were labelled and preserved in 80% ethanol. Samples were sorted in the laboratory by first picking out large animals and then passing each sample through a series of nets of different mesh sizes to separate large and small invertebrates. A final check of each sample with a dissecting microscope served to remove any smaller animals that could be missed in the coarse sorting.

Identification of animals was carried out using museum-voucher material for comparison, and where specimens of particular species were not available, the library of taxonomic papers held by the Albany Museum was used. Certain groups (Plecoptera, Odonata, and Megaloptera) have been sent to specialists for species identification. Other taxa also collected (various aquatic Hemiptera, coleopteran families Hydraenidae, Elmidae, Dytiscidae and various dipteran families including Chironomidae) will also be sent to specialists for identification. All material collected is stored and curated in the Albany Museum, Grahamstown or Stellenbosch University Insect collection. Material is stored under the Tsitsikamma Rivers catalogue (TSR). The collection contributed 616 separate TSR catalogue biotope sample entries. A synopsis of all 616 biotopes sampled during the surveys is given in Table 2. Samples sorted by different species have been given individual species identification labels under the TSR catalogue. A CD with digital images of selected species and sampling procedure and apparatus is provided with the report.

2.3.2 *SASS5 sampling to assess water quality and provide additional material*

The DWAF team collected SASS5 samples at all sites and made an assessment of water quality on the basis of the species composition of macroinvertebrates (identified to family level) in the river. The methods of collection are described by Dickens & Graham (2002). All invertebrates collected using this method were, however, preserved and retained as additional collections of representative macroinvertebrates from three major aquatic biotopes sampled at each site on every occasion. The biotopes surveyed included stones (both in and out of current), Vegetation (marginal, trailing or rooted macrophytes in and out of current), and gravel, sand, and mud samples, as described in detail for the SASS5 protocol. Samples collected were also given TSR catalogue numbers. In the laboratory, samples were examined and identified to species level where possible and data was added to the species compliment for each site.

Site maps (reproduced in the Appendix) form part of SASS5 assessments, the purpose being to produce rough sketches of instream localities where the biotopes were sampled. While it is realized that current speeds vary immensely according to geomorphological details and flow regime at the time of sampling at any particular point in a river, visual estimations of surface currents are included on the site maps as a means of indicating relative fast and slow current regions.

2.4 Analytical methods used

Taxa collected from all sites were identified and recorded in the hand-written TSR catalogue and transferred to Excel spreadsheets. The level of identification (family, genus or species) varies with different taxa and also much identification still needs to be verified. This is an ongoing process with material routinely sent to experts taking time to get species identification and description of new species formally published. Species recognised as undescribed are given a TSR catalogue number and alphanumeric code, and when this "species" is encountered in other samples they are referred to the original catalogue number allocated to that species. This is to enable the recording of all individuals of a particular species to be easily retrieved for taxonomic work. Information recorded in catalogues on SASS5 data sheets and on physicochemical data sheets was perused for accuracy and further synthesis.

For the analysis of the water chemistry results, both the on-site values as well as the detailed laboratory water chemistry values were placed into a combined data set and analyzed using Principal Component Analysis (PCA) to ascertain if any patterns exist between sites, based on their water chemistry (Statsoft, Inc 2009). The same process was carried out for the adult Trichoptera collected with light traps; presence/absence of species was used to characterize the sites sampled. In addition CANOCO (ter Braak and Smilauer 1998) was used to conduct ordination analyses on Trichopteran distribution patterns. The adult Odonata were analysed using PCA and Detrended Correspondence Analysis (DCA) separately as the collection technique for this group was different to the remaining taxa.

3. RESULTS OF DEPARTMENT OF WATER AFFAIRS AND FORESTRY SASS5 STUDY

3.1 SASS5 protocol

The routine assessment of water quality was determined by using the SASS5 protocol. In addition to this, physicochemical records of the water were also determined by collecting water samples and having these analysed by Talbot & Talbot Laboratory in Pietermaritzburg. All these assessments were undertaken by the DWAF team that partook in all four seasonal surveys.

Rapid biological assessment of water quality was carried out using the SASS5 (South African Scoring system version 5) collecting techniques with identification of aquatic invertebrates to family level in the field and scoring the taxa collected in each of three defined aquatic biotopes at each site separately, according to the protocol devised for that method (Dickens and Graham 2002). The water quality at each surveyed site was assessed in the field on each occasion. One modification of the technique was that all samples collected from each of the three biotopes sampled at each site and on each occasion were preserved in 80% ethanol, given catalogue collection numbers, and were added to the other samples to become part of collection of sites surveyed.

There are three main scoring categories of SASS5 used to assess the response of aquatic invertebrates to prevailing water quality: Total Score, Number of Taxa, and Average Score Per Taxon (ASPT).

The Total Score is simply the sum of the assigned scores of the families encountered in the sample. Generally, the Total Score increases with the number of available biotopes sampled, as many invertebrates have specialised habitat requirements (Chutter, 1998). However, as most pollution-tolerant taxa occur in a variety of biotopes, the Total Scores at severely polluted sites do not appear to be governed by biotope diversity (Chutter, 1998). The number of taxa are the number of families or taxa recorded from the SASS5 survey. The ASPT is calculated by dividing the Total Score by the number of taxa found in the sample. A significant variation of these scores between sampling times is indicative of changes in prevailing water quality at the particular site being monitored. Also, both the Total Score and the ASPT are likely to vary between sites with differing environmental conditions.

When Total Scores and ASPT's are compared for unimpacted pristine sections of rivers (as found in nature reserves or mountain catchments), moderately impacted (e.g. sites with some agricultural runoff or the recovery zone below a dam), and severely impacted sites (e.g. below sewage- or industrial-discharge points), both Total Score and ASPT decline with respect to declining water quality.

Chutter (1998) provided tentative guidelines for interpreting total scores and ASPTs with respect to prevailing water quality for acid mountain streams of the southern and Western Cape which at that stage covered the SASS4 version being used (See table below).

Chutter's guidelines for interpreting SASS4 scores in acidic waters ph<6).

Total score	**ASPT**	**Water Quality**	**Class**
>125	>7	water quality natural, biotope diversity high	**A**
<125	>7	water quality natural, biotope diversity reduced	**B**
>125	<7	Borderline case between water quality natural and some deterioration in water quality, interpretation should be based on the extent by which Total Score exceeds 125 and ASPT < 7	**C**
60-125	<7	some deterioration in water quality	**D**
<60	Variable	major deterioration in water quality	**E**

3.2 Results and discussion

The SASS data recorded in the field for all sites during each season are presented as: **1.** the selected aquatic orders, after checking for accuracy and removing erroneous data, in four synthesized tables (Appendix 1). **2.** The detailed SASS5 data for each site are presented in synthesized form on the 80 completed SASS5 data sheets (Appendix 2). Site maps, reproduced in this Appendix, provide rough sketches of instream localities where the biotopes were sampled. While it is realized that current speeds vary immensely according to geomorphological details and flow conditions at any particular time and point in a river, visual estimations of surface currents are included on the site maps as a means of indicating relative fast and slow current regions. A summary of the SASS5 data and major physicochemical parameters measured in the field is presented in four tables (Tables 3-6) (one for each season).

The macroinvertebrate assemblages collected indicated that water quality for the Matjies and Buffels Rivers consistently ranged between C and D indicating consistent deterioration in water quality in these rivers. The lower Salt River had water quality that ranged between A and C (natural and borderline showing some deterioration). The Lower Elands River with a score of D showed deteriorated water quality on all occasions. For the Lower and Upper Groot River East water quality ranged between natural and showing borderline indications of deterioration. The Upper Elands had excellent water quality in winter and spring but the biota revealed signs of deterioration in summer and autumn. All the other river sites were indicated to have excellent water quality with an A recorded on all occasions. The one exception was the Lower Groot River West where water quality dropped to a D in the summer of 2009. The deterioration in water quality can most likely be attributed to the drought which prevailed during the second half of the survey period.

4. IN-DEPTH SURVEY RESULTS

4.1 Physicochemical data

4.1.1 *Water Chemistry*

The water chemistry results obtained over the course of this study consisted of two types of readings: on-site measurements, and laboratory-generated measurements. It is important to point out that the Dissolved oxygen (DO) measurements taken by the DWAF team in the field over the winter and spring periods were suspected of being incorrect because levels of oxygen saturation recorded were too low to support aquatic faunal life, which was abundantly present at all sites. It became clear that their instrument for measuring this parameter was not functioning properly. A new, smaller instrument was brought in to replace the faulty one for the summer sampling but this also produced unreliable results. The field-recorded physicochemical measurements are presented in the summary SASS5 data records (Tables 3-6). The first series of DO readings recorded in autumn 2008 indicate from the biota collected that they can be assumed to be correct. Because there were no drastic changes in the community structure of biota collected during subsequent surveys it can be reasonably assumed that DO levels were high and reflect near 100% saturation at all times based on the first recorded series of measurements.

The second set of readings taken consisted of a detailed analysis of water chemistry carried out by Talbot & Talbot Laboratories, Pietermaritzburg. These measurements were also not without their own setbacks. The bottles provided by Talbot & Talbot and used by DWAF could best be described as flimsy and once the water sample was frozen, which is correct procedure for preserving water samples, the bottles would frequently split. While being transported from Port Elizabeth to Pietermaritzburg, in some cases most of the water leaked out of the sampling bottles, resulting in insufficient volumes being present for certain analyses. The consultants were only made aware of this during the spring survey when all parties were in Tsitsikamma together, after which a more concerted effort was made to ensure enough water was reaching Talbot & Talbot for undertaking a complete analysis.

After comparing the data from each sampling trip and using the parameters that were common and recorded at each site, it was decided that the results of tests for the following parameters were sufficiently reliable on each occasion and could be used: Ammonia, Chloride, dissolved Magnesium, Fluoride, Nitrate/Nitrite, Orthophosphate, Sodium, Sulphate, total Lead, total Zinc and total Iron. These parameters were used because they were measured consistently for each visit, thus making them suitable for comparative statistical analyses. The data of all measured physicochemical parameters recorded from water samples analyzed by Talbot & Talbot Laboratories are presented in Table 7. All data are presented as mg l^{-1} except Fluoride which is in µg l^{-1}. Data that show higher than normal values are highlighted in Table 7. The detailed analysis sheets from Talbot & Talbot laboratory outlining the analytical method used and recording the dates samples were analyzed can be found in Appendix 3.

The eigenvector plot (Figure 2) shows that the first two axes from the PCA analysis of the selected water physicochemical variables account for 53% of the ordination variation. Total Iron, total Zinc, total Lead and ammonia lie within the centre of the two axes indicating that they contribute little to the ordination of the sites. Orthophosphate and Nitrate/Nitrite group together on the second axis indicating that they are important contributors to the ordination. Turbidity and pH have positive values for both vectors and the remainder of the measurements group very closely to the right on the first axis. The ordination of river sites based on water physicochemical variables (Fig 3) when compared with the ordination of physicochemical parameters (Figure 2) show that the sites group together, based on the physicochemical parameters. For example, the lower Salt River site has extremely elevated levels of Orthophosphate and Nitrate/Nitrite for one sampling season (Winter) that coincides with a rainfall event. The increased runoff of nutrients, from developments in the catchment upstream of the site, following this event, or else a discharge of treated sewerage from the Kurland Sewerage Farm could explain why the levels of these chemicals were so high during the period when the water sample was collected. Furthermore, it is obvious that the Buffels/Matjies River system is very different in chemical composition to the rest of the rivers in this study, with particular reference to Electrical Conductivity, Fluoride, Sodium, Dissolved Magnesium and Chloride. Although seasonal variation in concentrations did occur, these values were consistently higher for the Buffels/Matjies River system throughout the survey when compared to results from the other nine rivers that were studied, (Tables 3-7).

The level of pH in the Buffels/Matjies River system was consistently above pH 7.0 indicating a higher concentration of OH^- ions when compared to rivers with pH<7.0 producing a higher concentration of H^+ ions in all the other rivers (Tables 3-6). This also made the Buffels River system significantly different from the other rivers surveyed. Elevated levels of pH >6.0 were also notable for the Lower Salt River, Lower Groot River East and Lower Elands River on all sampling occasions and the Lower Groot River west on one occasion in winter. This is an issue of concern and shows changes beyond the natural conditions in these rivers.

Turbidity measured as Nephelometric Turbidity Units (NTU's) was only reported on in the Talbot and Talbot laboratory reports for Spring and Summer (Appendix 3). The recorded values were below 4.0 NTU's for all sites, except the Buffels/Matjies River system in Spring where the NTU recorded, ranged from 13.8-18.3. Except for the last mentioned data these values are below the acceptable range for all natural waters in South Africa (Dallas and Day1993).

4.1.2 Water temperature

The results of one year's data from temperature loggers set at the 20 sites on the 11 river systems surveyed are presented in Table 8. The Upper sites on rivers all have lower mean annual water temperatures than the lower sites except for the Elandsbos River. This could have been because the site selected was fairly shallow over a wide stream width. There is an enormous amount of data obtained from the data loggers and this will be synthesized in detail in the publications and MSc thesis being produced from this data. Parameters such as rate of change during different seasons could play a major role in life-history alternatives in the different species.

4.2 Macroinvertebrate biota sampled

4.2.1 *Summary of survey results*

Of the 616 samples collected to date we have gone though and sorted all 60 light trap samples identifying Trichoptera to species level, have checked the 240 SASS samples for possible mistaken identifications and have sorted and identified all 249 aquatic biotope, aerial hand-net collected, Malaise trap and Drift net samples (where partial identifications have been completed). Except for the selection of certain species, the additional 47 samples collected during the March 2009 survey of the upper catchment of selected rivers have not been incorporated into the study. Thirty-two aquatic samples that were sorted had Odonata and Plecoptera extracted and sent, together with all adults collected during the surveys, to Mr John Simaika and Dr Mike Picker for further detailed identification respectively. The nymphal Odonata were returned unidentified so identifications were carried out in the Albany Museum. Some Ephemeroptera specimens have been sent to two specialists in Germany, but most Ephemeroptera have been identified in the Albany Museum and verified by Mrs Helen Barber-James. Megaloptera have been preliminarily identified by the authors and await further analysis using molecular techniques. The sorting and identification of this enormous volume of material was only completed to an acceptably satisfactory level in January 2010. For ease of assessing the abundance and numbers of individuals and taxa per site and per species two spreadsheet tables are presented, the first dealing with all the aquatic stages of Trichoptera and the adult and aquatic stages of all other taxa collected during all four seasons (Appendix 4, Table A) and a second dealing with only adult Trichoptera collected during autumn, spring and summer (Appendix 4, Table B)

4.2.2 Ephemeroptera (Discussion with part contribution by H.M Barber - James)

4.2.2.1 Adult and aquatic stages

The mayfly (Ephemeroptera) fauna comprising 20 species collected during the surveys on these rivers between 2008 and 2009 have a unique combination of Western Cape and more northern, tropical elements. While the diversity of species varies between the different rivers (Table 9), there are distinct trends. Common to most of the sites investigated were the widespread species (*Afroptilum sudafricanum*, *Baetis harrisoni* and *Pseudocloeon vinosum),* which are known from rivers across southern Africa. Unique species included *Bugillesia* sp, collected from one site, the Upper Salt River. The only other record of this genus is from the Kruger National Park in South Africa (Gattolliat *et al*., 2009) and it is otherwise known only from Central and West Africa. The Matjies River also provided the only record of *Cheleocloeon excisum*, but the species is known from many sites around South Africa, from the Western Cape, Eastern Cape and KwaZulu-Natal. The Lower Storms River produced a species of *Nigrobaetis*, the closest relative to this being *Nigrobaetis bethunae* from the Cunene River (Lugo-Ortiz and de Moor, 2000): the other species are known from Sudan (Soldàn, 1977), Madagascar and Reunion (Gattolliat, 2004). These southern Cape species are certainly undescribed species. *Cloeodes* sp was collected from a number of sites; this was already noted in 2000, and is also almost certainly a new species. The genus *Cloeon* is in need of revision and it is currently not possible to name species with certainty.

Caenidae were not abundant or diverse in these rivers, with only *Caenis capensis* being collected during the survey period. However, a specimen of *Barnardara* sp. was collected in April 2004 from Site 4, on the Lower Salt River (de Moor et. al 2004).

The Leptophlebiidae and Teloganodidae are, without exception, locally endemic to the Western and southern Cape rivers. Firstly, considering the Leptophlebiidae: *Aprionyx* could not be identified to species level as a revision of the systematics of this group is needed, linking the life history stages (nymphs and adults). *Castanophlebia calida* was abundant and collected at most sites, while *Adenophlebia ?auriculata* was confined to the Matjies and Buffels Rivers and was recorded once on the Lower Salt River. *Adenophlebia peringueyella* a species better known from Western Cape Rivers (Barnard, 1932) was not recorded in any of the rivers in the recent surveys but was recorded from the Salt River in previous surveys. In the Eastern Cape and KwaZulu-Natal this species is replaced by *Adenophlebia auriculata* and in some forested areas by *Adenophlebia sylvatica*. It is not clear what may be limiting the distribution of *A. peringueyella* further eastwards. The higher pH recorded in the Matjies, Buffels and Lower Salt Rivers may have enabled *A. auriculata* to colonise these rivers. Molecular analysis of the *Adenophlebia* species would help to clearly elucidate species differences, as some of the morphological identification criteria become obscure.

The family Teloganodidae are considered to be a cold-adapted Gondwanan relict, with other members known from Asia (McCafferty and Wang, 1997; Sartori et al 2008), Australia and Madagascar (McCafferty and Benstead, 2002). The recent surveys have resulted in the collection of three further species, currently undescribed. All three were found in the Upper Salt River, but most were found at several other sites (Table 9). Two new species of *Nadinetella*, one from a number of sites, and one from the Salt River only were recorded during the present surveys. A new genus of Teloganodidae was also noted from several rivers. *Lithogloea harrisoni* previously recorded on the Upper Salt River was not recorded during the 2008-2009 surveys. *Ephemerellina barnardi* was very rare and recorded from Upper sections of the Bobbejaans, Elands, Lottering and Groot River East. It was previously also recorded in greater abundance along the Upper Salt River during winter. During the four surveys conducted the Elands, Matjies and Buffels Rivers recorded no Teloganodids. Again this is most likely because of higher pH of the water (Tables 3-6). All four known genera of the southern African Teloganodidae are recorded from the rivers flowing off the Tsitsikamma mountains and the Salt River records all of these from the present and previous surveys. The surveys have also revealed an undescribed genus and three undescribed species making the region the most species diverse for this family in Africa.

A species of Tricorythidae, *Tricorythus discolor*, was collected from the Upper Bloukrans River only. This species is relatively common in the Western Cape, where they can occur in abundance, the nymphs preferring rapidly-flowing and relatively large streams. *Tricorythus* species are widespread across Africa, but a revision of the generic placement is needed. Once this is done, *Tricorythus discolor* will be in a new genus along with a few other close relatives from other parts of southern Africa (Barber-James, 2008).

4.2.3 Plecoptera

4.2.3.1 Adult and aquatic stages

Both the aquatic nymphal stages and the aerial adult stages of Notonemouridae (stoneflies) are recorded in Table 10. Two species close to *Aphanicerca capensis* (form S and form P) are both considered as valid undescribed species (M. Picker pers. Comm.). The *A. capensis* form P was the more commonly encountered species and during this survey was recorded only in the Spring season from the Lower Elandsbos, and the Upper and Lower Bloukrans River. It was previously also recorded along the Salt River. *Aphanicerca capensis* form S was only recorded from the Upper Storms

River along a forested stream in Spring and Summer. There is also an unconfirmed record of this species from the Upper Elands River. The nymphs of *Aphanicerca* spp. were found throughout the year along several rivers being more abundant along the lower reaches of rivers. The nymphs of *Aphanicerca* sp. found in greater abundance during the Summer and Autumn seasons in the Elandsbos and Upper Storms River could represent the form S, of the species.

Aphanicercella bifurcata was found throughout all seasons at both upper and lower sites on a number of rivers (Table 10). The much rarer species *Aphanicercella nigra* was only collected from a Malaise trap set along the Upper Storms River during the Summer season. This species was, however, also previously collected from the Salt River during the Winter season together with *Aphanicercella cassida* (Barber-James, 2000; de Moor and Barber-James, 2001). Nymphs of *Aphanicercella* were recorded along most rivers during the surveys but the nymphs of this genus were more common during the autumn and winter seasons than during the Spring and Summer seasons. The nymphs of the genus *Aphanicercopsis* sp. were the most abundant of all notonemourid species recorded. Adults in this genus confirmed as *Aphanicercopsis outeniquae* were collected from the Upper Groot River West, Lower Lottering River and Upper Storms River in Summer and Autumn. They were also collected from the Salt River in a previous survey. The adults collected do not fit the description of this species perfectly so it may be that this abundant species represents either a new species or a divergent population of this species.

There are 31 species of Notonemouridae in six genera recorded in southern Africa (Stevens and Picker, 2003). Although only six species of Notonemouridae have been recorded from the Tsitsikamma Rivers three of these are considered as undescribed species. It is noted by that there is a high level of endemism in Notonemouridae and to ensure survival of species pristine conditions in rivers where they are found should be preserved. Stevens and Picker (2003) note that *Aphanicercella nigra* and the different forms of *Aphanicerca capensis* to be described as new species should be candidates for inclusion in a red data list for Plecoptera. This would also lead to recommendations regarding conservation and preservation of the catchment where these species are found.

4.2.4 Odonata

4.2.4.1 Adult and aquatic stages

A separate report using the Dragonfly Biotic Index (DBI) as a predictor of conservation importance is being produced to cover this part of the study (Simaika and Samways in prep) however the adult species collected are discussed here by the authors. In addition all adult and nymphal Odonata taxa recorded during the four surveys conducted during the study are presented in Table 11 and Table 19 respectively.

A total of 31 adult species were collected from 20 genera, from nine families. The most common species collected were *Orthetrum julia capicola* (Libellulidae) and *Allocnemis leucosticta* (Platycnemididae), both occurring at 17 sites, followed by *Pseudagrion furcigerum* (Coenagrionidae) occurring at 14 sites. Three species of Synlestidae were the next most common species, *Chlorolestes conspicuus*, *Chlorolestes umbratus* and *Ecchlorolestes nylephtha* occurred at 12 sites each. Unique or uncommon species are difficult to distinguish as 14 of the species were collected at two sites or fewer, making nearly half of the total number of species collected "rare" with respect to this study.

The adult Damselflies (Zygoptera) and Dragonflies (Anisoptera) do not show the distinct distributional patterns amongst these rivers that the Mayflies do. The Damselfly families collected during this study included the Coenagrionidae, Lestidae, Platycnemididae, Protoneuridae and Synlestidae. The Coenagrionidae are by far the most species-rich in the Tsitsikamma region, containing seven species from four genera. The widespread species include *Africallagma glaucum*, *Ceriagrion glabrum*, *Ischnura senegalensis*, *Pseudagrion hageni hageni*, *Pseudagrion kersteni* and *Pseudagrion massaicum* which occur elsewhere in South Africa and much of Africa; *Pseudagrion furcigerum* is however endemic to the southern Cape region (Tarboton & Tarboton 2005). Of these species, it is the endemic *P. furcigerum* that is most common, occurring at 14 of the 20 sites surveyed as well as being nearly four times as abundant as any other coenagrionid species and the second most abundant species collected .

The species collected from both the families Protoneuridae and Platycnemididae are endemic to South Africa, with the Platycnemididae boasting two endemic genera. *Elattoneura frenulata* is restricted to the South Western Cape, with the Tsitsikamma Mountains forming the eastern border of its range. *Allocnemis leucosticta* is distributed from the South Western Cape to the Soutpansberg and was the most commonly collected and widely distributed, species within this study. The lestid damselfly, *Lestes plagiatus* has a widespread distribution and is known to occur as far South West as Knysna (Tarboton & Tarboton 2005), but was only collected from the upper and lower Groot (East) River sites within this study. What has restricted its distribution further west into the Tsitsikamma region is unclear, although this is most likely an artefact of sampling.

The Synlestidae were represented by four species in this study, three from the genus *Chlorolestes* and one from the genus *Ecchlorolestes*. Out of nine species of synlestid that occur in South Africa, eight are endemic to the CFR, with the majority of these having very restricted ranges (Samways 2008). *Chlorolestes conspicuus* and *C. umbratus* were the most common synlestid species, both occurring at twelve sites but neither species was collected from the Matjies and Buffels Rivers. *C. tessellatus* was not as common as these species, occurring at only six sites, three of which were the upper and lower Buffels and upper Matjies River sites. This may be due to the tolerance of this species to a wider range of habitat conditions, as seen from its distribution pattern across South Africa from the Cape through to KwaZulu-Natal, while *C. umbratus* and *C. conspicuus* are restricted to the southern Cape and coastal Eastern Cape, and the southern Cape respectively (Tarboton & Tarboton 2005). *Ecchlorolestes nylephtha* is a narrow endemic known primarily from the Tsitsikamma region (Tarboton & Tarboton 2005). During this study it revealed a similar distribution pattern to other endemic species, occurring at twelve sites, further indicating that where the endemic species occur, they are the most common and are restricted to a very specific suite of environmental conditions, which has serious implications for conservation of these endemic species.

The Aeshnidae, represented by three species from two genera, were not abundant anywhere; this is to be expected of large territorial, predatory taxa (Moore 1952; Corbet *et al* 1960; Kormondy 1961). Both *Aeshna minuscula* and *Aeshna subpupillata* are endemic to South Africa, where *Aeshna minuscula* has a more restricted (disjunct) range, occurring in the Drakensberg and the South Western Cape. The remaining Aeshnid species, *Anax speratus* is cosmopolitan in distribution and common from the Cape through to central East and West Africa in areas of high rainfall (Tarboton & Tarboton 2002). The two species of Corduliidae, *Syncordulia venator* and *Syncordulia gracilis* are both South African endemics, the former being a Cape endemic. These species occur sympatrically in the Tsitsikamma region as both were collected from the lower Storms River, a site that was particularly rich in dragonfly species. Only one species of Gomphidae was identified during the survey, *Ceratogomphus triceraticus*. Collected from the lower Bloukrans River site, this species is very shy and not easily caught (Samways 2008) and could possibly occur elsewhere in the Tsitsikamma region as gomphid nymphs were collected from the upper Lottering River but could not be identified to species.

The Libellulidae collected represented seven genera, *Crocothemis, Nesciothemis, Orthetrum, Palpopleura, Sympetrum, Tramea* and *Trithemis*. *Two species Crocothemis erythraea* and *Crocothemis sanguinolenta*, are common and are distributed throughout South Africa and extend north into Africa, with *C. erythraea* also extending into Europe (Samways 2008). Despite this, these two species were only collected from a total of five sites, *C. erythraea* from three and C. *sanguinolenta* from two. Their distributions within the study did not overlap though. *Nesciothemis farinosa* was collected from two sites, and like the *Crocothemis* species, is also a cosmopolitan in its distribution, ranging from Cape Town to southern Arabia, despite being rarely collected during this study. The *Orthetrum* species, consisting of *O. abbotti* and *O. julia capicola* showed very different trends in their distributions within this study. *Orthetrum abbotti* was recorded from one individual from a single site, the upper Elands River while *O. julia capicola* was the most widely distributed species, occurring at seventeen sites, along with *Allocnemis leucosticta*. *Orthetrum abbotti*, like all the Libellulidae discussed thus far, is a widespread species while the subspecies *O. julia capicola* is locally endemic to the South Western Cape region, west of Humansdorp, which lies on the far eastern edge of the Tsitsikamma mountains. East of Humansdorp, *O. julia falsum* occurs north through to tropical Africa (Tarboton and Tarboton 2002). *Palpopleura jucunda* and *Sympetrum fonscolombii* were both only collected from the upper Elands River and lower Groot River (West) respectively. Both species are widespread and common along the south east coast of South Africa and into Africa, with *S. fonscolombii* occurring into Europe and Asia too (Samways 2008). Only a single species of *Tramea*, out of a possible two occurring in South Africa, was collected. *Tramea limbata* is rare in the Highveld, but a common species throughout the coastal areas of South Africa, particularly northern KwaZulu-Natal. This species continues the trend of the cosmopolitan species being locally rare, as only a single *T. limbata* specimen was collected from a single site, the lower Groot River (East), a similar situation to *O. abbotti*, *S. fonscolombii* and *P. jucunda*. A total of three species were collected and identified from the genus *Trithemis*, viz. *Trithemis arteriosa*, *Trithemis furva* and *Trithemis stictica*. All three species are described as very common throughout South Africa (Samways 2008), but *T. furva* and *T. stictica* occur at fewer than half the sites within this study making these two species exceptions from the general trends described above.

4.2.5 Megaloptera

4.2.5.1 Adult stages

Two adult species of Corydalidae were collected during these surveys (Table 12). The first species, *Platychauliodes* sp. TSR11A, looks superficially similar to *Platychauliodes woodi* from the Western Cape with minor differences in the wing pattern and venation. It was collected only in the summer period in January during both 2008 and 2009. It was common but not abundant. The second species, *Patychauliodes* sp TSR48B, was collected from the Lower Lottering River in April 2008 and from the Upper Bloukrans River in late March 2009 and can therefore be considered to be an autumn species. A third species, *Chloroniella peringueyi*, was recorded from the Salt River in November 2000. It can therefore be considered to be an early summer species. The recording of this species extends its distribution further east from Knysna.

The South African Megaloptera have two families: Sialidae with only a single species *Leptosialis africana* (not recorded in this study), and Corydalidae with six species in three genera. There are four described species of *Platychauliodes* and one each of *Chloroniella* and *Taeniochauliodes*. All known species are endemic to South Africa. All three genera have been recorded in the southern Cape (Mansell, 2003).The family was last worked on and had South African species described by Esben Peterson (1924) and Barnard (1931, 1940). Megaloptera are considered to be a relict group with a restricted distribution in the mountainous regions of the western, southern and eastern Cape, Kwa-Zulu Natal and Mpumalanga. A revision of the South African Megaloptera needs to be undertaken as larval and adult stages of these insects cannot be correlated.

4.2.5.2 Aquatic stages

Aquatic larvae of Corydalidae were collected from all the rivers except the upper Matjies and Lower Elands Rivers (Table 12). It was considered from external morphological features that two species of Corydalidae were involved: *Platychauliodes* sp was more common than *Platychauliodes* sp1. It is not possible to link the larval stages with adults and therefore it would be difficult to assess whether the species belonged to either of the two adult species collected during the surveys.

4.2.6. Trichoptera

4.2.6.1 Adult stages

During the four surveys undertaken, a total of 42,683 specimens of adult Trichoptera, from 47 species, were identified and a total of 51 species are now recorded for the rivers of the Tsitsikamma mountains. There are 17 undescribed species and an additional two species of *Oecetis*, collected only as females, that could prove to be undescribed species. These surveys add a further seven undescribed species as well as more material of some of the undescribed species that were collected in previous studies on the Salt River. Four species collected along the Salt River previously were not recorded during the three survey periods conducted during this study. A table of adult Trichoptera collected over the entire period indicates the abundance of species collected (Table14). This data also presented in spreadsheet format indicates the occurrence and abundance of the total number of Trichoptera and species at all the sites for the entire period (Table B). In addition, seasonal presence and abundances of species for the Autumn (April 2008), Spring (October 2008) and Summer (January 2009) periods are also recorded in separate sheets within this table.

The summer period (January 2009) produced the greatest diversity (38 species) and largest number of Trichoptera specimens (24,080) collected. The autumn period (April 2008) produced 31 species and 17,418 specimens and the Spring period (October 2008) only recorded 21 species, comprising 1184 individuals. The cooler weather in Spring undoubtedly influenced the success of light trap collecting with only Chironomidae being collected at the Lower Elands and Upper Groot River East during this time (see Table A Spring).

Considering that the upper and lower sites selected on the rivers show quite an altitudinal range overlap as regards upper and lower river site designations, it is appropriate to keep in mind the altitudinal differences for the sites along each river. Sites on the upper and lower Buffels and Matjies Rivers differed by only 29 metres (61 and 32 masl) whereas the upper and lower Groot River (West) differed by 300m

(313 and 13 masl). This was a reflection on the nature of the rivers and the difficulty in getting access to sites suitable for all the sampling requirements of the surveys. The lower sites were between 2.7 -6.5 km from the river mouths so would not have had estuarine influences. The upper and lower sites on the rivers do not show significant differences in Trichoptera species diversity (Mann Whitney U-Test P>0.1) but numerical abundances of Trichoptera were significantly higher at the lower sites (Mann Whitney U-Test P<0.05). Light trap collections from the upper Bobbejaans River recorded the highest number of adult Trichoptera species (25) followed by the Lower Storms River (21), Upper Elandsbos (19) and Upper and Lower Lottering River (18 and 17, respectively) , Upper Salt River (16) and Lower Groot River West and Upper Storms River (15 each).

The most common and abundant species collected was *Athripsodes bergensis,* collected at all 20 sites, followed by *Chimarra ambulans* recorded at 14 sites. *Oecetis modesta,* collected at 15 sites, was common but never abundant.

Although light trapping is the most reliable method for collecting adult Trichoptera, this method does not always succeed in collecting all species, mainly because not all species are attracted to light. When a limited amount of collecting is undertaken weather conditions may influence flight activity of Trichoptera which also affects the success of light trap collection. In such cases there may be nights when no species will be recorded at certain sites. It was considered that the additional collecting efforts made would assist in getting a more accurate recording of the Trichoptera found at each site. Perusal of the aquatic samples, collected both for the detailed species analysis and for the SASS5 water quality determination, revealed more complete species distribution patterns and these were used for compiling a more complete inventory of species collected and for a multivariate analysis of the data (see section 4.2.8 below).

4.2.6.2 Aquatic stages

The Trichoptera from the handpicked samples, although they could not all be identified to species level, provided a considerable source of further information on species distribution and relative abundance. Whereas the adult light trap sampling provides an integrated estimate of species presence and relative abundance at the time of sampling, the aquatic stages live longer and provide an estimate of species presence and relative abundance in specific aquatic biotopes. This, however, means that rare and cryptic biotopes that fulfill certain species-specific habitat requirements may be missed. For this reason, collecting for diversity of species will have a different emphasis to collecting for abundance and population size estimations of selected species.

Table 13 gives an overview of the aquatic stages of species collected and what is immediately obvious is that *Barbarochthon ?brunneum* was found in abundance at all sites except the Buffels and Matjies Rivers, the Lower Groot River East, Lower

Elands River and (although there is one enigmatic record) the Lower Salt River. This single record of *B. ?brunneum* is considered not to reflect the natural situation as this species was never recorded in the many surveys conducted between 2000 and the 2008-2009 surveys. *Agapetus murinus*, *Dolophilodes urceolus* and *Sciadorus obtusus* display a similar distribution pattern to that shown by the adults although the data supplements the adult data by providing additional records at various sites.

Larvae of a hydroptilid (sp. TSR152G) that cannot be placed in any known South African genus, were collected in the lower Bloukrans River and this is the only additional record of an undescribed species that can be added to the list of 47 adults plus the four species previously recorded from the Salt River. The larvae of the hydropsychid *Cheumatopsyche* TSR136E are almost certainly those of the adult *Cheumatopsyche* TSR539K. There are a large number of different types of leptocerid larvae that could represent further species not collected as adults during the four surveys conducted. Some of these larvae as well as the many adults (Table 13) will be studied in more detail using molecular systematic techniques to verify species identification status.

4.2.7 Diptera (Simuliidae)

4.2.7.1 Aquatic stages

Only the larval and pupal stages of Simuliidae were collected during the study. There are 39 species of Simuliidae recorded in southern Africa (Palmer and de Moor 1998). During the 2008-2009 surveys a total of 9881 individuals comprising ten species of *Simulium* were recorded (Table 15). The two most abundant and common species were *S. vorax* and *S. merops* occurring at 16 and 17 sites respectively (Table 15 and Appendix 4, Table A). The larvae of one species of *Simulium* collected from the Lower Bloukrans and Upper Groot River West belong to an undescribed species. This was also previously collected in the Salt River. Pupae and adults need to be collected or larvae reared through to adults to complete the study to describe this as a new species.

For an indication of local flow conditions *S. vorax* indicates faster flowing conditions than the closely related *S. medusaeforme*. *Simulium dentulosum*, a cascade loving species, was only recorded from the Upper Buffels and Upper Bloukrans Rivers. *Simulium hessei*, a rare species also found in cascades, is a SW Cape endemic. It was found in very low abundance at four sites. *Simulium merops* is also a SW Cape endemic species that is restricted to cool acidic waters and its distribution and abundance in samples collected confirms this (Palmer and de Moor 1998). The presence of both these SW Cape endemic species' indicates excellent water quality. *Simulium bequaerti* is a warm-water species considered absent from the SW Cape. Its occurrence in the Lower Elands and Lower Groot River East extend its western distribution range. This species and the two above-mentioned endemic SW Cape species could possibly be used to monitor the effects of global warming.

Simulium impukane and *Simulium rutherfoordi* are widespread mountain stream species found in slow- flowing water. The former species was restricted to the western rivers during these surveys while the latter mentioned species was more widely distributed and abundant. *Simulium nigritarse* is one of the most widespread common species in South Africa and is found under a wide range of flow and water quality conditions. It is considered that this species may comprise a complex of up to 19 separate species that are very difficult to distinguish morphologically (Fain and du Jardin 1983). It was found at nine sites but was only abundant in the Upper Elandsbos River.

4.2.8 Analysis of community ordination of biota at the river sites

Information from the distribution and abundance analysis of taxa collected was further examined using Principle Component Analysis (PCA) and Detrended Correspondence Analysis (DCA) techniques (ter Braak and Smilauer 1998) to examine the ordination of sites based on the taxa and ascertain if there was a clear grouping of river sampling sites that could be used to identify rivers for conservation selection (Figs 4-7; 9-12). Based on the majority of taxa recorded the Buffels and Matjies Rivers group together separately from the other rivers in all the analyses done. The sites along the lower reaches of the Groot River East, Elands and Salt River also group together in the PCA analyses and are closest to the Buffels/Matjies River cluster. This indicated some form of disturbance as also recorded for the physicochemical ordination of river sites (Figs 2-3). A log transformed PCA of the adult Trichoptera abundance data also ordinates the Buffels/Matjies Rivers and reveals close similarities linking the upper and lower sites on the rivers as separate groups with one exception the Lower Lottering River (Fig6). This anomaly can be explained because the Lower Lottering is at an intermediate altitude (218 masl) whereas the other lower river sites, except for the Elandsbos River, are all between 14-65 masl. An ordination based on the log-transformed hand-collected aquatic fauna groups the four most species rich and near pristine upper sites together with the Lower Elandsbos River.

The analyses carried out on the adult Odonata (Figs 9-12) show similar results to those of the analyses carried out on the Trichoptera , Ephemeroptera, Plecoptera and Megaloptera (Figs 4-7). The Matjies and Buffels River sites ordinate separately, along with the Lower Groot (East) river site, while there seems to be little discernable signal in the data regarding the remaining 16 sites. In summarising the adult Odonata show similar yet less distinct trends in distinguishing sites based on aquatic invertebrate taxa. Over all though, three sites comprising the Buffels/Matjies River clearly come out as a distinct group. The Lower Elands, Groot (East) and Lower Salt Rivers show signs of having been modified and disturbed. The upper and lower sites on the rivers also show clearly a distinct separate grouping pattern.

5. DISCUSSION

5.1 Comparison of the eleven rivers surveyed with previous Salt River surveys

During the two surveys conducted on the Salt River in 2000 and the one survey conducted in 2004 three undescribed genera and 16 undescribed species were recorded (Barber-James 2000, de Moor and Barber-James 2001, de Moor et al 2004, de Moor 2007).

A total of 21 species in 18 genera in five families of Ephemeroptera were collected during the three previous surveys along the Salt River. It was ascertained that the *Cloeodes* species -- tentatively identified as *C. inzingae* -- is in fact an undescribed species, and further research on this will be carried out along with several other species of this genus from southern Africa and Madagascar. Of further interest is the undescribed species of *Barnardara* from the Salt River which was not collected during the most recent surveys. This was an interesting record as the genus is currently only known from more tropical regions within South Africa. *Afronurus peringueyi* was common along the Salt River in the earlier surveys. *Afronurus barnardi* was recorded from both the upper and the Lower Salt River in December 2000 but only *A. peringueyi* was recorded from several of the 11 rivers during the 2008-2009 surveys. These two species are superficially very similar, and adult material is required to confirm their identification. Nymphs of *Aprionyx* sp. that could not be confirmed to species level were recorded in several biotopes at all sites along the Salt River in April 2004. Several of the known *Aprionyx* species have not been described as nymphs, and it is important to rear mature nymphs to adults, to confirm if they are a known, or an undescribed species. Molecular techniques could also be employed to help resolve this problem.

Lithogloea harrisoni and the species recorded as *Nadinetella brincki* were recorded at the Upper Salt River in April 2004 whereas they were recorded all the way down to the Lower Salt River in December 2000. It is apparent that the nymphs previously recorded as *Nadinetella brincki* and *Nadinetella crassi* are actually the undescribed species *Nadinetella* TSR173E and *Nadinetella* TSR378K recorded in the 2008-2009 surveys. The undescribed Genus sp TSR151A is also a Teloganodid mayfly previously recorded from the Salt River.

In summary of the 20 species of Ephemeroptera recorded in the 2008-2009 survey only *Bugillesia* sp and *Nigrobaetis* sp are new undescribed species that can be added to the list of Ephemeroptera not previously recorded from the Salt River. The records of the 21 species of Ephemeroptera from the earlier Salt River surveys add *Afronurus barnardi*, *Adenophlebia peringueyella*, *Aprionyx pellucidus* and *Barnardara* sp. not recorded from any of the other rivers flowing off the Tsitsikamma Mountains during the 2008-2009 surveys. The total number of new undescribed species of Ephemeroptera for the region now stands at one or two new genera and nine species.

During the 2000-2004 surveys all the species of Notonemouridae recorded during the 2008-2009 surveys were also recorded and only the differentiation of the forms S and P of *Aphanicerca capensis* were recognised as different species during the recent surveys. All these species except the one form of *Aphanicerca capensis* have been recorded from the Salt River.

The 2008-2009 surveys represented the most comprehensive study of the Odonata of the Tsitsikamma region that the authors are aware of. An additional 18 species were collected that were not recorded from previous surveys in the region.

Two species of *Platychauliodes* were recognised during the 2008-2009 survey. *Chloroniella peringueyi* was recorded from the Salt River previously but not in the recent survey.

In the Trichoptera 29 species in 18 genera in 11 families had been recorded in the Salt River previously and of these 17 species were recognized as SW Cape endemic species (de Moor 2007). Of these species, one genus and 11 species were recognized as undescribed after the 2004 survey of the Salt River. *Barbarochthon ?brunneum* is considered to possibly be a new species. A molecular study conducted on specimens from the southern Cape and further afield by Keevey (2007) revealed that there was considerable genetic differentiation between larval populations of *Barbarochthon* sp. from the Southern and Western Cape, the latter of which is the type locality of *Barbarochthon brunneum*. Further research is needed to refine this analysis and good collections of adult male material would help with resolving if there are any morphological and behavioral differences that would warrant separate species recognition. What was recognized as *Athripsodes schoenobates* in the 2000-2004 Salt River surveys has, with further close examination, revealed small morphological differences that would suggest that this represents an undescribed species, *Athripsodes* TSR472C. The collection of adult *Agapetus murinus* confirm that this is the only species in this genus presently recorded in the southern Cape.

The recent 2008-2009 surveys produced a further 19 species not recorded from the Salt River previously, and of these seven are new undescribed species with a possible further two species of *Oecetis* collected only as females that could also be undescribed species.

In summary of the 48 species of Trichoptera recorded during the 2008-2009 survey, 20 species were not recorded from the Salt River. In addition, there is one genus and 11 undescribed species that were not recorded from the Salt River but have now been found only on some of the other rivers in the Tsitsikamma region. They include Hydroptilidae Genus TSR152G from the Lower Bloukrans River, *Orthotrichia* sp SCR164A from the Bobbejaans River (also recorded from the Kouga River catchment), *Ecnomus* TSR39K from the Lower Groot River East, *Parecnomina* TSR545 from several rivers. A new distribution record for *Paranyctiophylax* SCR213T from the Lower Bloukrans and Lower Storms Rivers (also recorded from the Kouga River catchment), and further new species; *Dyschimus* TSR28S from the Upper Storms River, *Leptecho* TSR491i from the Lottering and Bobbejaans Rivers, *Leptecho* TSR363H from the Upper Elandsbos River, *Oecetis* TSR13B from the Lower Buffels and Lower Groot Rivers, *Oecetis* TSR547L from several rivers, and *Petroplax* TSR447E from the Lower Groot West and Lower Storms Rivers. There is also one new genus and species of Dipseudopsidae only recorded along the Salt River. When compared with the other 10 rivers surveyed, the Upper Salt River produced the highest number of undescribed Trichoptera species totaling nine. The Upper Bobbejaans and Lower Storms River each produced seven of the undescribed new species and each of these rivers also recorded one unique new species. The Lottering River produced six of the new species but none of these was unique. The Elandsbos River produced six of the undescribed species of which one was unique. The Lower Buffels, Lower Groot West, Upper Bloukrans, Upper Storms, Upper Elands and Upper Groot East Rivers each produced four of the undescribed species. In addition the Lower Buffels, Upper Storms and Lower Groot East Rivers each contributed a unique new species.

The total number of new undescribed species of Trichoptera for the region surveyed now stands at two new genera and 20 species.

For the Diptera (Simuliidae) the surveys between 2000-2004 recorded five species for the Salt River which comprised *Simulium dentulosum*, *Simulium medusaeforme*, *Simulium merops*, *Simulium nigritarse* and an unknown species of which larvae and pupae could not be placed. This was considered as a possible undescribed species but adults would be needed to confirm this. In the survey of the 11 rivers carried out in 2008-2009 ten species were collected including the larvae of what appears to be a second undescribed species. All species collected previously except for *Simulium dentulosum* and the one considered to be a new species were recorded from the Salt River in 2008-2009. In addition *Simulium rutherfoordi* and *Simulium impukane* were also recorded. It is thus possible that there are now two undescribed species of Simulium from the region; one species recorded from the Salt River, and the second one from the Upper Groot River (West) and Lower Bloukrans River.

5.2 Assessment of the Conservation status and importance of the Tsitsikamma hydrobiological region on a Regional and National scale

Taking the Trichoptera as an example to illustrate the regional and National diversity of aquatic macroinvertebrates in southern Africa, the following figures can be calculated. There are 85 species of Trichoptera recorded by de Moor and Scott (2004) in the SW and southern Cape hydrobiological region, designated as 'Region A' by Harrison (1959). This figure was re-estimated in December 2005, following research undertaken in this region, and had increased to 111 species (de Moor 2007). With the data from this survey added, this now increases further to an estimated 123 species of Trichoptera.

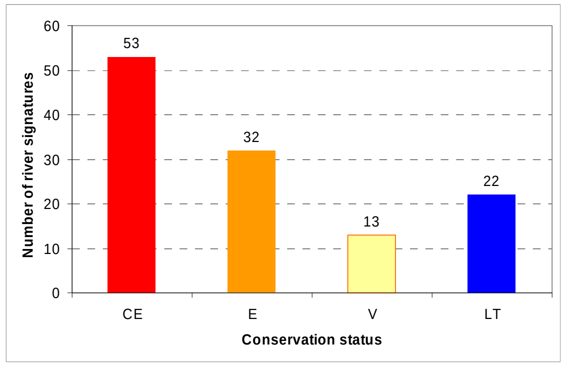
The rivers flowing into the sea off the Tsitsikamma mountains form a small subregion within Harrison's hydrobiological region A and this is designated as the southern Cape 'Region K' (as classified by DWAF). There are currently 51 species of Trichoptera recorded in this region indicating that 41.5% of Harrisons Region A Trichoptera species are represented here. Taking this further and examining this from a South African perspective this clearly shows that Region A contributes the largest diversity of Trichoptera in South Africa with 73.2% of the species endemic to the region (Table 16).

From a perspective of determining the uniqueness of rivers there is a protocol that has been developed for classifying rivers in cases where only limited biological information is available from surrounding rivers (Roux et al. 2002). There are a number of short, small-catchment Rivers that flow from the Tsitsikamma mountains directly into the sea without passing through extensive floodplains. From a biological perspective there are three rivers in the 11 rivers studied in the southern Cape 'Region K' that do not have any fish (Table 17). Furthermore, all the rivers have two distinct assemblages of aquatic macroinvertebrate communities: the first an upper mountain stream biota; and secondly, biota downstream in the foothills. Unfortunately a detailed profile survey of sites to identify the downstream changes in communities, as was done for the Salt River during the earlier studies, could not be carried out in the rivers selected for this study due to time constraints and the large number of rivers that had to be surveyed. Access to the upper and in some instances lower sites on the rivers was also a limiting factor. Nevertheless it is possible to characterise the upstream and downstream fauna by focussing on certain species of Trichoptera, Plecoptera and Ephemeroptera. These aquatic insects are indicative of a very ancient history, dating back to around 135 million years. The recent surveys (2000-2009) have uncovered no fewer than four possible undescribed genera and 33 undescribed species. From a local, regional and National perspective this makes these rivers worthy of special conservation measures.

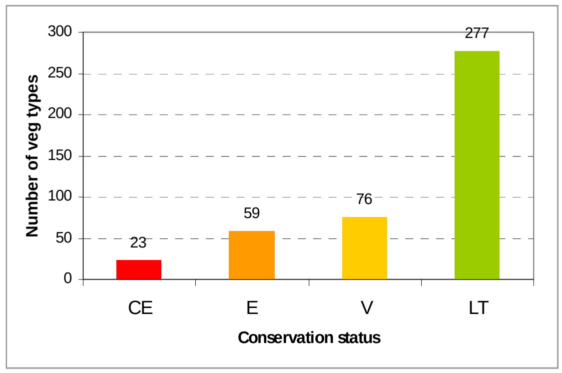
The surveys of these rivers have revealed an exceptionally high diversity in CFK (Cape Floral Kingdom) endemic aquatic insects and hence, because they are closely approximated rivers, they can, as they must have done in the past, serve as refuges during times of environmental stress when local extinctions could occur. The rivers in which primary fish species have not been recorded (neither indigenous nor exotic aliens) are also special and it is no co-incidence that that all three of these rivers (Salt, Bobbejaans and Lottering Rivers) have been identified as being of high conservation importance. The Bobbejaans River recorded the highest diversity of species and the Upper Salt River contains the highest number of new undescribed species. The Lottering River recorded high numbers of some of the new undescribed species. It is during times of stress, such as droughts, that such rivers can maintain sufficiently large populations of these endemic species in small areas without the additional pressure from predation by fish. Via the adult phases of the life cycles, these species can then re-colonise adjacent streams along the upper catchments and via forest corridors.

In order to gain some perspective on the Regional and National significance of the rivers surveyed it should be noted that these rivers are but a few of the many acid-pH rivers that form part of the southern and south-western Cape Fynbos biome (or CFK), a region that has been designated as being of both National and International conservation significance. An earlier comparison of the species numbers, from four important orders of freshwater insects, collected in the Salt River in the southern Cape with those of the Great Berg River (another acid river, from the Western Cape) (de Moor et al 2004) puts the regional conservation value of the rivers of the Tsitsikamma mountains into perspective. It should be noted that the collecting effort of the Great Berg River was intense, with samples being collected at 13 sites on a monthly basis over a full annual cycle (Harrison & Elsworth 1958; Scott 1958) compared to three brief surveys carried out in the Salt River between 2000 and 2004 (Table 18). The recording of more Trichoptera species in the Salt River than those recorded in the Great Berg River (a much larger river) gives some indication of the high diversity of species found in the Salt River. The present survey results reinforce the recommendation of the previous reports relating to the proposed proclamation of the Salt River and some of the other eleven rivers surveyed as sanctuaries for freshwater aquatic macroinvertebrates.

A



B



Comparison of conservation status of the classified number of **A.** river signature types of ecosystems, with the identified number of **B.** terrestrial vegetation types. CE=Critically Endangered, E= Endangered, V=Vulnerable, LT= Least Threatened. Figure taken from Anon 2004.

In an assessment on national spatial biodiversity patterns prepared by Environmentek (Anon 2004) it was noted that there was a need to place more emphasis on the conservation of biodiversity in rivers. While acknowledging the need for the conservation of rare and endangered species, the need to conserve threatened ecosystems was also strongly emphasized. A comparative study revealed that only 23 out of 435 terrestrial vegetation types were considered as critically endangered, whereas 53 out of 120 unique river signatures (each identifying a specific type of river) were critically endangered (see Figure above).

The signature type typifying the Salt River was identified in the vulnerable class (Anon 2004). This classification is based only on the eco-regions, geomorphological and hydrological features of a river and does not take aquatic biota into consideration. The high number of endemic families and genera of aquatic insects recorded in the rivers in the Tsitsikamma Mountains has been typified by many of the rivers studied in this survey. Two of these rivers, the Salt River and Lottering River, have the additional feature of being rivers with no primary freshwater fish, from the headwaters to the coast. This means that the macroinvertebrates of such rivers have evolved under unique conditions in terms of predation pressure, which has many implications in terms of morphological and behavioural evolution. Such factors are of great importance when assessing the conservation status of particular biotopes and ecosystems. There is no doubt that such rivers are unique and worthy of special conservation protection at a national level.

5.3 Selection of rivers for special conservation attention

Based on the four recent surveys and the previous studies conducted on the Salt River the main criteria for a selection of a river, or rivers, for special conservation attention can be summarized as follows. The surveys have produced four undescribed genera and 33 undescribed species and a family (that was previously recorded but not reported on) that is new for the region. Clearly a consideration of the rivers of the Tsitsikamma Mountains is an important component to consider in the context of conservation planning ensuring the continued protection of our natural heritage and biodiversity.

In the ordination analyses conducted (Figs 2-7) the Buffels and Matjies River cluster together as regards water chemistry and species composition and they can be considered as a separate cluster of rivers deserving individual attention. These rivers contribute one unique undescribed species of *Oecetis* and a further four of the undescribed species of Trichoptera recorded during these surveys but only widespread species of Ephemeroptera, Plecoptera, Megaloptera and Odonata. Some of the regionally important endemic species are, however, represented and the fauna found there must be considered to be adapted to the conditions in these rivers that are different from the other clusters of rivers produced in the ordination analyses.

The lower sites surveyed on the rivers also ordinate in two clusters (Groot East, Groot West, Salt and Elands Rivers) and (Storms, Elandsbos, Lottering and Bloukrans). The first mentioned cluster includes the lower rivers that show evidence of anthropogenic chemical and physical disturbance. They contribute one unique undescribed species of *Ecnomus* and eight of the new species of Trichoptera shared with other rivers in the region. There were no unique species, but three of the new species of Ephemeroptera were recorded on the Lower Groot River West. The second cluster of Lower river sites in the ordination produced no unique new species but nine of the undescribed species of Trichoptera shared with other rivers, seven of these species were recorded on the Lower Storms River, which was also the lower river site with the greatest diversity of Trichoptera (21 species) with a third of the species regarded as undescribed. One unique new species of Ephemeroptera on the Storms River and another three of the new species were found in this cluster of rivers.

The upper rivers all group together in the ordination analysis and therefore can be considered as a separate group for conservation selection. The Bobbejaans River is the single river that stands out as producing the greatest diversity of Trichoptera (25 species) including one unique new species and seven of the undescribed species recorded. With previous survey records included, the Salt River records two unique species and is the river with the highest number (totaling nine) of the undescribed species. The most recent surveys on the Salt River record 16 Trichoptera species. The Lottering and Elandsbos Rivers record 19 and 17 species of Trichoptera respectively, with one unique species and each river also recorded five undescribed species. Ephemeroptera also attained their highest number (11 species) including one unique species and six undescribed species on the Salt River. The Elandsbos River also produced 11 species with four of these belonging to undescribed species also recorded from the Salt River. The Salt River also records all species of Teloganodidae found in the region and in terms of the conservation of Ephemeroptera this is the most important river.

5.4 Future threats

The threats to river health and conservation status identified for the Salt River (de Moor et al. 2004) also apply to most of the rivers surveyed during this study. They are listed below.

g. Reduction in flow due to water abstraction for various purposes. Reduced runoff yield resulting from increased biomass of alien vegetation that has invaded the riparian zone will also cause a reduction in flow volume.

h. Increase in water temperature due to reduced flow volume and global warming. The indigenous biota is adapted to cool summer water temperatures.

i. Decline of water quality (increase in pH and nutrient loads in rivers). Development along the riparian zones of rivers, discharge of treated sewerage and industrial wastes as point sources of pollution and diffuse runoff of waste matter from development along the riparian zone of the rivers.

j. Invasion of alien fish into the rivers and the introduction of either alien or indigenous fish into the fishless rivers.

k. Sedimentation in rivers due to clear felling of plantation forests, land clearing, road building and other anthropogenic developments.

l. Possible poisoning of the rivers by pesticides, herbicides and cattle dips

The impacts of all the above threats are all exacerbated by a decrease in water flow volume and this must be seen as the most serious threat to the continued survival of the adapted indigenous biota found in these cool, acidic southern Cape Rivers.

6. CONCLUSIONS

6.1 Findings of the study

The upper reaches of all the Tsitsikamma Rivers are important to maintain and conserve the full diversity of endemic CFK species. These rivers should also be considered as being important for the conservation of adjacent rivers, as migration between rivers enables recolonization during times of environmental stress. As such, indigenous forests and fynbos along the upper reaches of rivers should be conserved to maintain migration corridors where species exchange between catchments can occur. This will also maintain good quality water at a sustained rate in the rivers by preventing excessive sediment discharge and by filtering rainfall and regulating water discharge by recharging aquifers .The conservation of rivers without freshwater fish is also considered to be a very important aspect as this will maintain large populations of indigenous aquatic insects, keystone species in maintaining aquatic ecosystem functioning.

Some of the most serious threats to the survival of the rare endemic species are increases in sediments, nutrients and pH and a decrease in flow volumes which leads to an increase in water temperature. Mitigation measures that can be implemented to help this cause are mentioned. Development of land which leaves soil exposed is a threat since it causes increased sedimentation. Prohibition of the 'clear felling' of vegetation should be recommended. If land must be cleared then this should be done in an ecologically sensitive manner and mitigating actions, such as the construction of berms, as recommended in Allanson (2002), should be taken to ensure against excessive runoff of sediments into the rivers.

Increased nutrients cause eutrophication and replacement of the moss, growing on stones that support the endemic CFK aquatic insects, by filamentous algae. Increased nutrient loads also lead to elevated pH and this will place stress on, and eventually eliminate, the species that have adapted physiologically to live in the acid, oligotrophic waters of the region. Adoption of irrigation procedures that minimize the amount of nutrient runoff from pastures and turf fields as recommended by Schuman (2004) should be implemented wherever farming occurs.

If good quality water is maintained then it will require minimal to no purification for human consumptive use. The quality of water is one aspect that is reflected by the community structure of aquatic invertebrates and a diverse natural community of aquatic invertebrates act as good indicators of water quality. Natural communities of filter feeding and other functional feeding groups of invertebrates, help remove unwanted organisms such as bacteria from the water and hence serve as protectors of the water quality. Many of these invertebrates can be identified as keystone species that play a vital role in maintaining the natural ecological status of the river ecology. The right balance of filter feeding, detritivore collectors, shredders of decaying leaf litter and predators is very important and from the information gathered during this study it should be possible to identify keystone species for selected rivers.

The endemic CFK aquatic insects are adapted to cool water conditions with high levels of dissolved oxygen. It is vitally important to ensure that a sufficient quantity of water flows down the rivers at all times to maintain oligotrophic conditions and cool water temperatures. This will maintain the adapted indigenous invertebrate fauna. Any form of flow reduction should be carefully monitored and the impact of this on the invertebrate community should be kept to a minimum. The effect of reduced water quality in the rivers would be minimized by maintaining the highest natural flow volumes possible.

7. RECOMMENDATIONS

7.1 Research, monitoring and conservation management recommendations

- To conserve CFK functional ecosystems, there is a need to focus on conservation of important keystone species and not only rare or new species found. These need to be identified and evaluated.

- The status of all the new undescribed species needs to be ascertained, and until known their environment needs to be protected.

- Conduct a detailed conservation planning exercise to ensure representation and persistence of biodiversity is addressed (Nel et al. 2010 in press) and identify rivers that would fulfill such requirements. This would involve a workshop with the various researchers and affected parties involved. GIS planning would form a fundamental component of this exercise.

- For developing a conservation plan for the Tsitsikamma Mountain's rivers a combination of the Biodiversity Act, National Environmental Management Act, Spatial Development Framework and Water Act should be invoked to motivate a request for higher flow levels in the selected rivers. For the Salt River a water management plan for the whole catchment and a full reserve determination and biodiversity provisions should be considered.

- Conservation of the lower zones of rivers to remain ecologically functional as CFK Rivers is important.

- To allow connectivity of the upper, middle and lower reaches of rivers a 30-50m wide protected corridor of indigenous riparian vegetation should be established along all rivers where possible.

- To allow connectivity between the upper catchments of rivers indigenous forest and fynbos should be preserved so that natural intercatchment migration of flying insects is enhanced.

- Undertake routine surveys annually to monitor the diversity of aquatic insects to assess changes and take remedial action to maintain viable population levels of the indigenous and CFK endemic species in all river reaches of the rivers selected for conservation.

- Monitor water quality and flow using SASS5 and water chemistry parameters such as pH and nutrients as well as flow gauges where they are installed. This will be addressed by DWAE but information needs to be requested so that action can be taken if things go wrong.

- Limit the amount of water abstraction to ensure maintenance of cool temperature, low pH and low nutrient levels in the rivers.

- Monitor land management to prevent increased siltation and pollution of the rivers. Investigations into irrigation methods that can be used to minimise nutrient runoff (for example, that proposed by Schuman 2004 in de Moor et al. 2004) should also be considered.

- Ensure that the rivers with no freshwater fish in them are maintained as fishless rivers because they serve as sources of indigenous CFK macroinvertebrates.

- Prohibit of 'clear felling' of vegetation. If land must be cleared then this should be done in an ecologically sensitive manner and mitigating actions, such as the construction of berms, as recommended in Allanson (2002), be taken to ensure against excessive runoff of sediments into rivers.

- Select a number of species that can be used as indicators of conditions favourable to CFK freshwater endemics. These species should be fairly common.

- Test the tolerance of selected species to increased levels of sediments, nutrients, pH and water temperature both in the laboratory and in the field under natural conditions. Some of this research is already being undertaken by Dr M Picker and students from UCT.

- Determine the habitat requirements of all life-cycle stages of selected keystone species to ensure informed conservation management of the riverine ecosystem.

7.2 Possible candidate species to use

From the studies conducted to date a possible list of suitable species to use for further studies to ascertain the tolerance limits of the adapted CFK macroinvertebrates has been drawn up. This is based on findings made on their distribution and perceived sensitivity to changes in pH, Nutrients and temperature ranges.

- *Barbarochthon* ?*brunneum*
- *Petrothrincus demoori*
- *Sciadorus obtusus*

- *Agapetus murinus*
- *Dolophilodes urceolus*
- *Parecnomina resima*
- *Dyschimus collyrifer,*
- *Dyschimus* SCR248F
- *Athripsodes prionii*
- *Leptecho* SCR265K
- *Aprionyx* spp.
- *Ephemerellina barnardi*
- *Lestagella penicillata*
- Teloganodidae Genus & sp TSR151A
- *Nadinetella* spp.
- *Aphanicerca* spp.
- *Simulium merops*
- *Simulium hessei*
- *Syncordulia* spp.
- *Chlorolestes conspicuus* ??
- *Ecchlorolestes nylephtha*

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10. FIGURES, TABLES AND APPENDICES

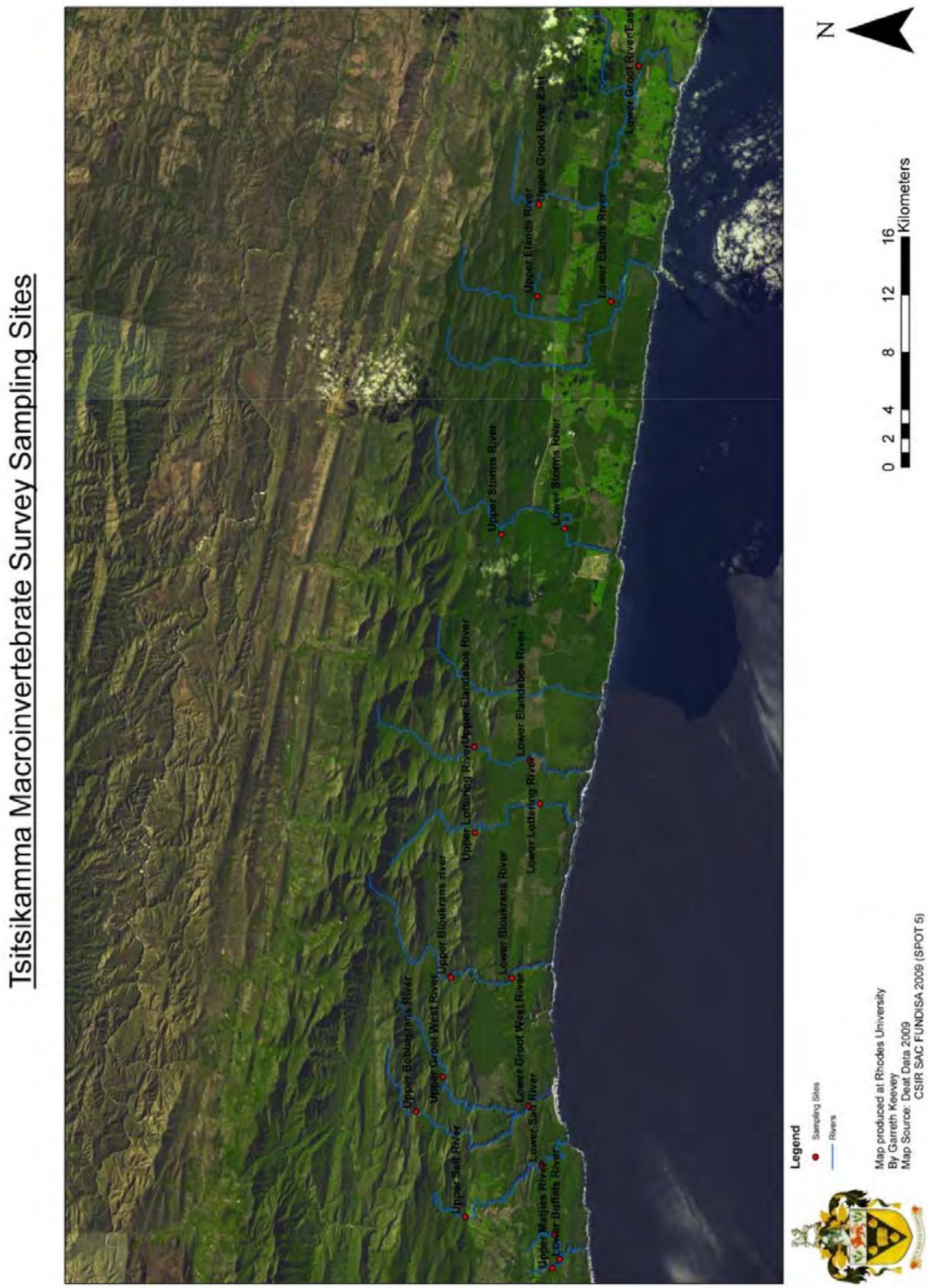

Figure 1: Map of rivers and their corresponding sampling sites.

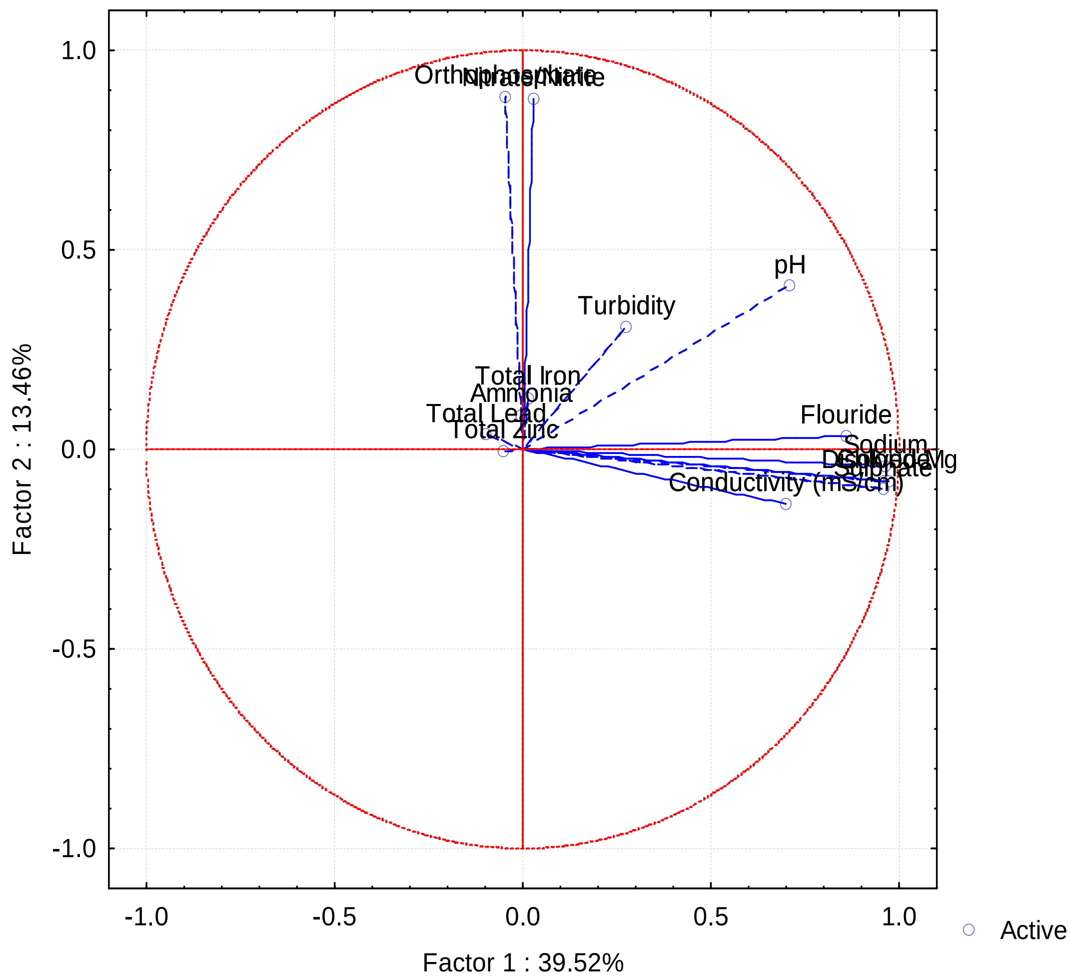

Figure 2: Eigenvector plot of the factor variables for the PCA of water chemistry measurements. The parameters that fall within the centre of the plot are of little importance in distinguishing sites, whereas those that lie on the edges of the plot are the parameters that reveal the greatest change between sites and are used to characterize the rivers. The illegible grouping on the right of the plot includes Sodium, dissolved Mg, Chloride and Sulphate while the two variables that are grouped at the top of the graph are Orthophosphate and Nitrate/Nitrite.

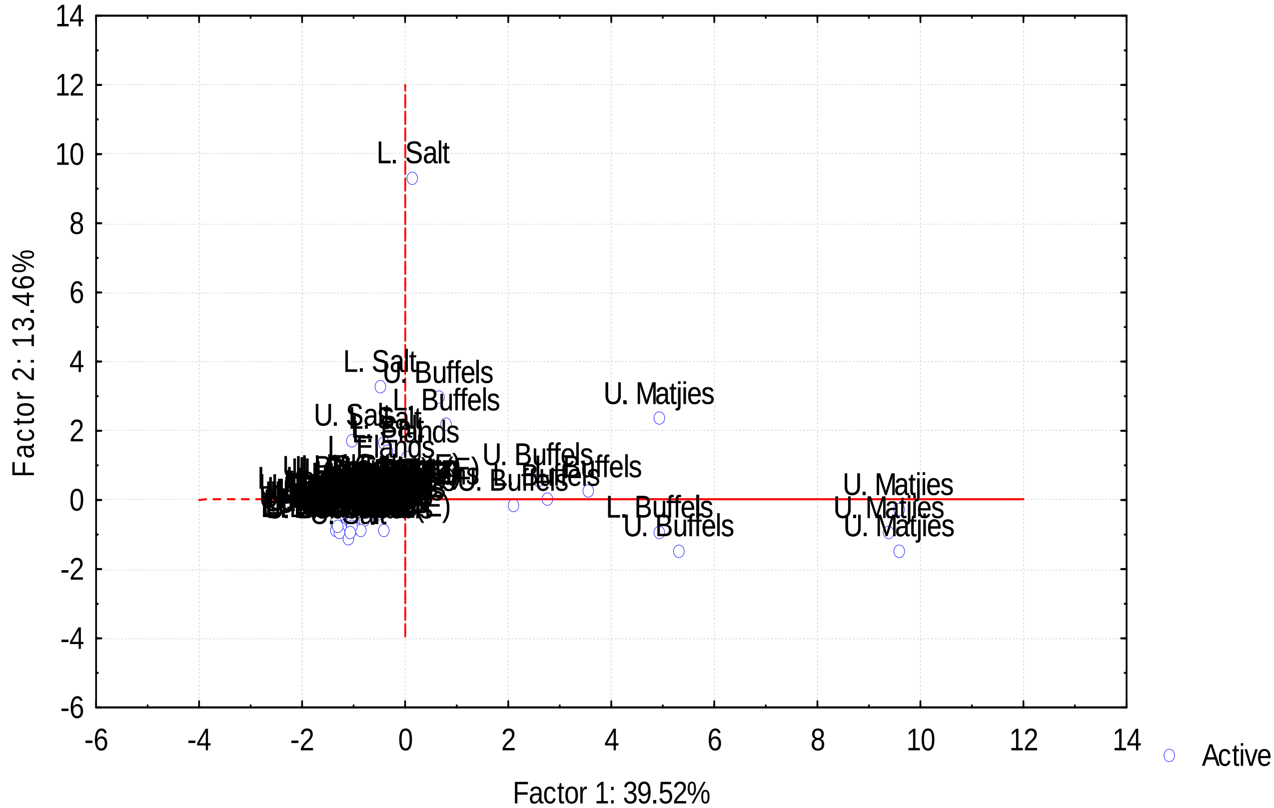

Figure 3: Scatter plot showing ordination of river sites based on the PCA of the water chemistry parameters. The lower Salt River site stands clear of the rest of the sites as a result of elevated Orthophosphate and Nitrate/Nitrite levels while the Matjies and Buffels rivers are separated by a number of parameters including Sulphate, Sodium, Chloride, Fluoride, Conductivity and Dissolved Magnesium (Fig. 2). It should also be noted that, apart from these differences, all of the other sites group closely together, indicating uniformity of water chemistry between these sites.

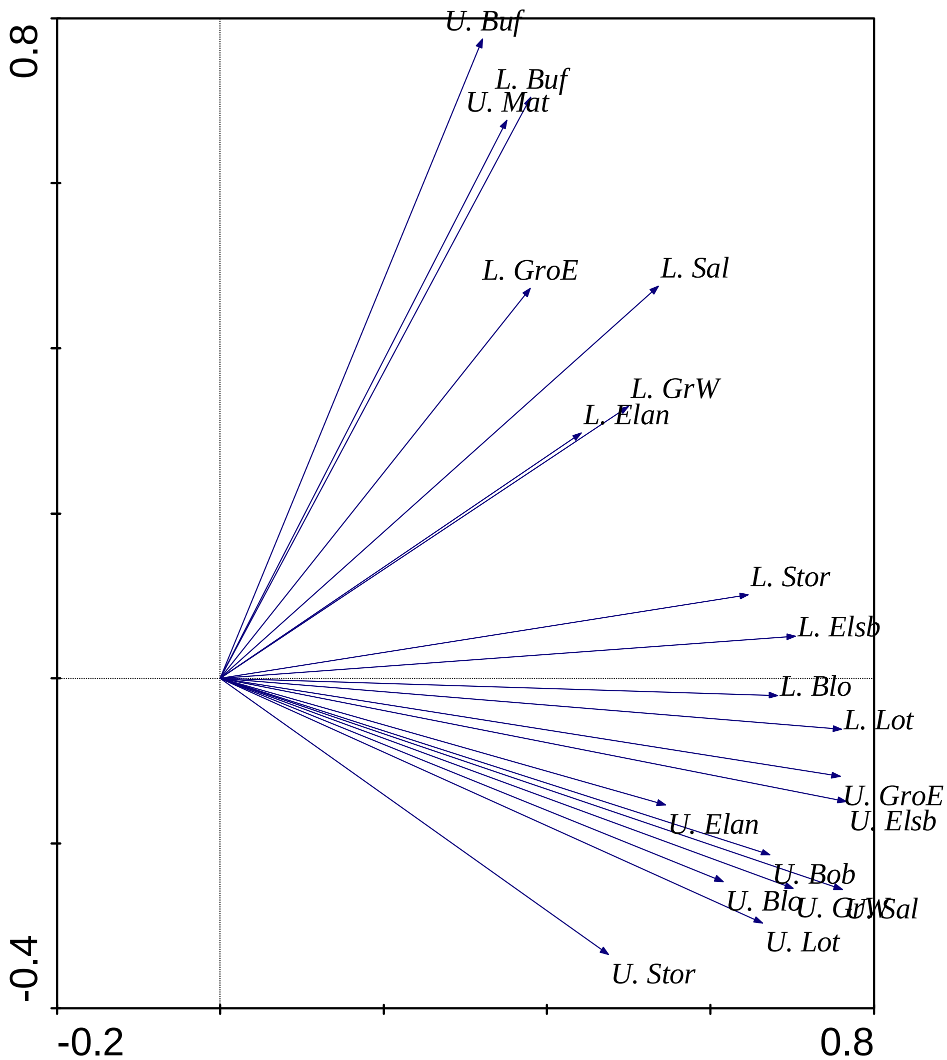

Figure 4: Ordination plot of river sites from a Principle Component Analysis (PCA) carried out on all data in the form of presence/absence of species per site, using CANOCO. Trichoptera species were combined for both light trapping as well as hand collection techniques in order to have each site represented fully by all species found to have occurred there.

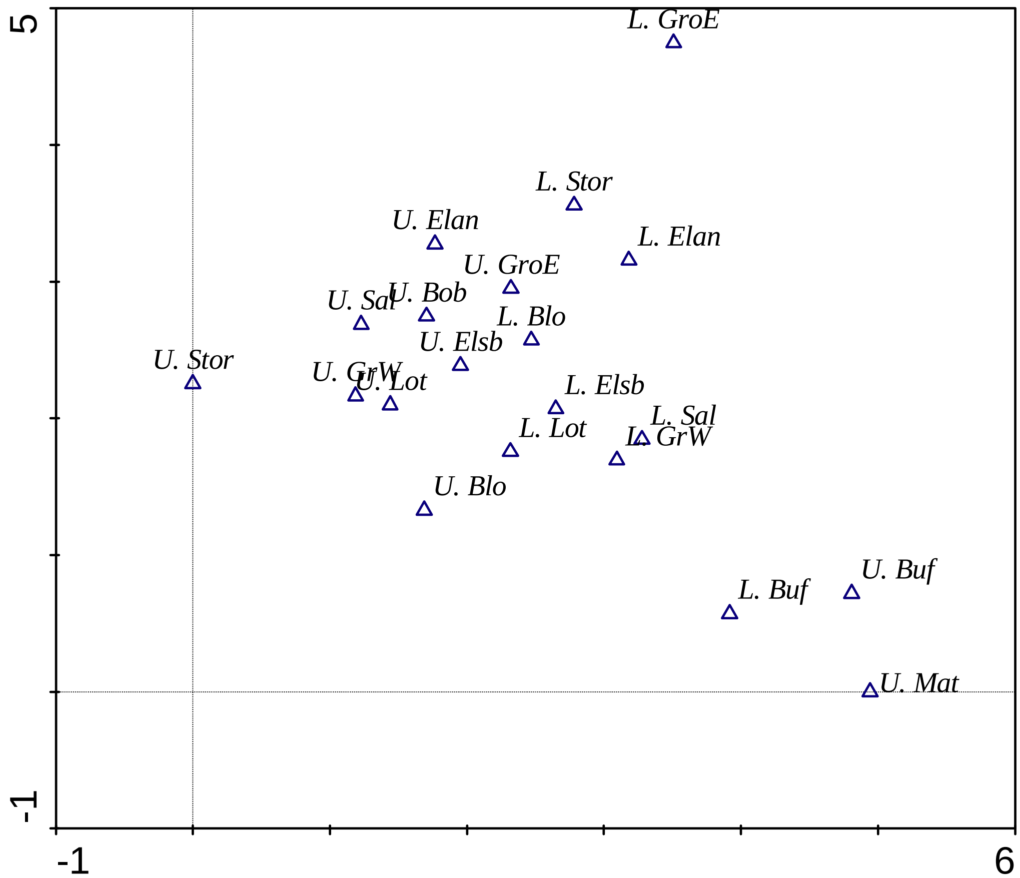

Figure 5: Ordination plot from a detrended correspondence analysis, performed using CANOCO. The analysis was carried out using only the scores of taxa present or absent at each site, the same data used to produce the plot shown in Figure 2.

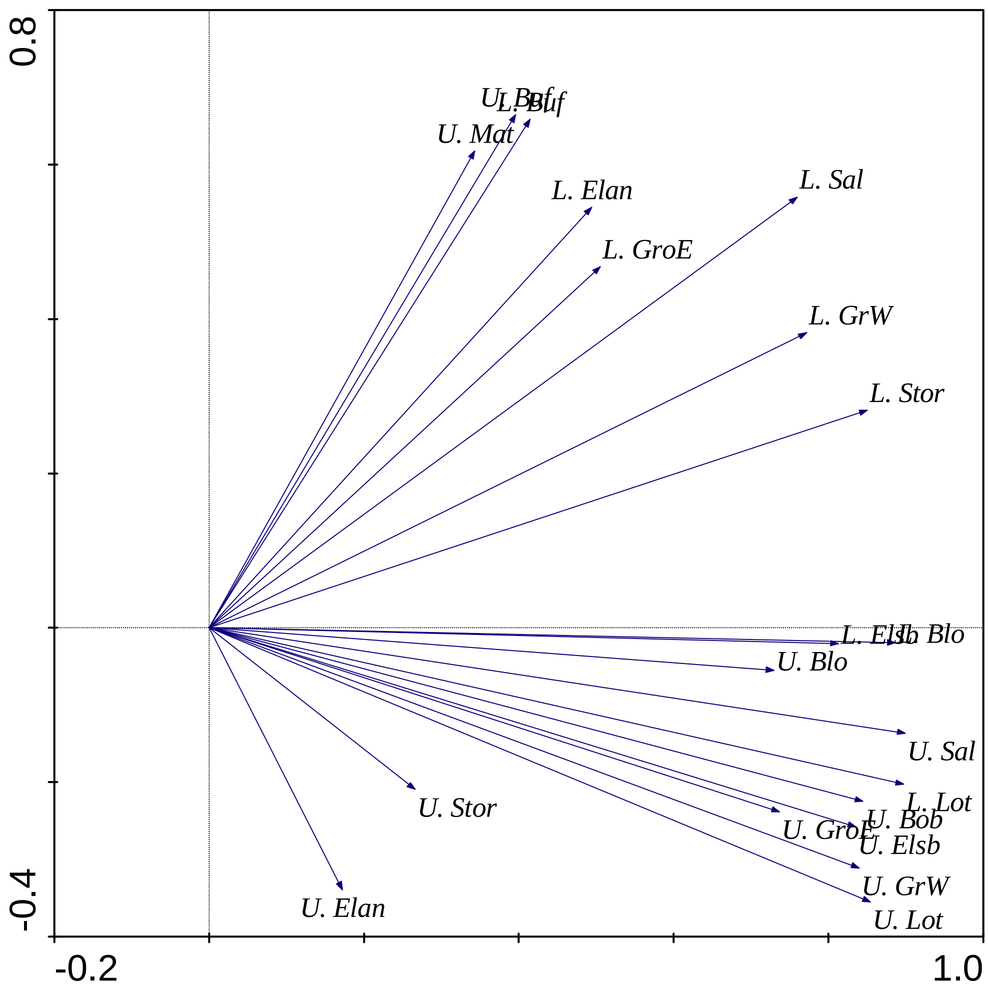

Figure 6: Ordination plot generated from a PCA using relative abundance values from the collection of adult Trichoptera. The data was log-transformed in order to minimise the effect that high numbers of some species would have on the results. With the exception of the lower Lottering River site, the upper sites group together closely, below the first axis while the lower sites are more scattered above the first axis. As also observed in figures 4 and 5, the Lower Groot River (East) and Lower Salt River again group quite closely to the Matjies and Buffels River sites, with the exception that the Lower Elands River site also groups here.

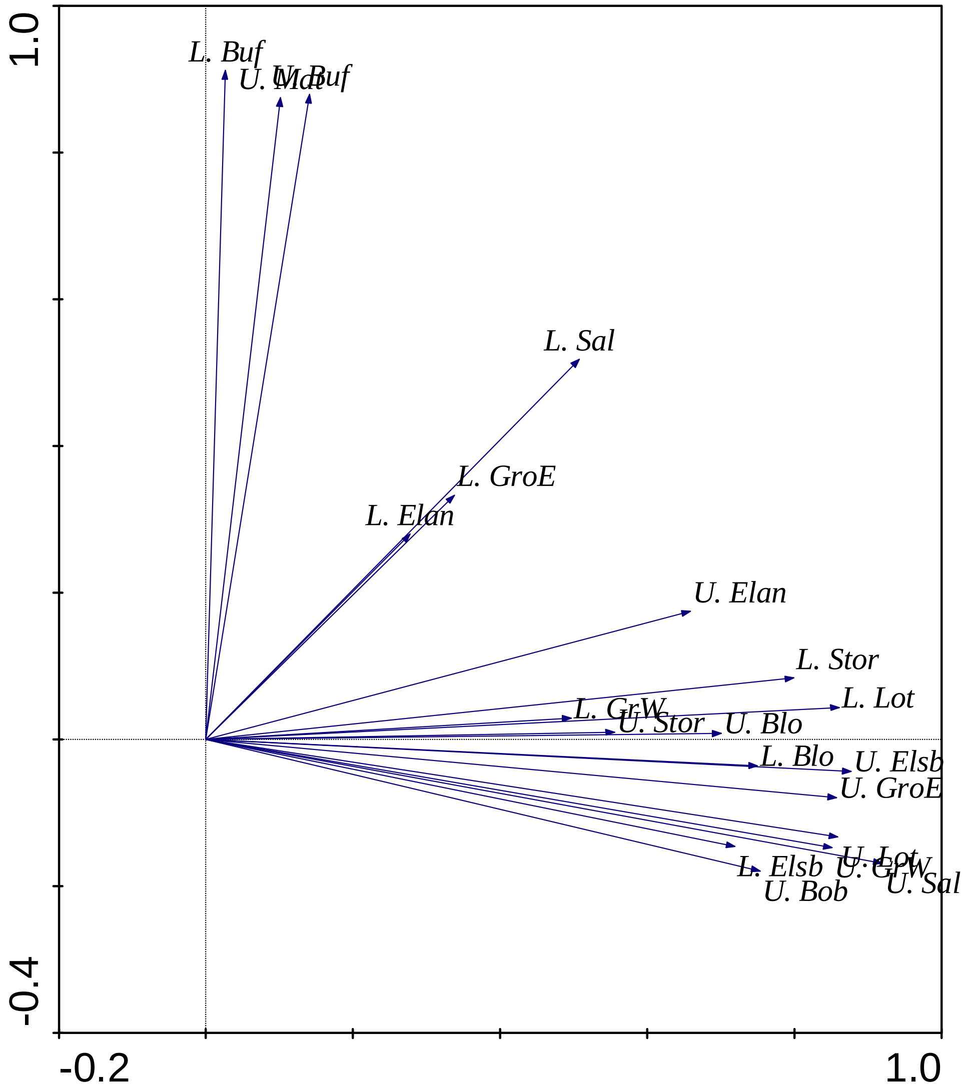

Figure 7: Ordination plot generated from a PCA using relative abundance values of taxa from the hand collected aquatic data. This included the Trichoptera, Ephemeroptera, Megaloptera and Plecoptera. As with the analysis used to produce figure 6, the data was log transformed. The ordination groups the sites most similar with respect to taxa found. As for the other ordinations, the Buffels/Matjies River system stands apart from the rest of the sites, together with the disturbed and species poor sites. The Lower sites of the Elands, Groot (East) and Salt Rivers all group together. The remaining sites group together loosely as a mix of upper and lower sites. At the extreme opposite of the plot below the first axis, five pristine and species rich sites group together. These are the upper Lottering, lower Elandsbos, upper Groot (West), Bobbejaans and Salt River sites.

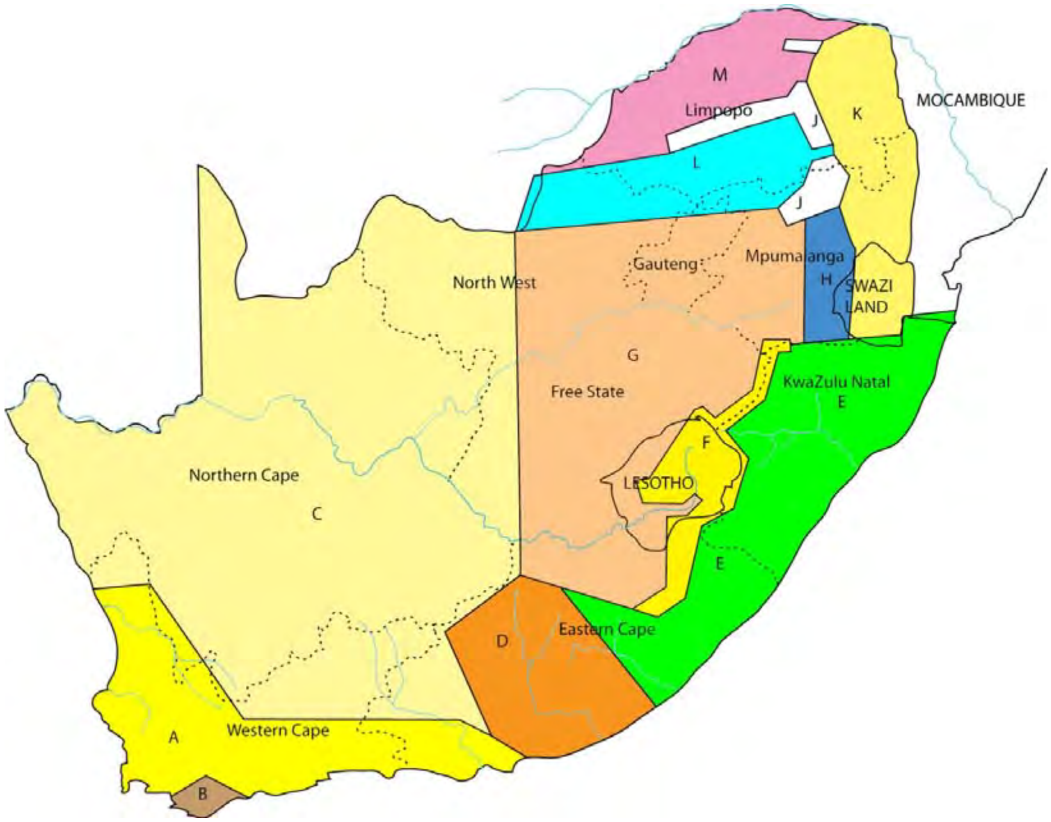

Figure 8: Hydrobiological regions as outlined by Harrison, 1959.

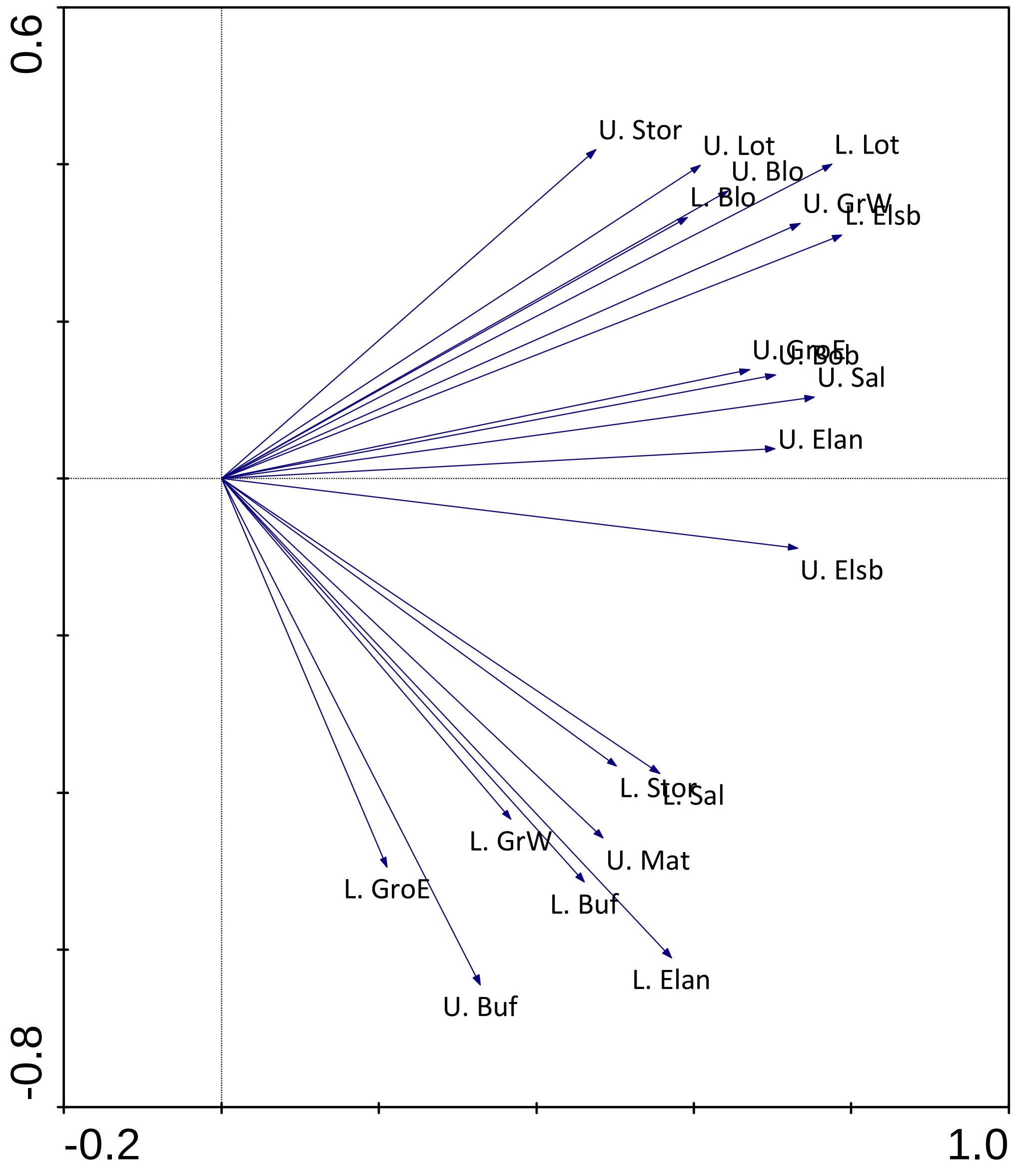

Figure 9: A principle component analysis of the adult Odonata collected by John Simaika and the team of SANParks rangers. The data used for the analysis took the form of presence/absence scores before being analysed using CANOCO. The Odonata data suggests two grouping of sites, one containing primarily lower sites along with the Matjies and Buffels sites, and another containing the remainder of the sites surveyed.

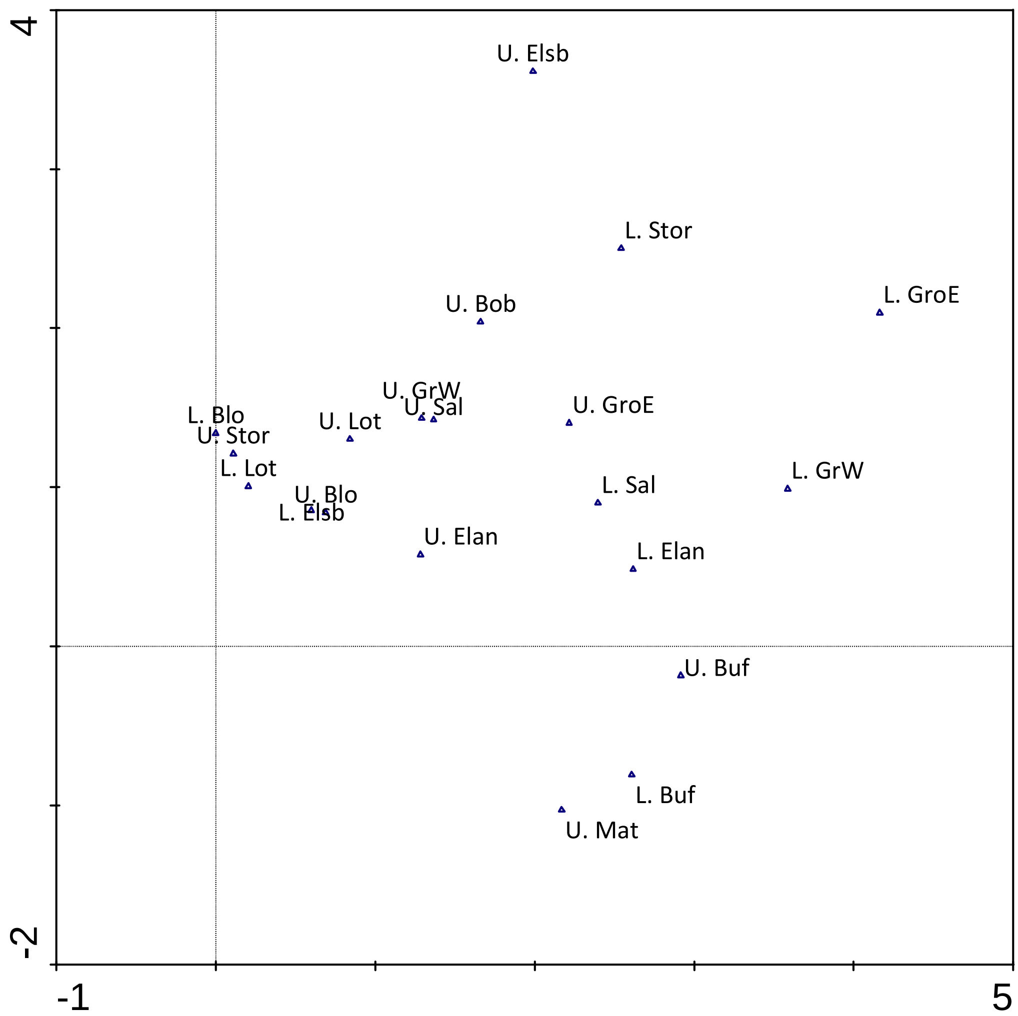

Figure 10: A detrended correspondence analysis of the adult Odonata collected by John Simaika and the team of SANParks rangers. The data used for the analysis took the form of presence/absence scores before being analysed using CANOCO. The resulting figure suggests a weak grouping of the Matjies and Buffels Rivers sites

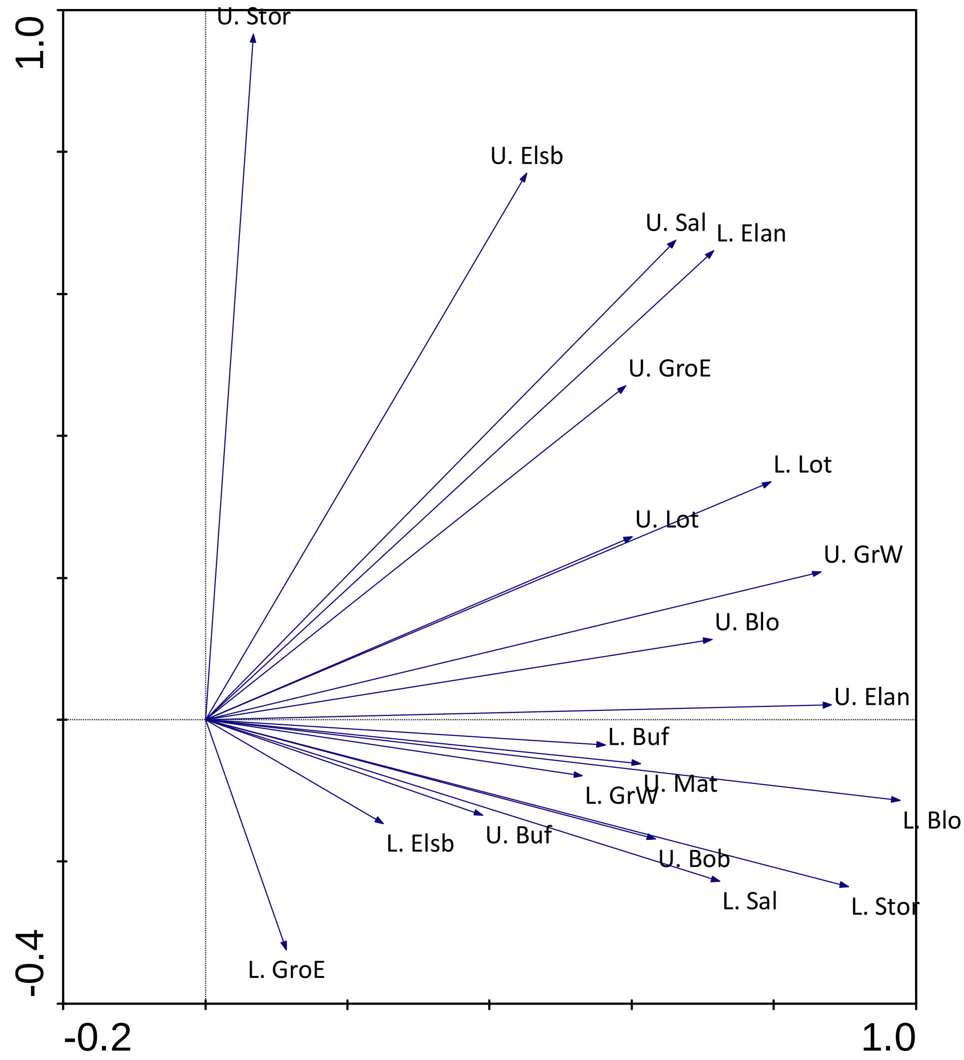

Figure 11: A principle component analysis of the adult Odonata collected by John Simaika and the team of SANParks rangers. The data used for the analysis was composed of actual count values recorded during the collection of the taxa. The resulting ordination plot does not provide an explicable distribution of sites

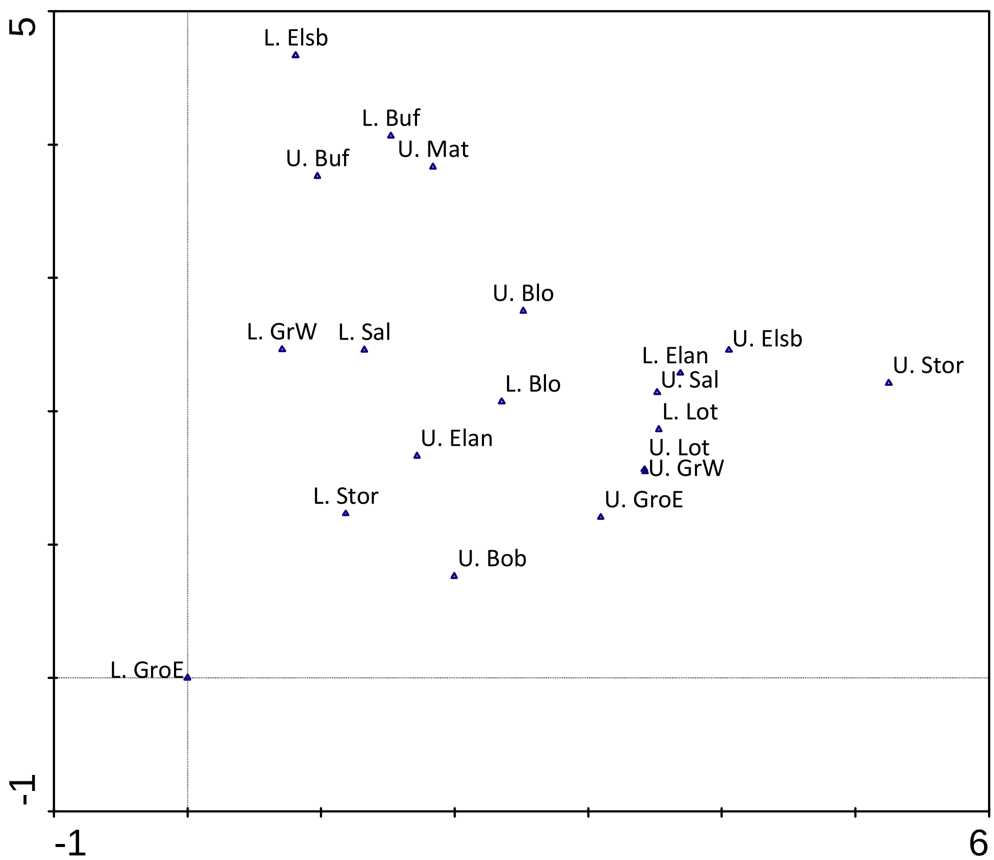

Figure 12: A detrended correspondence analysis of the adult Odonata collected by John Simaika and the team of SANParks rangers. The data used for the analysis was composed of actual count values recorded during the collection of the taxa. The results of the analysis suggest a grouping of the lower Elandsbos, Matjies, and Buffels sites apart for the remaining sites, while the lower Groot River (East) stands apart from all of the other sites completely.

Table 1: Key to abbreviations of biotopes sampled during the Tsitsikamma Rivers surveys.

Biotope	Description
BRIC	Bedrock in current
BROC	Bedrock out of current
DRIFT	Drift net sample
FNW	Flying near water
GSM	Gravel, sand and mud
HYG	Hygropetric splash zone or waterfall
(IC)	Suffix for in-current biotope
LIGHT	Light trap sample
LPIC	Leaf pack or leaf litter in current
LPOC	Leaf pack or leaf litter out of current
MALAISE	Malaise trap set
MIC	Moss in current
MOC	Moss out of current
MUD	Mud sample
MV	Marginal vegetation
MVIC	Marginal vegetation in current
MVOC	Marginal vegetation out of current
(OC)	Suffix for out-of current biotope
RAM	Rooted aquatic macrophytes
RIC	Roots in current
ROC	Roots out of current
SASS	SASS Method used for sampling biotope
SED	Sediment sample
SEEP	Groundwater seepage
SNAG	Log jam, submerged wood
SED	Sediment sample
SIC	Stones in current
SOC	Stones out of current
SOP	Surface of pool

Table 2. Recorded catalogue numbers of biotopes sampled and dates and localities where collected

TSR cat	Date	Locality	Biotopes	Notes
1	08/01/2008	Lower Bloukrans River	FNW	
2	08/01/2008	Upper Bloukrans River	FNW	
3	09/01/2008	Upper Lottering River	MVIC/SIC	
4		Lower Elandsbos River	SIC	
5	11/01/2008	Upper Elands River Tributary	SOC	
6		Upper Groot River East	SIC/SOC/BRIC/BROC	
7	12/01/2008	Lower Storms River	FNW	
8	14/01/2008	Upper Storms River Tributary	SIC/SOC/BRIC/BROC	
9	16/01/2008	Matjies River	FNW	
10	17/01/2008	Buffels River near J Schmids	LIGHT	
11		Buffels River near J Schmids	LIGHT	
12	13/02/2009	Upper Groot River West	SIC	
13	01/04/2008	Upper Storms River Tributary	SASS SIC/SOC	
14		Upper Storms River Tributary	SASS MVIC/MVOC	
15		Upper Storms River Tributary	SASS GSM	
16		Upper Storms River Tributary	Leaf litter	
17		Upper Storms River Tributary	BRIC	
18		Upper Storms River Tributary	SIC	
19		Upper Storms River Tributary	FNW	
20		Lower Storms River	FNW	
21		Lower Storms River	SASS SIC/SOC	
22		Lower Storms River	SASS MVIC/MVOC	
23		Lower Storms River	SASS GSM	
24		Lower Storms River	MVIC/MVOC	
25		Lower Storms River	BRIC/SIC	
26		Lower Storms River	MIC	
27	02/04/2008	Lower Storms River	LIGHT	
28		Upper Storms River Tributary	LIGHT	
29		Upper Groot West	SASS MVIC/MVOC	
30			SASS SIC/SOC	
31			SASS GSM	
32			SIC/SOC	
33			SNAG/MV/Leaf litter	
34		Upper Bobbejaans River	SASS MVIC/MVOC	
35			SASS SIC/SOC	
36			SASS GSM	
37			SIC/SOC/BRIC/BROC	
38			MV/GSM	
39	03/04/2008	Upper Groot West	LIGHT	
40		Upper Bobbejaans River	LIGHT	
41		Lower Elandsbos River	LIGHT	
42			SASS SIC/SOC	
43			SASS MVIC/MVOC	
44			SASS GSM	
45			MVOC	
46			SED seep	
47		Lower Lottering River	SIC	
48			LIGHT	
49			SASS SIC/SOC	

50			SASS MVIC/MVOC	
51			SASS GSM	
52			MVIC/MVOC	Scirpus & Palmiet in pools
53		Lower Bloukrans River	FNW	
54			SASS GSM	
55			SASS SIC/SOC	
56			SASS MVIC/MVOC	
57	04/04/2008	Upper Lottering River	LIGHT	
58			RAM/MVIC	
59			BRIC/MIC	
60			SIC/SOC	
61			SASS GSM	
62			SASS SIC/SOC	
63			SASS MVIC/MVOC	
64			SOP	
65		Lower Elandsbos River	LIGHT	
66	05/04/2008	Upper Elandsbos River	MVOC seep	Seep below pool
67			BRIC/MIC	moss growth on bedrock
68			SOC	stones, cobbles, boulders
69			SOC/GSM	Cobbles & gravel on side of river
70			SASS SIC/SOC	
71			SASS GSM	
72			SASS MVIC/MVOC	
73			FNW	
74		Elandsbos River Tributary	LIGHT	
75	07'04/2008	Lower Groot River East	SASS SIC/SOC	
76			SASS MVIC/MVOC	
77			SASS GSM	
78			SIC	Hand picked
79			GSM	Terence below causeway
80			SNAG	woody snag
81		Upper Groot River East	SASS MVIC/MVOC	
82			SASS SIC/SOC	
83			SASS GSM	
84			SIC/SOC	Hand picked
85			MVIC/ RIC	Roots & trailing vegetation
86			BRIC/MIC	Bedrock with moss
87	08/04/2008	Upper Groot River East	LIGHT	
88		Lower Groot River East	LIGHT	
89		Lower Elands River	LIGHT	
90			SIC/SOC	Hand picked
91			MVIC/MVOC	
92			MIC	moss growth on stones
93			SASS MVIC/MVOC	
94			SASS SIC/SOC	
95			SASS GSM	
96		Upper Elands River	LIGHT	
97			SASS MVIC/MVOC	
98			SASS SIC/SOC	
99			SASS GSM	
100			MIC	
101			SOC/SIC	
102			BRIC	

103		Lower Groot River West	SASS MVIC/MVOC	
104			SASS SIC/SOC	
105			SASS GSM	
106			MVIC/MVOC	
107			SIC	
108	09/04/2008	Lower Bloukrans River	LIGHT	
109		Lower Groot River West	LIGHT	
110		Upper Bloukrans River	SASS MVIC/MVOC	
111			SASS SIC/SOC	
112			SASS GSM	
113			BRIC/MIC	
114			SIC/SOC	
115			GSM	
116		Upper Salt River	SASS MVIC/MVOC	
117			SASS SIC/SOC	
118			SASS GSM	
119			SIC	
120			MIC/BRIC	
121		Lower Salt River	SASS MVIC/MVOC	
122			SASS GSM	
123			SASS SIC/SOC	
124			SIC	Hand picked
125			MOC	
126	10/04/2008	Upper Bloukrans River	LIGHT	
127		Upper Bloukrans Tributry	LIGHT	
128		Upper Salt River	LIGHT	
129		Upper Buffels River	SASS MVIC/MVOC	
130			SASS SIC/SOC	
131			SASS GSM	
132			MIC	Hand picked
133			SIC/SOC	
134			FNW	
135		Matjies River	MIC	Hand picked
136			SIC	Hand picked
137			SASS MVIC/MVOC	
138			SASS SIC/SOC	
139			SASS GSM	
140		Lower Buffels River confluence	SASS MVIC/MVOC	
141			SASS SIC/SOC	
142			SASS GSM	
143			SIC	Hand picked
144			MIC	Hand picked
145			FNW	
146	10/04/2008	Upper Buffels River	LIGHT	
147	11/04/2008	Lower Salt River	LIGHT	
148		Lower Buffels River confluence	LIGHT	
149		Lower Bloukrans River	SIC	Hand picked
150			MVIC/MVOC	
151			MIC	Main stream
152			MIC	Stream close to road
153	12/04/2008	Matjies River	LIGHT	Below J Schmid's house
154		Kurland Spring	LIGHT	
155	01/07/2008	Upper Salt River	SIC	Hand picked

156			BRIC	D-shaped net on Weir
157			GSM/ROC	Roots out of current and gravel on bank
158			FNW	Adults collected off stones
159			SASS MVIC/MVOC	
160			SASS GSM	
161			SASS SIC/SOC	
162		Lower Bloukrans River	SIC/HYGRO	Hygropetric surface
163			SIC/GSM	Hand picked
164			SIC	
165			MVIC	Hand picked
166			SASS MVIC/MVOC	
167			SASS GSM	
168			SASS SIC/SOC	
169	02/07/2008	Upper Groot River East	SASS MVIC/MVOC	
170			SASS GSM	
171			SASS SIC/SOC	
172			SIC	In pool
173			RIC/MVIC	
174			BRIC/SIC	D-shaped net
175		Lower Groot River East	SASS MVIC/MVOC	
176			SASS GSM	
177			SASS SIC/SOC	
178			SIC	Hand picked
179			SNAG	woody snag
180			BRIC/SIC	D-shaped net
181		Upper Elands River	SASS MVIC/MVOC	
182			SASS GSM	
183			SASS SIC/SOC	
184			SOC	Hand picked
185			SIC	Hand picked
186			BRIC/SIC	D-shaped net
187	03/07/2008	Lower Elands River	SASS MVIC/MVOC	
188			SASS SIC/SOC	
189			MV	Hand picked
190			BRIC/MIC	D-shaped net
191			SIC	Hand picked
192		Upper Storms River Tributary	SASS SIC/SOC	
193			SASS MVIC/MVOC	
194			MIC	D-shaped net
195			BRIC	
196			SIC	
197		Lower Storms River	SASS MVIC/MVOC	
198			SASS GSM	
199			SASS SIC/SOC	
200			SIC	
201			MIC	
202			SOC	
203	04/07/2008	Upper Elandsbos River	SASS MVIC/MVOC	
204			SASS GSM	
205			SASS SIC/SOC	
206			SIC	Hand picked
207			SOC	Hand picked
208			MIC	D-shaped net

209		Upper Lottering River	SASS MVIC/MVOC	
210			SASS GSM	
211			SASS SIC/SOC	
212			MIC	Hand picked
213			RIC/MVIC	Hand picked
214			SIC	Hand picked
215			BRIC	Surface of boulders
216		Upper Bloukrans River	SASS SIC/SOC	
217			SASS GSM	
218			SIC	
219			MIC	
220	05/07/2008	Lower Groot River West	SASS MVIC/MVOC	
221			SASS GSM	
222			SASS SIC/SOC	
223			SIC	Hand picked
224			MVIC/MVOC	Hand picked
225		Lower Lottering River	SASS MVIC/MVOC	
226			SASS SIC/SOC	
227			SASS GSM	
228			RAMIC	Rooted macrophytes
229			FNW	Adults
230			SIC	Hand picked
231			MIC	Surface of boulders
232		Lower Elandsbos River	SASS MVIC/MVOC	
233			SASS GSM	
234			SASS SIC/SOC	
235			SIC	2 vials
236	07/07/2008	Lower Salt River	SASS MVIC/MVOC	
237			SASS SIC/SOC	
238			SASS GSM	
239			SOC	Hand picked
240			SIC	Hand picked
241			MVOC	Hand picked
242				Sample number skipped
243		Upper Buffels River	SASS GSM	
244			SASS SIC/SOC	
245			MIC	Hand picked
246			SIC	Hand picked
247			SOC	Hand picked
248		Lower Buffels River confluence	SASS MVIC/MVOC	
249			SASS GSM	
250			SASS SIC/SOC	
251				Sample number skipped
252			MOC	Moss out of current
253				Sample number skipped
254		Upper Matjies	SASS GSM	
255			SASS SIC/SOC	
256			SIC	Hand picked
257		Upper Groot River West	SASS MVIC/MVOC	
258			SASS GSM	
259			SASS SIC/SOC	
260		Upper Bobbejaans River	SASS MVIC/MVOC	
261			SASS GSM	

262			SASS SIC/SOC	
263			SIC	Hand picked
264			RIC	Hand picked
265			MV	Hand picked
266		Upper Groot River West	SIC	Hand picked
267			SOC	Hand picked
268			FNW	Adults
269	01/10/2008	Lower Elandsbos River	SASS MVIC/MVOC	
270			SASS SIC/SOC	
271			SASS GSM	
272			SIC	Hand picked
273			FNW	Adults
274		Lower Lottering River	SASS MVIC/MVOC	
275			SASS SIC/SOC	
276			SASS GSM	
277			SIC	Hand picked
278			SOC	Hand picked
279			MVIC/MVOC	Hand picked
280		Lower Bloukrans River	SASS MVIC/MVOC	
281			SASS SIC/SOC	
282			SASS GSM	
283			SIC	Hand picked
284			SOC	Hand picked
285			SIC/SOC	Hand picked
286			FNW	Adults
287	02/10/2008	Lower Lottering River	LIGHT	
288		Lower Elandsbos River	LIGHT	
289		Lower Bloukrans River	LIGHT	
290		Lower Storms River	LIGHT	
291		Upper Groot River East	SASS MVIC/MVOC	
292			SASS SIC/SOC	
293			SASS GSM	
294			SIC	
295			MIC	
296			RIC	
297	03/10/2008	Lower Storms River	SASS MVIC/MVOC	
298			SASS SIC/SOC	
299			SASS GSM	
300			SIC	Hand picked
301			MVIC	Hand picked
302			MIC	D-shaped net
303			SIC/BRIC	Riffle/run
304			FNW	Adults
305		Upper Storms River Tributary	SASS MVIC/MVOC	
306			SASS SIC/SOC	
307			SASS GSM	
308			BRIC	
309			RIC	
310		Upper Lottering River	SASS MVIC/MVOC	
311			SASS SIC/SOC	
312			SASS GSM	
313			SIC/SOC	Hand picked
314			RIC	Hand picked

315			SOC/SIC	Hand picked
316			SOC/SIC	
317			FNW	Adults
318	04/10/2008	Upper Storms River Tributary	LIGHT	
319		Upper Lottering River	LIGHT	
320		Lower Groot River East	SASS MVIC/MVOC	
321			SASS SIC/SOC	
322			SASS GSM	
323			SIC	Hand picked
324			SNAG	woody snag
325			SNAG/MV/Leaf litter	
326			SIC	Simuliidae cases
327		Lower Elands River	FNW	Adults ovipositing
328			SASS MVIC/MVOC	
329			SASS SIC/SOC	
330			SASS GSM	
331			MIC	Hand picked
332			SIC	Hand picked
333			BRIC	Hand picked
334			GSM	Gravel below fall-eddy in flow
335		Upper Elands River Tributary	SASS MVIC/MVOC	
336			SASS SIC/SOC	
337			SASS GSM	
338			SIC	Hand picked
339			FNW	Adults
340			SIC/SOC	In pool
341	05/10/2008	Upper Elands River	LIGHT	
342		Upper Groot River	LIGHT	
343		Lower Elands River	LIGHT	
344		Lower Groot River	LIGHT	
345		Upper Elandsbos River	SASS MVIC/MVOC	
346			SASS SIC/SOC	
347			SASS GSM	
348			MIC	Hand picked
349			BRIC	Hand picked
350			SIC	Hand picked
351			SOC	Hand picked
352			MVOC	Insects for Ento prac
353		Upper Bloukrans	SASS MVIC/MVOC	
354			SASS SIC/SOC	
355			SASS GSM	
356			SIC	Hand picked
357			MIC	Hand picked
358			SIC	Hand picked
359			BRIC	Hand picked
360			SOC	Hand picked
361			SOP	Adult caddis and shuck
362			FNW	Adults
363	07/10/2008	Upper Elandsbos River	LIGHT	
364		Upper Bloukrans River Tributary	MIC	
365			SIC	
366		Upper Bloukrans River	LIGHT	

367		Lower Groot River West	LIGHT	
368	06/10/2008	Lower Groot River West	FNW	Adults
369	07/10/2008		SASS MVIC/MVOC	
370			SASS SIC/SOC	
371			SASS GSM	
372			SIC	
373			SOC	
374		Upper Salt River	SASS MVIC/MVOC	
375			SASS SIC/SOC	
376			SASS GSM	
377			MIC	
378			SIC	
379			SOC	
380			SOP	
381			FNW	Adults in cop
382			BRIC	Possible material for Ento Prac
383			GSM	Fine gravel below stones
384		Lower Salt River	SASS MVIC/MVOC	
385			SASS SIC/SOC	
386			SASS GSM	
387			SIC	Hand picked
388			FNW	Adults collected off stones
389			SIC	Simuliidae, Hydrops, Philops
390	09/10/2008	Upper Buffels River	SASS MVIC/MVOC	
391			SASS SIC/SOC	
392			SASS GSM	
393			SIC	Hand picked
394		Upper Matjies	SASS MVIC/MVOC	temp 5
395			SASS SIC/SOC	temp 6
396			SASS GSM	temp 7
397			SIC	Hand picked
398	10/10/2008	Lower Buffels River confluence	SASS MVIC/MVOC	
399			SASS SIC/SOC	
400			SASS GSM	
401			SIC	Hand picked
402			LIGHT	
403		Upper Matjies	LIGHT	
404		Upper Buffels River	LIGHT	
405		Upper Bobbejaans	SASS MVIC/MVOC	
406			SASS SIC/SOC	
407			SASS GSM	
408			MVIC/MVOC	Hand picked
409			BRIC	Hand picked
410		Upper Groot River West	SASS MVIC/MVOC	
411			SASS SIC/SOC	
412			SASS GSM	
413			FNW	Adults off stones
414			SIC	
415			BRIC	
416	11/10/2008	Upper Groot River West	LIGHT	
417		Upper Bobbejaans River	LIGHT	
418	12/10/2008	Upper Salt River	LIGHT	
419		Lower Salt River	LIGHT	

420	10/10/2008	Upper Groot River West	FNW	Adults off stones
421	16/01/2009	Upper Groot River East	SASS MVIC/MVOC	
422			SASS SIC/SOC	
423			SASS GSM	
424			SIC	Hand picked
425			SOC	Hand picked
426			MIC	Hand picked
427			RIC	Hand picked
428	17/01/2009		LIGHT	
429	16/01/2009	Upper Elands River	SASS MVIC/MVOC	
430			SASS GSM	
431			SASS SIC/SOC	
432			MIC	Hand picked
433			SIC	
434			BRIC	
435			SOC	
436	17/01/2009	Lower Groot River East	SASS MVIC/MVOC	
437			SASS SOC	River not flowing data logger exposed
438			SASS GSM	
439			SOC	
440			LIGHT	
441				Sample number skipped
442		Lower Elands River	SASS MVIC/MVOC	
443			SASS GSM	
444			SASS SIC/SOC	
445			MV	Hand picked
446			SIC	Hand picked
447		Upper Elands River	LIGHT	Hand picked
448		Lower Elands River	LIGHT	
449	19/01/2009	Upper Storms River Tributary	SASS GSM	
450			SASS SIC/SOC	
451			BRIC	Hand picked
452			SIC	Hand picked
453			SOC	Hand picked
454	20/01/2009		LIGHT	
455	19/01/2009		MIC/HYG	Hand picked
456			FNW	
457		Lower Storms River	SASS MVIC/MVOC	
458			SASS GSM	
459			SASS SIC/SOC	
460			MIC	Hand picked
461			SIC	
462			MVIC/MVOC	
463	20/01/2009		LIGHT	
464	19/01/2009		FNW	Large pyralid
465			FNW	Adults
466	20/01/2009	Upper Lottering River	SASS MVIC/MVOC	
467			SASS GSM	
468			SASS SIC/SOC	
469			SIC	
470			RIC	
471			SOC	
472	21/01/2009		LIGHT	

473	20/01/2209	Upper Elandsbos River	SASS MVIC/MVOC	
474			SASS GSM	
475			SASS SIC/SOC	
476			SOC	
477			BRIC/MIC	
478	21/01/2009		LIGHT	
479	20/01/2009	Lower Elandsbos River	SASS MVIC/MVOC	
480			SASS GSM	
481			SASS SIC/SOC	
482			SIC	
483	21/01/2009		LIGHT	
484	20/01/2009		SOC	
484	21/01/2009	Lower Lottering River	SASS MVIC/MVOC	Sample number duplicated
485			SASS GSM	
486			SASS SIC/SOC	
487			SIC	Hand picked
488			MVIC/MVOC	Hand picked
489			SOC	Hand picked
490			MIC/BRIC	Hand picked
491		Lower Lottering River	LIGHT	Sample number duplicated
492		Lower Bloukrans River	SASS MVIC/MVOC	
493			SASS GSM	
494			SASS SIC/SOC	
495			SIC	Hand picked
496			SOC	Hand picked
497			MVIC/MVOC	Hand picked
498			FNW	Adults
499	22/01/2009		LIGHT	
500	21/01/2009	Lower Groot River West	SASS MVIC/MVOC	
501			SASS GSM	
502			SASS SIC/SOC	
503	23/01/2009	Upper Bloukrans River	SASS MVIC/MVOC	
504			SASS GSM	
505			SASS SIC/SOC	
506			SIC	Hand picked
507			SOC	Hand picked
508	24/01/2009	Upper Bloukrans River	LIGHT	
509		Upper Bloukrans River Tributary	LIGHT	
510	21/01/2009	Lower Groot River West	SIC	Surface of boulders
511			SIC	
512			MVIC/MVOC	
513	22/01/2009		LIGHT	
514	21/01/2009		SOC	
515	24/01/2009	Lower Salt River	SASS MVIC/MVOC	
516			SASS GSM	
517			SASS SIC/SOC	
518			SIC	
519			SOC	
520	25/01/2009		LIGHT	
521	25/01/2009	Upper salt River	LIGHT	Sample number duplicated
521	24/01/2009	Upper Salt River	SASS MVIC/MVOC	
522	21/01/2009	Lower Lottering River	LIGHT	

522	24/01/2009	Upper salt River	SASS GSM	
523	24/01/2009	Upper salt River	SASS SIC/SOC	
523	24/01/2009	Upper Bloukrans River Tributary	LIGHT	
524	26/01/2009	Upper Matjies	SASS MVIC/MVOC	
525			SASS GSM	
526			SASS SIC/SOC	
527	27/01/2009		LIGHT	
528	26/01/2009		SIC	Two samples
529		Lower Buffels River confluence	SASS MVIC/MVOC	
530			SASS GSM	
531			SASS SIC/SOC	
532	27/01/2009		LIGHT	
533	26/01/2009		SIC	Hand picked
534			SOC	Hand picked
535	26/01/2009	Upper Matjies	SOC	
536	24/01/2009	Upper Buffels River	SASS MVIC/MVOC	
537			SASS GSM	
538			SASS SIC/SOC	
539	27/01/2009		LIGHT	
540	26/01/2009		SIC	Hand picked
541	26/01/2009		SOC	
542	24/01/2009	Upper salt River	SIC	
543	24/01/2009	Upper salt River	MIC	
544	29/01/2009	Lower Salt River	FNW	Adults off stones
545		Malaise Traps info on labels		Adults from Malaise traps
546		Malaise Traps info on labels		Adults from Malaise traps
547		Malaise Traps info on labels		Adults from Malaise traps
548		Malaise Traps info on labels		Adults from Malaise traps
549		Malaise Traps info on labels		Adults from Malaise traps
550		Lower Storms River	GSM	
551		Upper salt River	LPIC/LPOC	
552		Stream in forest at Malaise trap	SIC/SOC	Stream at Malaise trap info on labels
553	29/01/2009	Upper Bobbejaans River	SASS MVIC/MVOC	
554			SASS GSM	
555			SASS SIC/SOC	
556		Upper Groot River West	SASS MVIC/MVOC	
557			SASS GSM	
558			SASS SIC/SOC	
559	30/01/2009	Upper Bobbejaans River	LIGHT	
560	30/01/2009		LIGHT	
561	30/01/2009	Upper Groot River West	LIGHT	
562	30/01/2009		LIGHT	
563	29/01/2009	Upper Bobbejaans River	SIC	
564			MVIC/MVOC	
565			SOC	
566		Upper Groot River West	SIC	
567			BRIC	
568			SOP	Adults and shucks
569	26/03/2009	Bloukrans first stream	SIC/SOC	
570		Upper Bloukrans River	FNW	Adult Corydalidae
571		Bloukrans second stream	SIC	
572	27/03/2009		LIGHT	

573	26/03/2009	Bloukrans second stream	SIC/BRIC/LPIC	
574	27/03/2009	Upper Bloukrans River	DRIFT	
575			SOC/LPOC	
576			GSM	Between boulders
577			FNW	Adults sweeping
578			SIC	
579		Bloukrans second stream	MALAISE	Malaise trap stuff from Ashley
580	28/03/2009	Uper Bloukrans River	LIGHT	Trap 1 next to forest
581			LIGHT	Trap 2 below confluence and waterfall
582			DRIFT	
583			SIC	Top of RH Tributary under forested canopy
584			SOC	Oecetis from Pool below waterfall
585		Bloukrans second stream	MALAISE	Malaise trap stuff from Ashley
586		Upper Bloukrans River Tributary	SIC/SOC	Stream in small forested patch on way out
587			MALAISE	Malaise trap 26-28 Mar
588		Keurbos Hut Forest	LIGHT	Adults from sheet light trap
589	29/03/2009	Twin Tubs pool	LIGHT	Adults from light trap 28-29 Mar
590			SOC/LPOC	Sericost, Pisul, Petrothr, Leptocer
591		Lottering River upper site	SIC	over cascades & riffles
592			BRIC	selected Ephemeroptera
593			FNW	Adults
594			SOC	Hand picked
595			GSM	Gravel and shuck
596	30/03/2009		LIGHT	Main stream Light trap
597			LIGHT	Lottering Tributary Light trap
598	29/03/2009	Forest edge Benebos stream	LPOC	Shaded small stream
599		Forest stream within Benebos	SOC/SIC/LPOC	Sericos, Pisul, Petro,
600			SIC	Hand picked
601			SIC	Tadpoles & insects
602			GSM	Sericos
603			FNW	Adults sweeping
604			LIGHT	Residue from Light trap 599
605	30/03/2009	Keurbos Hut Forest	MALAISE	Malaise trap near hut
606		Twin Tubs pool	MALAISE	Malaise trap set 29-30 Mar
607	31/03/2009	Storms River Sleepkloof	MALAISE	Malaise trap set 31 Mar
608	01/04/2009	Upper Storms River Tributary	LIGHT	Light traps below waterfall
609		Upper Storms River next stream	LIGHT	Next stream on path
610			SOC	Terence collected
611			SOC	Terence collected
612			BRIC/SIC	Terence collected
613			FNW	Adults off stones
614			SIC/SOC/BROC	
615		Plaatbos near forest stream	MALAISE	Malaise trap set 31 Mar- 2 Apr
616	15/04/2009	Lower Groot River West	FNW	Adults collected during photography

Table 3: Summary of the SASS scores and data for each site for the Autumn sampling period. Rating of the site water quality appears in the far right column

River Name	# of Taxa	ASPT	SASS 5 Score	Date	Temp	pH	DO	EC	Site rating
Upper Matjies	18	6.5	117	10-Apr-08	12.8	7.5	13.80	4.178	D
Upper Buffels	20	6.1	122	10-Apr-08	13.1	6.9	13.60	1.260	D
Lower Buffels	22	6.7	148	10-Apr-08	14.7	7.6	15.00	1.317	C
Upper Sout	24	8.4	201	09-Apr-08	15.9	4.9	12.70	0.072	A
Lower Sout	19	6.9	131	09-Apr-08	16.2	6.2	12.90	0.300	C
Bobbejaans	18	7.6	136	03-Apr-08	20.3	5.2	12.70	0.056	A
Upper Groot (West)	18	7.8	140	02-Apr-08	18.9	4.7	12.50	0.060	A
Lower Groot (West)	23	7.2	166	08-Apr-08	17.8	5.4	10.50	0.107	A
Upper Bloukrans	24	7.5	181	09-Apr-08	12.7	5.4	13.00	0.070	A
Lower Bloukrans	23	7.9	182	03-Apr-08	18.8	4.6	13.20	0.890	A
Upper Lottering	24	7.4	178	04-Apr-08	18.0	4.6	13.00	0.056	A
Lower Lottering	22	8.4	185	03-Apr-08	18.5	4.6	12.80	0.090	A
Upper Elandbos	25	7.5	187	05-Apr-08	18.6	4.9	13.00	0.063	A
Lower Elandbos	20	8.0	160	03-Apr-08	18.3	4.7	12.60	0.074	A
Upper Storms Tributary	19	7.5	142	01-Apr08	16.7	5.1	12.90	0.088	A
Lower Storms	26	7.5	194	01-Apr-08	21.0	5.1	12.70	0.075	A
Upper Elands	22	6.8	149	08-Apr-08	14.4	4.6	11.20	0.069	C
Lower Elands	15	5.9	88	08-Apr-08	15.4	6.6	12.60	0.200	D
Upper Groot (East)	22	8.0	176	07-Apr-08	15.3	4.7	12.36	0.076	A
Lower Groot (East)	24	6.7	160	07-Apr-08	18.3	6.1	10.60	0.200	C

Table 4: Summary of the SASS scores and data for each site for the Winter sampling period.
Rating of the site water quality appears in the far right column

River Name	# of Taxa	ASPT	SASS 5 Score	Date	Temp	pH	DO	EC	Site rating
Upper Matjies	14	6.6	93	05.07.08	10.7	7.4	0.30	3.700	D
Upper Buffels	19	6.6	126	05.07.08	10.2	7.1	0.40	1.200	C
Lower Buffels	22	6.3	138	08.07.08	10.6	7.2	0.40	1.500	C
Upper Sout	23	8.3	191	01.07.08	10.4	4.9	8.22	0.069	A
Lower Sout	18	7.0	126	07.07.08	11.5	6.8	0.80	0.300	A
Bobbejaans	21	8.3	174	12.07.08	7.7	6.4	0.90	0.100	A
Upper Groot (West)	21	7.8	164	12.07.08	7.6	5.2	0.60	0.100	A
Lower Groot (West)	17	8.2	140	05.07.08	11.0	6.9	1.90	0.100	A
Upper Bloukrans	20	7.5	149	04.07.08	9.6	5.5	3.90	0.100	A
Lower Bloukrans	19	7.9	148	01.07.08	11.1	5.2	8.80	0.100	A
Upper Lottering	24	8.8	210	04.07.08	9.3	4.6	4.20	0.100	A
Lower Lottering	23	8.6	198	05.07.08	10.3	4.8	2.20	0.100	A
Upper Elandbos	16	7.8	125	04.07.08	9.9	5.2	4.20	0.100	A
Lower Elandbos	31	7.5	232	05.07.08	11.4	4.9	1.70	0.100	A
Upper Storms Tributary	16	8.0	129	03.07.08	10.3	4.9	6.20	0.100	A
Lower Storms	23	7.8	179	03.07.08	11.1	5.4	6.40	0.100	A
Upper Elands	17	8.7	148	02.07.08	10.2	4.5	7.20	0.100	A
Lower Elands	15	6.3	94	03.07.08	9.5	6.7	5.70	0.100	D
Upper Groot (East)	22	7.7	169	02.07.08	9.1	5.0	8.30	0.100	A
Lower Groot (East)	24	7.3	176	02.07.08	10.1	6.1	6.80	0.200	A

Table 5: Summary of the SASS scores and data for each site for the Spring sampling period. Rating of the site water quality appears in the far right column

River Name	# of Taxa	ASPT	SASS 5 Score	Date	Temp	pH	DO	EC	Site rating
Upper Matjies	22	6.1	134	09.10.08					C
Upper Buffels	23	5.8	133	01.10.08					C
Lower Buffels	28	6.9	194	10.10.08					C
Upper Sout	30	7.5	225	07.10.08					A
Lower Sout	24	6.7	160	07.10.08					C
Upper Bobbejaans	13	8.2	140	10.10.08					A
Upper Groot (West)	24	7.8	186	10.10.08	14.6	4.90			A
Lower Groot (West)	27	7.5	203	04.10.08					A
Upper Bloukrans	31	7.1	219	06.10.08					A
Lower Bloukrans	31	7.5	231	01.10.08	14.3	5.00	20.80	0.1	A
Upper Lottering	24	7.8	187	03.10.08					A
Lower Lottering	27	7.7	207	01.10.08	13.0	5.20	22.20		A
Upper Elandbos	23	7.4	171	06.10.08					A
Lower Elandbos	28	8.0	225	01.10.08	12.6	5.40	22.10	0.1	A
Upper Storms Tributary	20	8.1	161	03.10.08					A
Lower Storms	27	7.7	207	03.10.08					A
Upper Elands	21	7.4	155	04.10.08					A
Lower Elands	18	5.0	90	04.10.08					D
Upper Groot (East)	27	8.0	215	02.10.08					A
Lower Groot (East)	26	8.6	172	04.10.08					A

Table 6: Summary of the SASS scores and data for each site for the Summer sampling period. Rating of the site water quality appears in the far right column

River Name	# of Taxa	ASPT	SASS 5 Score	Date	Temp	pH	DO	EC	Site rating
Upper Matjies	19	5.0	112	26.01.09	16.6	8.1	2.50	4.90	D
Upper Buffels	21	6.1	129	24.01.09	22.3	7.6	0.80	1.50	C
Lower Buffels	27	5.7	154	26.01.09	19.5	7.9	1.20	2.30	C
Upper Sout	25	7.0	176	23/01.09	20.1	5.1	0.00	0.10	A
Lower Sout	27	6.7	181	24.01.09	21.1	6.7	0.16	0.30	C
Upper Bobbejaans	26	6.8	177	29.01.09	24.6	4.5	0.00	0.10	C
Upper Groot (West)	27	7.0	189	29.01.09	21.7	4.8	0.00	0.10	A
Lower Groot (West)	14	5.6	79	21.01.09	23.5	5.9	0.10	0.10	D
Upper Bloukrans	25	7.9	198	23.01.09	20.6	5.3	0.00	0.10	A
Lower Bloukrans	21	7.4	155	21.01.09	22.0	5.2	0.00	0.10	A
Upper Lottering	23	7.3	169	20.01.09	19.1	5.0	0.10	0.00	A
Lower Lottering	26	8.4	218	21.01.09	18.8	5.3	0.00	0.10	A
Upper Elandbos	19	7.4	141	20.01.09	22.0	5.1	0.00	0.00	A
Lower Elandbos	22	7.0	153	20.01.09	24.6	5.1	0.00	0.10	A
Upper Storms Tributary	16	7.1	113	19.01.09	17.0	4.9	0.00	0.10	B
Lower Storms	24	7.5	180	19.01.09	22.3	5.7	0.00	0.10	A
Upper Elands	13	7.8	102	16.01.09	18.8	4.5	0.00	0.10	B
Lower Elands	22	5.2	115	17.01.09	22.2	6.9	0.10	0.14	D
Upper Groot (East)	24	6.8	164	16.01.09	19.2	4.8	0.00	0.10	C
Lower Groot (East)	23	5.6	129	17.01.09	25.2	6.5	0.1	0.30	C

Table 7: Water chemistry parameters common throughout survey period, obtained from Talbot &Talbot. All data in mg l^{-1} except fluoride µg l^{-1}

River site	Month	Ammonia	Chloride	Dissolved Mg	Fluoride	Nitrate/ Nitrite	Orthoph osphate	Sodium	Sulphate	Total Lead	Total Zinc	Total Iron
U. Storms	Mar/Apr	0.38	4.0	0.2	110	0.51	0.007	5.7	9.35	0.04	0.04	0.34
L. Storms	Mar/Apr	0.36	4.0	0.2	100	0.57	0.002	7.1	8.93	0.04	0.04	0.43
U. Bobbejaans	Mar/Apr	0.40	14.0	0.9	50	0.56	0.001	12.0	7.40	0.04	0.04	0.27
U. Groot (W)	Mar/Apr	0.29	5.0	0.2	90	0.54	0.002	6.2	10.40	0.04	0.04	0.27
L. Elandsbos	Mar/Apr	0.34	16.0	1.2	180	0.48	0.001	15.0	15.50	0.04	0.04	0.46
L. Lottering	Mar/Apr	0.31	4.0	0.2	70	0.53	0.010	8.2	10.70	0.04	0.05	0.43
L.Bloukrantz	Mar/Apr	0.32	20.0	1.2	130	0.52	0.004	14.0	13.40	0.04	0.04	0.16
U.Lottering	Mar/Apr	0.34	11.0	0.9	170	0.49	0.003	10.0	18.50	0.04	0.04	0.43
U. Elandsbos	Mar/Apr	0.18	14.0	1.0	150	0.31	0.002	12.0	13.80	0.04	0.04	0.31
L. Groot (E)	Mar/Apr	0.30	47.0	3.7	220	0.52	0.001	29.0	17.00	0.04	0.04	0.97
U. Groot (E)	Mar/Apr	0.23	18.0	1.2	49	0.43	0.001	14.0	10.00	0.04	0.04	0.38
L. Elands	Mar/Apr	0.22	41.0	3.1	110	1.08	0.005	28.0	10.50	0.04	0.04	0.40
U. Elands	Mar/Apr	0.33	15.0	1.1	170	0.50	0.001	11.0	18.10	0.04	0.04	0.50
L. Groot (W)	Mar/Apr	0.32	28.0	1.4	130	0.55	0.001	19.0	12.10	0.04	0.07	0.43
U. Bloukrantz	Mar/Apr	0.23	17.0	1.2	49	0.43	0.001	14.0	10.00	0.04	0.04	0.38
U. Salt	Mar/Apr	0.22	41.0	3.1	110	1.08	0.050	28.0	10.50	0.04	0.04	0.40
L. Salt	Mar/Apr	0.38	77.0	4.8	90	1.46	0.070	47.0	17.00	0.04	0.08	0.26
U. Buffels	Mar/Apr	0.29	360.0	48.0	220	0.55	0.001	152.0	91.40	0.04	0.04	0.47
U. Matjies	Mar/Apr	0.35	1270.0	151.0	530	0.42	0.005	500.0	406.00	0.04	0.08	0.25
L. Buffels	Mar/Apr	0.31	390.0	49.0	370	0.51	0.001	159.0	87.70	0.04	0.04	0.26
U. Salt	Jun/Jul	0.19	16.0	1.2	280	0.23	0.037	12.0	7.29	0.06	0.04	0.30
L. Bloukrantz	Jun/Jul	0.27	21.0	1.3	290	0.38	0.024	14.0	11.00	0.08	0.04	0.38
U. Groot (E)	Jun/Jul	0.12	18.0	1.4	280	0.18	0.019	12.0	7.56	0.08	0.03	0.50
L. Groot (E)	Jun/Jul	0.16	72.0	4.8	360	0.43	0.011	41.0	12.20	0.08	0.02	1.10

U. Elands	Jun/Jul	0.17	18.0	1.2	370	0.23	0.015	11.0	16.60	0.08	0.03	0.50
L. Elands	Jun/Jul	0.09	35.0	2.8	320	0.56	0.037	24.0	9.55	0.08	0.03	0.50
U. Storms	Jun/Jul	0.13	18.0	1.4	300	0.30	0.014	13.0	9.34	0.08	0.04	0.40
L. Storms	Jun/Jul	0.13	19.0	1.4	230	0.24	0.011	12.0	9.94	0.08	0.05	0.91
U. Elandbos	Jun/Jul	0.12	15.0	1.2	300	0.20	0.015	8.0	16.00	0.08	0.04	0.59
U. Lottering	Jun/Jul	0.19	14.0	1.0	310	0.30	0.015	9.0	17.20	0.08	0.05	0.46
U. Bloukrantz	Jun/Jul	0.08	12.0	1.8	260	0.16	0.009	12.0	6.10	0.07	0.03	5.40
L. Groot (W)	Jun/Jul	0.20	34.0	2.1	280	0.45	0.013	20.0	13.50	0.06	0.04	0.62
L. Lottering	Jun/Jul	0.20	30.0	2.8	390	0.51	0.014	22.0	24.60	0.07	0.04	0.80
L. Elandsbos	Jun/Jul	0.26	18.0	1.5	280	0.43	0.015	14.0	15.80	0.06	0.02	0.66
L. Salt	Jun/Jul	0.21	85.0	5.8	270	4.47	0.136	48.0	14.20	0.08	0.03	0.34
U. Buffels	Jun/Jul	0.20	312.0	52.0	410	0.57	0.016	150.0	84.00	0.07	0.04	0.80
L. Buffels	Jun/Jul	0.15	387.0	68.0	560	0.55	0.012	194.0	98.10	0.06	0.04	0.66
U. Matjies	Jun/Jul	0.20	1035.0	158.0	760	0.50	0.014	730.0	265.00	0.07	0.03	0.56
U. Bobbejaans	Jun/Jul	0.19	18.0	1.3	320	0.31	0.012	10.0	6.58	0.06	0.03	0.40
U. Groot (W)	Jun/Jul	0.22	18.0	1.4	180	0.44	0.011	12.0	10.50	0.08	0.03	0.47
L. Salt	Sep/Oct	0.08	11.0	2.0	180	0.02	0.075	21.0	7.35	0.04	0.01	0.16
U. Buffels	Sep/Oct	0.07	58.0	4.7	250	1.39	0.033	35.0	18.30	0.04	0.01	0.68
U. Matjies	Sep/Oct	0.07	482.0	55.0	560	0.47	0.025	256.0	132.00	0.06	0.04	1.18
L. Buffels	Sep/Oct	0.07	75.0	7.0	320	1.04	0.028	43.0	23.00	0.05	0.03	0.90
U. Groot (W)	Sep/Oct	0.07	13.0	0.9	190	0.27	0.016	10.0	8.70	0.04	0.01	0.16
U. Bobbejaans	Sep/Oct	0.19	10.0	0.6	180	0.26	0.015	9.7	6.28	0.04	0.01	0.13
L. Elandsbos	Sep/Oct	0.07	18.0	1.3	190	0.27	0.016	13.0	9.96	0.05	0.03	0.34
L. Lottering	Sep/Oct	0.07	15.0	1.2	230	0.42	0.016	13.0	12.50	0.06	0.05	0.40
L. Bloukrantz	Sep/Oct	0.13	20.0	1.4	200	0.35	0.015	14.0	9.31	0.07	0.05	1.19
U. Groot (E)	Sept/Oct	0.20	21.0	1.4	180	0.49	0.021	16.0	8.26	0.05	0.06	0.30
L. Storms	Sept/Oct	0.07	21.0	1.4	230	0.29	0.016	14.0	6.82	0.06	0.06	0.40
U. Storms	Sept/Oct	0.14	19.0	1.3	300	0.36	0.015	14.0	8.22	0.07	0.05	0.28

U. Lottering	Sept/Oct	0.07	10.0	0.7	260	0.25	0.015	8.8	22.10	0.06	0.06	0.38
L. Groot (E)	Sept/Oct	0.07	82.0	6.0	200	0.46	0.016	4.9	12.60	0.07	0.05	0.51
L. Elands	Sept/Oct	0.07	34.0	2.6	90	0.17	0.016	23.0	8.33	0.08	0.09	0.26
U. Elands	Sept/Oct	0.25	17.0	1.3	230	0.30	0.016	12.0	12.20	0.08	0.07	0.39
U. Elandsbos	Sept/Oct	0.07	14.0	1.3	190	0.30	0.014	14.0	9.51	0.08	0.07	0.46
U. Bloukrantz	Sept/Oct	0.09	20.0	1.2	130	0.45	0.021	15.0	3.26	0.10	0.06	0.27
L. Groot(W)	Sept/Oct	0.15	31.0	1.8	120	0.27	0.017	21.0	7.33	0.04	0.06	0.24
U. Salt	Sept/Oct	0.10	15.0	0.9	140	0.21	0.014	10.0	5.51	0.04	0.07	0.17
U. Groot (E)	Jan/Feb	0.07	23.0	1.4	120	0.31	0.015	13.0	6.60	0.04	0.01	0.09
U. Elands	Jan/Feb	0.07	20.0	1.6	200	0.31	0.008	12.0	16.70	0.04	0.01	0.23
L. Groot (E)	Jan/Feb	0.07	79.0	5.9	200	0.22	0.001	45.0	10.20	0.04	0.01	0.24
L. Elands	Jan/Feb	0.07	21.0	2.8	110	0.37	0.001	21.0	6.72	0.04	0.01	0.05
U. Storms	Jan/Feb	0.07	23.0	1.5	160	0.47	0.019	13.0	8.72	0.04	0.01	0.11
L. Storms	Jan/Feb	0.07	26.0	1.6	200	0.33	0.001	17.0	7.78	0.04	0.01	0.11
U. Lottering	Jan/Feb	0.16	15.0	1.1	210	0.41	0.017	11.0	9.14	0.04	0.06	0.14
U. Elandsbos	Jan/Feb	0.11	22.0	1.0	90	0.38	0.010	10.0	7.48	0.04	0.03	0.11
L. Elandsbos	Jan/Feb	0.10	13.0	1.0	120	0.44	0.002	8.7	8.34	0.04	0.01	0.13
L. Lottering	Jan/Feb	0.07	9.0	0.6	200	0.44	0.008	7.3	7.04	0.04	0.01	0.10
L. Bloukrantz	Jan/Feb	0.07	11.0	1.6	80	0.40	0.003	16.0	7.76	0.04	0.01	0.09
L. Groot (W)	Jan/Feb	0.07	37.0	2.3	110	0.39	0.004	23.0	8.05	0.04	0.01	0.08
U. Bloukrantz	Jan/Feb	0.07	5.0	0.8	110	0.39	0.001	8.5	5.44	0.04	0.01	0.04
U. Salt	Jan/Feb	0.07	20.0	1.4	190	0.32	0.001	13.0	6.32	0.04	0.01	0.01
L. Salt	Jan/Feb	0.07	93.0	5.9	180	0.39	0.063	49.0	11.90	0.04	0.01	0.01
U. Buffels	Jan/Feb	0.07	387.0	52.0	520	0.31	0.001	189.0	123.00	0.04	0.01	0.04
U. Matjies	Jan/Feb	0.07	1588.0	134.0	700	0.29	0.001	536.0	295.00	0.04	0.01	0.01
L. Buffels	Jan/Feb	0.07	610.0	87.0	590	0.37	0.001	268.0	178.00	0.04	0.01	0.03
U. Bobbejaans	Jan/Feb	0.07	19.0	0.8	170	0.29	0.003	9.6	2.22	0.04	0.01	0.03
U. Groot (W)	Jan/Feb	0.07	18.0	1.0	100	0.41	0.008	11.0	6.55	0.04	0.01	0.04

Table 8: Summary of water temperature data from loggers

	Paramters (°C)				Comments
River site	Min	Max	Range	Mean with stdev	
U. Groot (E)	8.0	24.0	16.0	15.2 +- 3.2	
L. Groot (E)	7.0	26.5	19.5	16.9 +-5.3	Logger exposed - River not flowing in Jan 2009
U. Elands	8.5	24.0	15.5	14.8 +- 3.3	
L. Elands	7.5	25.0	17.5	15.4 +- 4.2	
U. Storms	8.0	19.0	11.0	13.5 +- 2.7	
L. Storms	9.0	29.0	20.0	16.4 +- 4.4	
U. Lottering	7.5	25.0	16.5	15.0 +- 3.6	
L. Lottering	8.0	23.5	15.5	15.4 +-3.8	
U. Elandsbos	8.5	25.5	17.0	16.1 +-3.8	
L. Elandsbos	7.5	25.0	17.5	15.7 +- 3.9	Logger found exposed in March 2008
U. Bloukrans	5.5	28.5	23.0	15.4 +- 4.9	Logger suspected to be exposed/faulty in Jan 2008
L. Bloukrans	8.5	25.0	16.5	15.9 +- 4.4	Logger removed in Feb then replaced in May
U. Groot (W)	6.0	24.0	18.0	14.0 +- 4.0	
L. Groot (W)	10.5	24.0	13.5	16.4 +- 3.5	
U. Bobbejaans	7.0	26.5	19.5	14.3 +- 3.9	Logger found exposed in March 2008
U. Salt	8.0	23.0	15.0	15.2 +- 3.3	
L. Salt	8.0	26.5	18.5	16.3 +- 4.2	
U. Buffels	4.5	22.5	18.0	13.8 +- 4.2	
L. Buffels	5.5	22.5	17.0	12.9 +- 4.0	Logger malfunctioned for Summer period - no data
U. Matjies	5.5	20.5	15.0	13.5 +- 3.5	

Table 9: Ephemeroptera collected over the entire sampling period, represented by relative abundance values

EPHEMEROPTERA	U. Matjies	L. Buffels	U. Buffels	U. Salt	L. Salt	L. Groot (W)	U. Groot (W)	U. Bobbejaans	U. Bloukrans	L. Bloukrans	U. Elandsbos	L. Elandsbos	U. Lottering	L. Lottering	U. Storms	L. Storms	U. Elands	L. Elands	U. Groot (E)	L. Groot (E)
Baetidae																				
Afroptilum sudafricanum	28	49	53		7					1				2						
Baetis harrsoni	4	4	11	4	11	5	1	1	1	162	5		1			48		73	3	53
Bugiliesia sp				1																
Cheleocloen excisum	22																			
Cloeodes sp				217	1	13	34	14		3	12	31	13	1					1	
Nigrobaetis sp																1				
Pseudocloeon vinosum	1			789	53	8	14	28	18	341	239	119	472	542	3	347	18	146	823	16
Cloeon sp	1	4	2										9			1			2	35
Caenidae																				
Caenis capensis	5	466	27			1														26
Heptageniidae																				
Afronurus peringueyi						4		1		43	1	9				2			1	
Leptophlebiidae																				
Aprionyx sp				11		1	2	1	25	2	15	5			6	3			6	
Castanophlebia calida			1	137		7	19	29	3	234	7	58	38	69	31	26			55	2
Choroterpes nigrescens			6	12	1	75			2	171	2	42	12	12		48	2			113
Adenophlebia ?auriculata	48	36	55		1															
Teloganodidae																				
Ephemerellina barnardi								1			1		1						1	
Lestagella penicillata				89	1	13	2	1	7	38	62	131	6	45	1	75			92	8
Genus sp TSR151A				43				3	7	1	22			1					6	
Nadinitella sp TSR173E				1		1		13	1		25		19						34	
Nadinitella sp TSR378K				1																
Tricorythidae																				
Tricorythus sp									1											

Table 10: Plecoptera collected over the entire sampling period, represented by relative abundance values

PLECOPTERA	U. Matjies	L. Buffels	U. Buffels	U. Salt	L. Salt	L. Groot (W)	U. Groot (W)	U.Bobbejaans	U. Bloukrans	L. Bloukrans	U. Elandsbos	L. Elandsbos	U. Lottering	L. Lottering	U. Storms	L. Storms	U. Elands	L. Elands	U. Groot (E)	L. Groot (E)
Notonemouridae																				
Aphanicerca capensis form P							2		4	1		1					1			
Aphanicerca capensis form S															2					
Aphanicerca sp. nymphs				55	6		7		1	31		12	2	79	18	2	7		12	3
Aphanicercella bifurcata		3		1			2	1	1	2		1		1	17	1				
Aphanicercella nigra															25					
Aphanicercella sp. nymphs	8	12	1	1		4		9	3	2	1	3	1		3	1	4		17	7
Aphanicercopsis outeniquae							3							1	2					
Aphanicercopsis sp. nymphs	27	13	12	266	1	3	25	3	24	36	456	14	31	96	358	1	161		79	7

Table 11: Odonata collected by J. Simaika and his team of rangers over the entire sampling period.

Odonata	U. Matjies	L. Buffels	U. Buffels	U. Salt	L. Salt	L. Groot (W)	U. Groot (W)	U. Bobbejaans	U. Bloukrans	L. Bloukrans	U. Elandsbos	L. Elandsbos	U. Lottering	L. Lottering	U. Storms	L. Storms	U. Elands	L. Elands	U. Groot (E)	L. Groot (E)
Aeshnidae																				
Aeshna minuscula						1														
Aeshna subpupillata			1						1	1			2			1				
Anax speratus								1	1	1			2	2		1	2			
Corduliidae																				
Syncordulia gracilis					1											3				
Syncordulia venator									1							1				
Coenagrionidae																				
Africallagma glaucum																				1
Ceriagrion glabrum	3	3	3	4		1					1	2				5	15		1	2
Ischnura senegalensis						8														
Pseudagrion furcigerum				8	8	14	12	19	5	55			13	29		31	18	16	1	5
Pseudagrion hageni hageni		3	3		5	9						12				1	6			1
Pseudagrion kersteni				1						1										
Pseudagrion massaicum																				1
Gomphidae																				
Ceratogomphus triceraticus										1										
Lestidae																				
Lestes plagiatus																			1	3

	U. Matjies	L. Buffels	U. Buffels	U. Salt	L. Salt	L. Groot (W)	U. Groot (W)	U. Bobbejaans	U. Bloukrans	L. Bloukrans	U. Elandsbos	L. Elandsbos	U. Lottering	L. Lottering	U. Storms	L. Storms	U. Elands	L. Elands	U. Groot (E)	L. Groot (E)
Libellulidae																				
Crocothemis erythraea				1												2	2			
Crocothemis sanguinolenta								2	1											
Nesciothemis farinosa																6				1
Orthetrum abbotti																	1			
Orthetrum julia capicola	1	1	3	5	6	16		2	2	5	1	3	4	5		7	1	8		7
Palpopleura jucunda																	1			
Sympetrum fonscolombii						13														
Tramea limbata																				1
Trithemis arteriosa				1	3	4		2		5	1					11	6			16
Trithemis furva		1	1			8												1		
Trithemis stictica			2			11		1				1				6	6			2
Platycnemididae																				
Allocnemis leucosticta	2	15	6	12	7	8	6	3	1	6	1	1		8		2	3	13	1	
Protoneuridae																				
Elattoneura frenulata						3	1	2				1	1			6	1		5	1
Synlestidae																				
Chlorolestes conspicuus				4			5	3	5	1	2		5	3	5		2	1	3	
Chlorolestes tessellatus	7	8	6		6				8			19								
Chlorolestes umbratus				8	1	7	3	22	5	16		1				9	1		1	7
Ecchlorolestes nylephtha		1		19		4	4		3		14		4	13	29		8	22	7	

Table 12: Megaloptera collected over the entire sampling period, represented by relative abundance values

MEGALOPTERA	U. Matjies	L. Buffels	U. Buffels	U. Salt	L. Salt	L. Groot (W)	U. Groot (W)	U. Bobbejaans	U. Bloukrans	L. Bloukrans	U. Elandsbos	L. Elandsbos	U. Lottering	L. Lottering	U. Storms	L. Storms	U. Elands	L. Elands	U. Groot (E)	L. Groot (E)
Corydalidae																				
Platychauliodes sp.	1	6	3	11		4	3	3	14	11	11	3	7	14	17	7	29		7	1
Platychauliodes sp1				2		6	1		3		1		1		3					
Platychauliodes TSR11a	4	8	4		1		9	7	3	3	1			2	2		1	1		
Platychauliodes TSR48b									3					1						

Table 13: Larval Trichoptera collected over the entire sampling period, represented by relative abundance values.

TRICHOPTERA	U. Matjies	L. Buffels	U. Buffels	U. Salt	L. Salt	L. Groot (W)	U. Groot (W)	U. Bobbejaans	U. Bloukrans	L. Bloukrans	U. Elandsbos	L. Elandsbos	U. Lottering	L. Lottering	U. Storms	L. Storms	U. Elands	L. Elands	U. Groot (E)	L. Groot (E)
Glossosomatidae																				
Agapetis murinus				31			11	6		1	38	48	38	179	51	24	19		1	
Hydroptilidae																				
Hydroptila cruciata																		19		
Orthotrichia barnardi		1																		
Oxyethira velocipes											2							5		2
Genus sp TSR152G										2										
Philopotamidae																				
Dolophilodes urceolus				18			1		4	11	8	3	5	32	7	3	53		4	
Chimarra sp	73	49	62	6	65	11	51	5	2	29	222	23	36	48	3	172	21		6	3
Hydropsychidae																				
Cheumatopsyche afra			6											4		75		46	1	39
Cheumatopsyche TSR136E	9	123	67		6				1	2	5	6		9		1		116	7	17
Sciadorus obtusus				214			15	3	16	1	83		9	53	87	1	22		54	
Macrostemum capense		5	2																	57
Ecnomidae																				
Ecnomus thomasseti																				
Ecnomus sp.	1			1						8			1							1
Parecnomina sp.				5			2	4		2	3	15	14	31	2	7			2	
Polycentropodidiae																				
Paranyctiophylax SCR213T										5						6				1
Dipseudopsidae																				
Dipseudopsis capensis																				

	U. Matjies	L. Buffels	U. Buffels	U. Salt	L. Salt	L. Groot (W)	U. Groot (W)	U. Bobbejaans	U. Bloukrans	L. Bloukrans	U. Elandsbos	L. Elandsbos	U. Lottering	L. Lottering	U. Storms	L. Storms	U. Elands	L. Elands	U. Groot (E)	L. Groot (E)
Pisuliidae																				
Dyschimus sp.				4		1			1	3	3		15	5	1		11		2	
Leptoceridae																				
Athripsodes prionii				4	1	1	4	8		6	1	27	1	1					1	6
Athripsodes harrisoni						1		35		5		5	11	1					2	19
Athripsodes schoenobates						1							11							
Athripsodes bergenisis				42	6	183	2	12	32	76	86	64	3			4		1	1	282
Oecetis sp				42	8	21	11	5	17	4	2		19		5	32	57	3	3	124
Leptecho twisted case sp.						1		1		1					82		21		6	
Barbarochthonidae																				
Barbarochthon bruneum				63	1	143	58	222	7	152	184	14	74	62	4	15	43		35	
Petrothrincidae																				
Petrothrincus demoori				1		1	3	1	2		12	2	29	4	5		59		27	
Sericostomatidae																				
Petroplax sp.				1				2		2	1	1	2	3	2	1	1		2	1
Rhoizema sp																	3			

Table 14: Adult Trichoptera collected using light traps, for the entire sampling period.

TRICHOPTERA	U. Matjies	L. Buffels	U. Buffels	U. Salt	L. Salt	L. Groot (W)	U. Groot (W)	U. Bobbejaans	U. Bloukrans	L. Bloukrans	U. Elandsbos	L. Elandsbos	U. Lottering	L. Lottering	U. Storms	L. Storms	U. Elands	L. Elands	U. Groot (E)	L. Groot (E)
Glossosomatidae																				
Agapetus murinus				2			8	1			1	15		4	1					
Hydroptilidae																				
Hydroptila cruciata	1	6	12		11	5	3	1			1	3		4		2		335	2	1
Orthotrichia barnardi		1						5												
Orthotrichia SCR164A								1												
Oxyethira velocipes		15	22	5	49	9		4	2	1	1	2		5		1		1	2	
Philopotamidae																				
Chimarra ambulans		1	3	27	153	6	242	62		239	7	411	165	9		199			4	
Chimarra cereris								1												
Chimarra georgensis			1																	
Dolophilodes urceolus				19	1	2	38	23	15	26	17		3	9	27	2	24		1	
Hydropsychidae																				
Cheumatopsyche afra	3	9			21	1			2	2						219		78		6
Cheumatopsyche TSR539K	4	17	34		83							4			1					
Macrostemum capense																				6
Sciadorus obtusus				2				1	2		3				3					
Ecnomidae																				
Ecnomus oppidanus						1		3										1		6
Ecnomus similis	15	67	22	12	1	21	9	13		1				3		5	1		1	13
Ecnomus thomasseti																				7
Ecnomus TSR440G																				5

	U. Matjies	L. Buffels	U. Buffels	U. Salt	L. Salt	L. Groot (W)	U. Groot (W)	U. Bobbejaans	U. Bloukrans	L. Bloukrans	U. Elandsbos	L. Elandsbos	U. Lottering	L. Lottering	U. Storms	L. Storms	U. Elands	L. Elands	U. Groot (E)	L. Groot (E)
Parecnomina resima				13			34	29	2	38	29	24	14	99		13			2	
Parecnomina TSR545E								1	1				1		1		1			
Ploycentropodidae																				
Paranyctiophylax SCR213T										78						9				
Dipseudopsidae																				
Dipseudopsis capensis					1					1										2
Genus species SCR265F																				
Pisuliidae																				
Dyschimus collyrifer				5			19	9	1		1		1	1	13	2	13		1	
Dyschimus ensifer																				
Dyschimus TSR28S															2					
Dyschimus SCR248F				7					6		3	5	9	2		1	2			
Leptoceridae																				
Athripsodes bergensis	5	12	11	42	1236	116	621	524	311	4244	354	436	896	112	35	3744	1	14	56	19
Athripsodes harrisoni	1	12	7																	
Athripsodes oryx =164P							29	1	4	4	2		1		34	2				
Athripsodes potes											1					8				
Athripsodes prionii		3		8		9	6				11	15	2	3		1				2
Athripsodes scramasax				1					1				3	2	83		169		1	
Athripsodes spatula								22					8							
Athripsodes SCR258N																1				
Athripsodes TSR472C				1		6		3			2	12	12	15		1			1	2

	U. Matjies	L. Buffels	U. Buffels	U. Salt	L. Salt	L. Groot (W)	U. Groot (W)	U. Bobbejaans	U. Bloukrans	L. Bloukrans	U. Elandsbos	L. Elandsbos	U. Lottering	L. Lottering	U. Storms	L. Storms	U. Elands	L. Elands	U. Groot (E)	L. Groot (E)
Leptecho TSR491i								1					2	1						
Leptecho TSR363H											1									
Leptecho SCR258K =478E						4					153	3	13	14					123	
Leptecho SCR265K =499F		2		75			727	442	7	24	3	2	59	225		9	3	1	32	
Oecetis modesta	2	4	12	5	18	4		4		29	2		1	1	1	14		1		5
Oecetis SCR164N		3		1		1	2	1	6						11					
Oecetis TSR513B	5					2														
Oecetis TSR547L		1	2													1				
Barbarochthonidae																				
Barbarochthon ?brunneum								1												
Petrothrincuidae																				
Petrothrincus demoori							6	3			4	2	26	54	7					
Sericostomatidae																				
Petroplax prionii							4													
Petroplax SCR213F								9								1	1		2	1
Petroplax TSR447E						1									2	1				
Rhoizema montanum															9					

Table 15: Simuliid larvae collected over the entire sampling period, represented by relative abundance values.

Diptera	U. Matjies	L. Buffels	U. Buffels	U. Salt	L. Salt	L. Groot (W)	U. Groot (W)	U. Bobbejaans	U. Bloukrantz	L. Bloukrantz	U. Elandsbos	L. Elandsbos	U. Lottering	L. Lottering	U. Storms	L. Storms	U. Elands	L. Elands	U. Groot (E)	L. Groot (E)
Simuliidae																				
Simulium bequaerti																		1		5
Simulium dentulosum			97						178											
Simulium hessi				1				1		1									12	
Simulium impukane	46	89	121		8	6														
Simulium medusaeforme					4	186	1				155			2		58	27	342		44
Simulium merops	8			126	232		33	18	68	33	243	16	278	13	46	161	39	8	35	3
Simulium nigritarse				1	2				1		159				57	4	21	38		2
Simulium rutherfoordi	89	112	432		27	1							2	15	66		325			
Simulium vorax		4	257	255			1	21	784	63	743		185	242	19	37	364	5	246	18
Undescribed *Simulium sp.*										14										

Table 16. The number of families, genera and species of Trichoptera recorded for each of Harrison's twelve hydrobiological regions as at December 2005. Figures in parentheses indicate families, genera and species endemic to that region

Region	Families	Genera	Species
A	15(5)	38(15)	123(90)
B	0	0	0
C	5	16	25(3)
D	11	17	26(2)
E	13(1)	37(3)	73(16)
F	11	27	45(5)
G	7	23	39(3)
H	6	15	20(1)
J	7	14	20(1)
K	6	26	42(7)
L	6	17	34(6)
M	3	5	5

Table 17. Distribution of primary freshwater fish species in rivers in the Tsitsikamma moutains in the southern Cape (* & **see refs below for sources of information)

River	**Indigenous primary freshwater fish species present***	**Alien freshwater fish species present****
Groot East	*Pseudobarbus afer*	
Elands	*?*	
Storms	*Sandelia capensis*	
Lottering	**Nil**	
Elandsbos	*Sandelia capensis*	
Bloukrans	*Pseudobarbus afer*	
Groot West	*Pseudobarbus afer*	
Bobbejaans	**Nil** (above confluence with Groot River)	
Salt	**Nil**	
Buffels/Matjies	*Pseudobarbus afer*	
Keurbooms	*Pseudobarbus afer, Pseudobarbus tenuis, Galaxia zebratus, Sandelia capensis*	*Salmo trutta*

* Barnard (1943) ** de Moor & Bruton 1988 & 1996; Cambray and Skelton (pers comm. based on records from the Albany Museum and South African Institute for Aquatic Biodiversity records of 1980 and 1988); N P James (pers. obs.).

Table 18. Number of species of selected insect taxa recorded in surveys of the Great Berg River, surveyed at 13 stations at monthly intervals for a year (Harrison & Elsworth 1958: Scott 1958) and the Salt River surveyed three times at 10 sites with only six sites surveyed on two occasions and no sites were surveyed three times.

Taxon	**Great Berg River**	**Salt River**
Ephemeroptera	22	21
Odonata	14	11
Trichoptera	24	29
Diptera (Chironomidae)	83	57