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# BIOMONOTORING OF THE GREAT KEI RIVER SYSTEM

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## EXECUTIVE SUMMARY

The main objective of the South African National Aquatic Environmental Health Monitoring Programme (NAEHMP) makes use of the instream and riparian biological communities like vegetation, invertebrates and fish to assess the ecological 'health' of rivers as well as physical attributes or drivers of the ecosystem like hydrology, geomorphology and water quality. These biological communities are always found in rivers and they are often affected by any disturbance that occurs in the river ecosystem.

This report provides the results of the biomonitoring survey that was undertaken in in the Great Kei River Basin in February 2009 (Summer survey). Field indices used for data collection included the Geomorphology, Water Quality, South African Scoring System version 5.0 (SASS5) for macro invertebrates, and the Fish Assemblage Integrity Index (FAII) for fish.

The Department: Water Affairs and Forestry (DWAF): Eastern Cape National Aquatic Environmental Health Monitoring Programme (former RHP) involves the use of Biomonitoring as a tool to determine the health of the aquatic ecosystems. The programme aims to promote standardized and continuous monitoring and reporting on the Eastern Cape rivers ecosystem health. The Great Kei River is one of the systems monitored by the Eastern Cape DWAF, hence monitoring survey was conducted.
This report provides information on the Present Ecological State of the Great Kei River Basin.

## INTRODUCTION AND BACKGROUND

The Great Kei River starts from an altitude of approximately 2 100 meters above sea level (masl) and meanders its way towards the Indian Ocean. Using the ArcView GIS software with 1: 50 000 image data, it can be estimated that the Great Kei Basin occupies the area of approximately 20 480 square kilometers. The mainstem of the drainage basin originates as two branches; the Black Kei in the West and a White Kei in the East and it becomes the Great Kei River at the confluence until it opens in the Indian Ocean. Major tributaries of the Great Kei River are the Tsomo, Kubusi, Gcuwa and Tyityaba rivers; the latter being inaccessible due to its location in a gorge area and a rough, steep terrain (see 1:50 000 toposheets and Google Earth images). The Great Kei River and its tributaries flow through confined valleys with gentle slopes hence meandering. The figure below shows the terrain of the Kei River Basin from source to mouth.

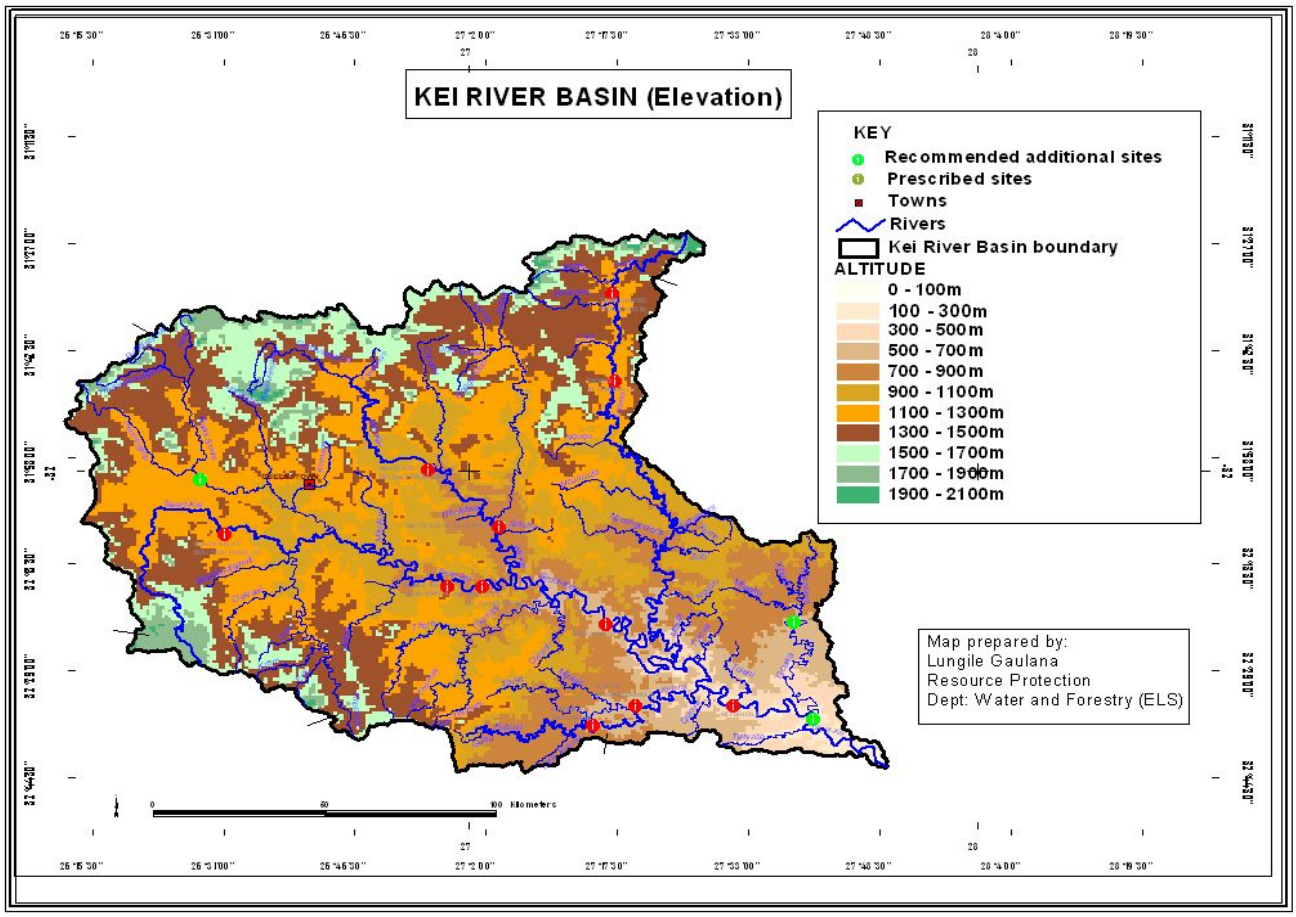


Figure 1: Topography of the Kei River drainage basin.

**Climate**

The Kei River catchment receives its rainfall mainly in summer. Due to its location in the driest part of the country, numerous dams and weirs had been built to extend water supply potential and to meet water requirement demands. Major reservoirs include the following:

- Lubisi Dam with the capacity of 158 million cubic meters.
- The Ncora Dam with about 150 million cubic meters
- The Xonxa of about 97.5 million cubic meters and
- Wriggleswage Dam of about 91.5 million cubic meters (www.ewisa.co.za).

Other numerous dams include the Bongolo, Bushmanskrantz, Doringrivierdam, Gubu, Limietskloof, Macubeni, Mitford, Oxkraal, Sam Meyer, Shiloh, Tentergate, Thrift, Toleni, Waterdown and Tsajana. These dams increase evaporation potential on the catchment.

In addition, a lot of windmills for harvesting groundwater could be observed, especially on the upper part of the catchment. This suggests that the catchment is facing water resource deterioration crisis, including the groundwater, surface water and rainwater.

**Geology and Soils**

The Great Kei catchment is dominated by rocks of the Karoo Supergroup (mainly shale, mudstones and sandstones) the Molteno along the Tsomo, the Tarkastad along the entire Great Kei and some patches of Adelaide and Suurberg Supergroups (Figure 2). Both the Adelaide and the Tarkastad consist of sandstones and mudstones; the Molteno, Clarens, Elliot formation contains sandstones, mudstones, shales and siltstones. Soils in the Great Kei Basin comprise mainly of moderate to deep clayey loams along the Thomas River sub-catchment and very shallow and rocky soils in the Tsomo River subctchment (see also www.waterinformation.co.za). According, soils on the area are poorly developed, being shallow and rocky and mostly not suitable for crop production with alluvial soils mainly obtained on the valleys.

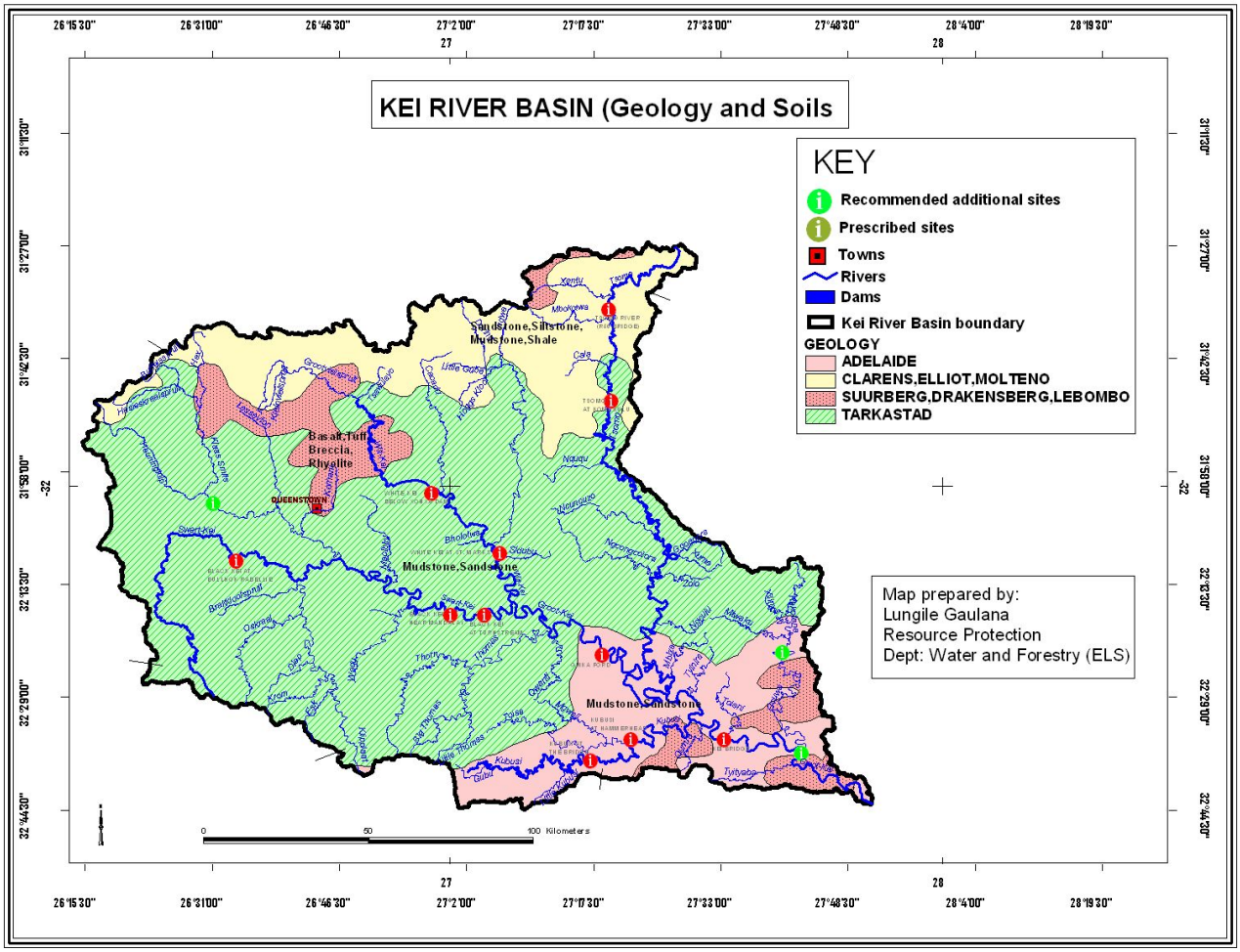


Figure 2. Geology and soils of the Kei River Basin

**The Natural Vegetation.**

The plateau area is mainly covered by grasslands (Moist upland and South-Eastern Mountain Grasses) with unreliable degrees of Acacia Karoo thornveld as well as some patches of Afromontane forest and huge proportion of Sub-arid thorn bushveld. Valley thicket is located in the lower reaches of the Black Kei River valley, lower reaches of the White Kei River valley, middle and lower reaches of the Thorn River, upper reaches of Kubusi River and the rest of Great Kei River. Alien invasive vegetation includes the black wattle (*Acacia meansii)* that can be observed throughout the river system. This was more invasive especially at Tsomo at Komkhulu site. The figure below shows the vegetation types on the Great Kei River Basin.

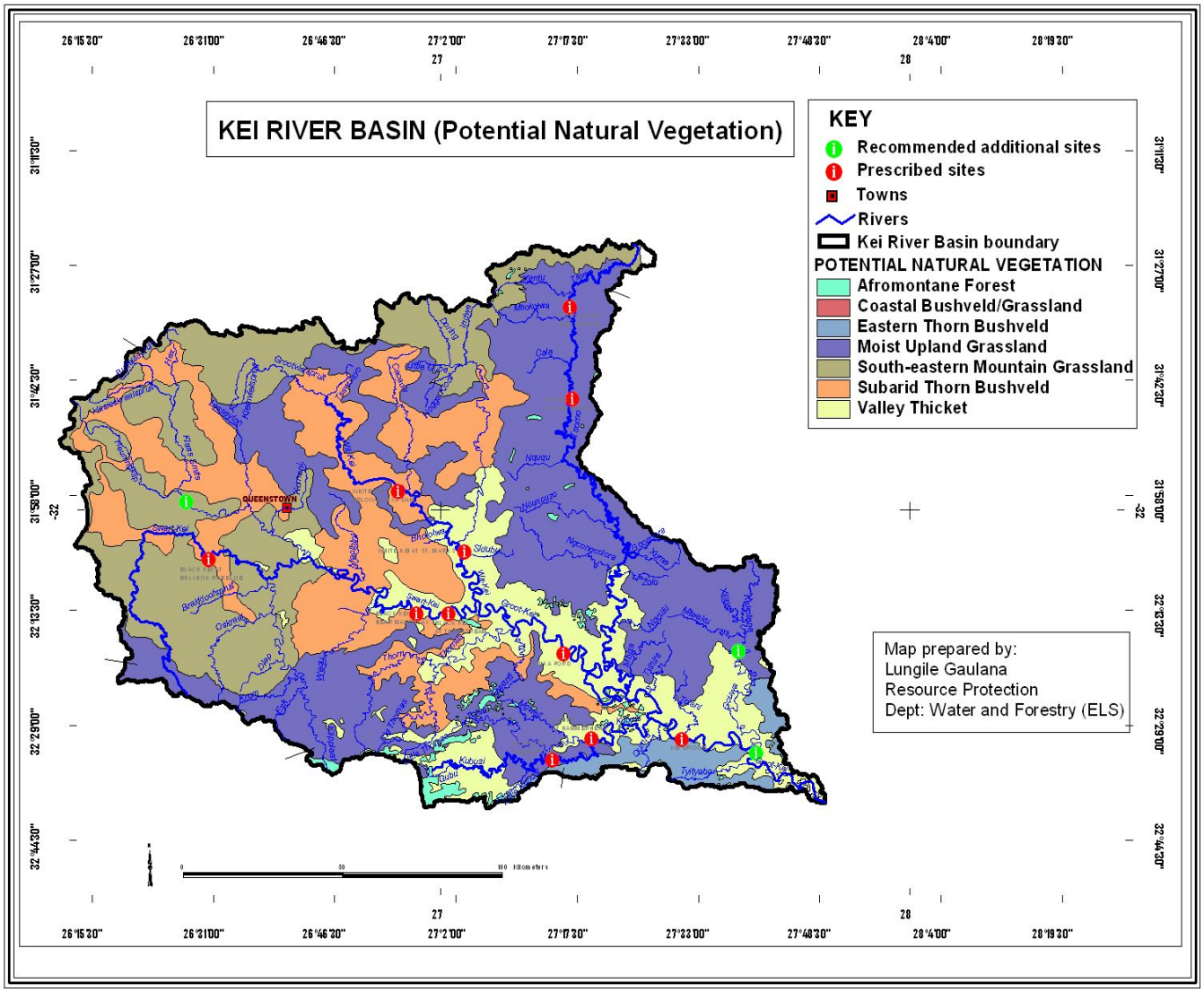


Figure 3: Vegetation of the Great Kei River Basin (After Louw and Rebelo 1996).

**Ecoregions.**

The large portion of the Great Kei River Basin consists of the Drought Corridor Level I Ecoregion around Queenstown and the South Eastern Uplands Level I Ecoregions around areas of Cala, Komga and Butterworth. Small percentage of the catchment has the Eastern Escarpment Mountains and the Eastern Coastal Belt Level I Ecoregions on the upper reaches and coastal areas respectively. The figure below shows the Levels I and II ecoregions of the Great Kei River Basin.

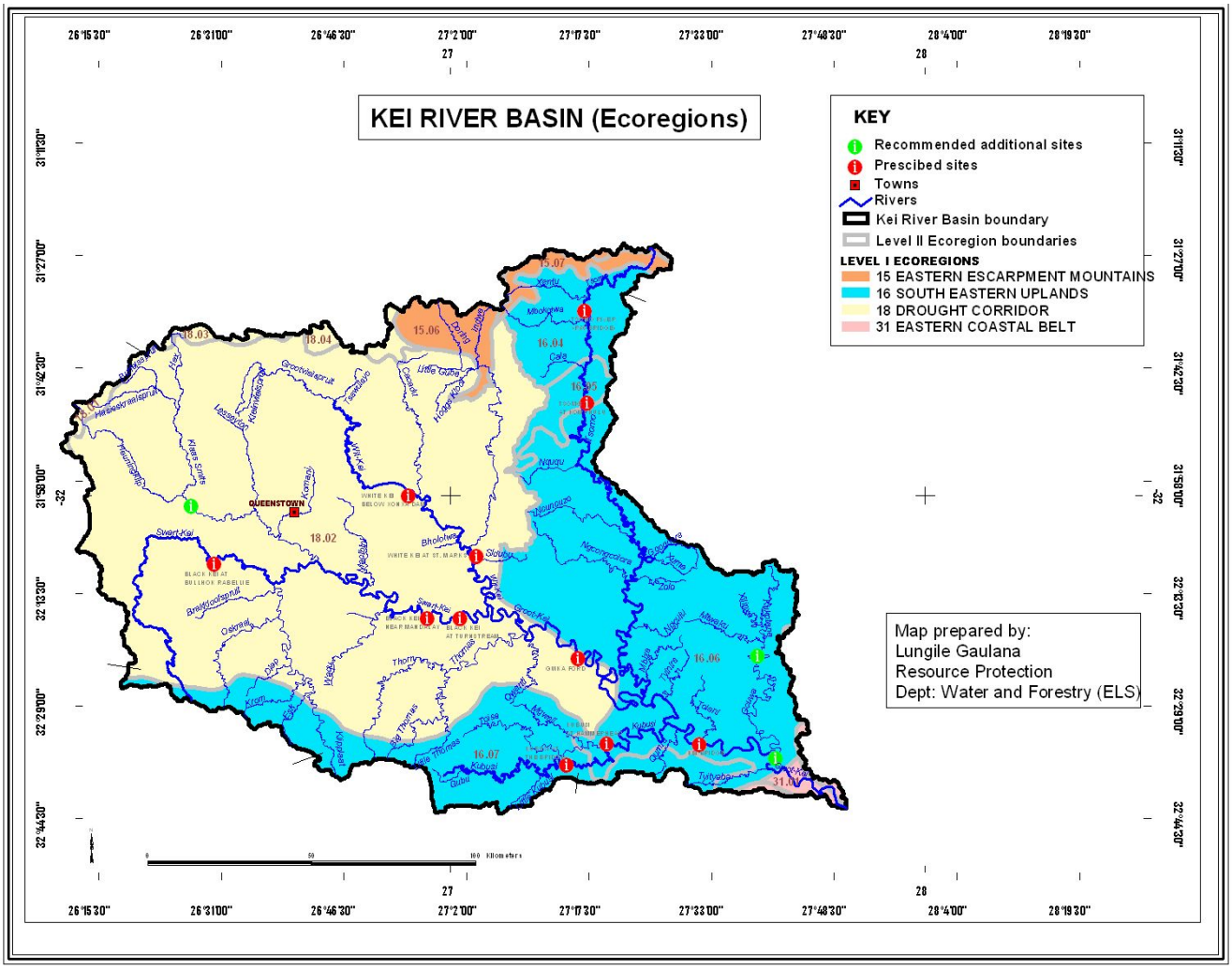


Figure 4: Levels I and II Ecoregions of the Great Kei River Basin.

**Quaternary Catchments**

By dividing the catchments into smaller units can increase the efficiency of the management of any ecosystem. Therefore each Catchment Management Agency can be allocated to manage a particular Quaternary catchment effectively. The figure below shows the Quaternary catchments of the Great Kei River Basin.

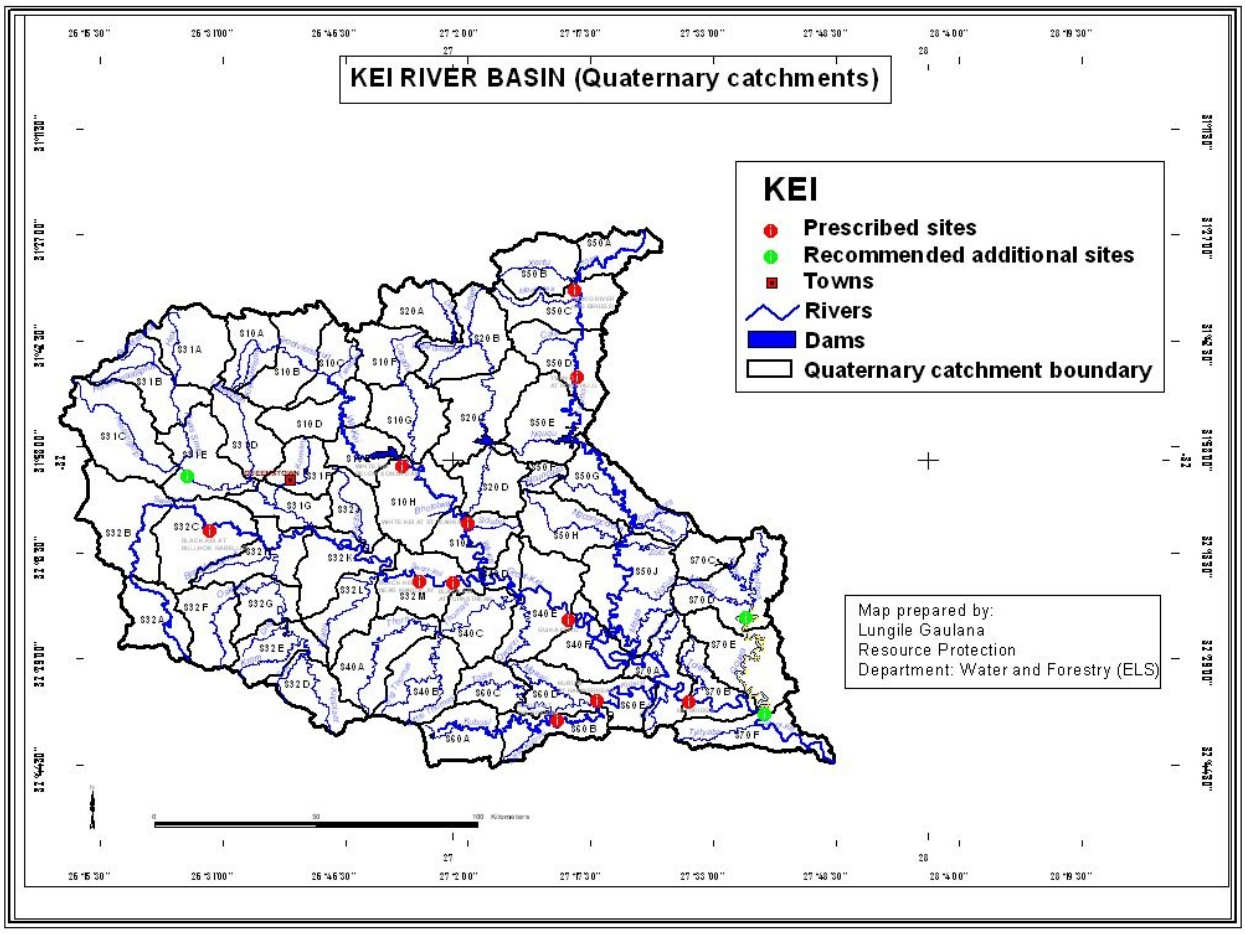


Figure 5: Quaternary catchments of the Great Kei River Basin.

**Major Land Use Activities**

Observed on the study area are markedly different units of landuse activities which include the following:

- Live stock farming (Beef, dairy, sheep, poultry and goats)
- Subsistence farming (maize and vegetables)
- Game farming (Builder beast, antelope, bushpig or warthog and kudu)
- Rural and Urban settlements.
- Commercial farming lands occur mostly on the western side of the catchment (mainly Lucerne). This is where extensive irrigation occurs.

It could be noticed that most of the land in the catchment is unimproved and degraded grassland. The figure below demonstrates the landuse map of the Kei River Basin.

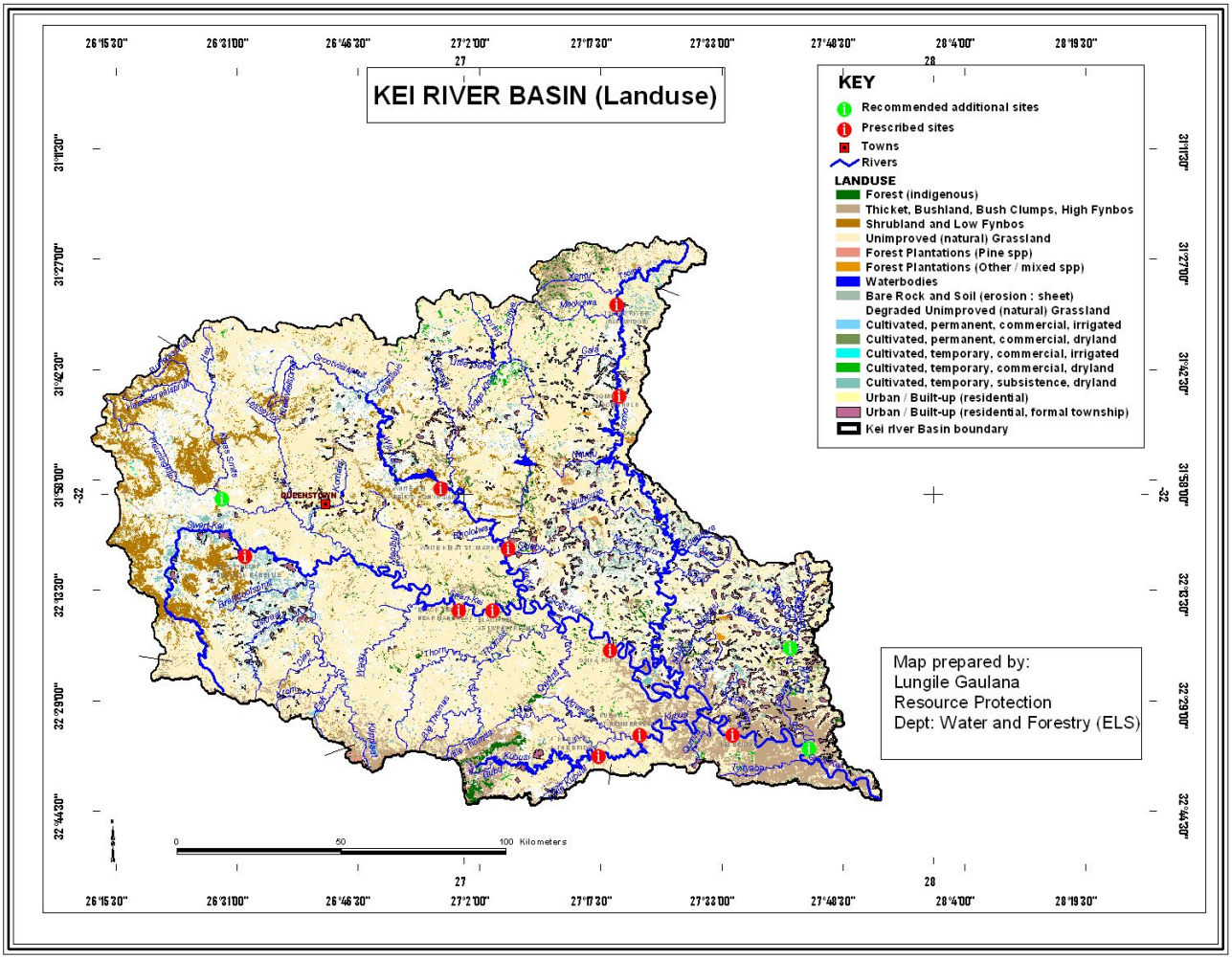


Figure 6 Landuse of the Kei River Basin.

## METHODOLOGY

The Great Kei River survey was conducted in summer (2nd February 2009 until 6th of February 2009). Site selection for the survey was previously done during the ground truthing survey conducted in 10th to 19th November 2008 and some additional sites on the lower reaches of the Great Kei before the estuary, and other sites on the Gcuwa and the Klass Smith tributaries with the aim of finding reference sites for the South-Eastern Uplands and Drought Corridor Level I Ecoregions respectively.

Ecosystem components assessed were two drivers of the ecosystem; geomorphology and water quality as well two responses of the ecosystem, mainly macro invertebrates and fish.

This was a transect survey that was conducted on the Mzimvubu to Keiskamma Water Management Area. The survey was done by collecting data on predetermined accessible sites. These sites were selected in three sections of the catchment viz:

1. The upper reaches, where the survey took place right upstream of all the selected major tributaries.
2. The middle reaches, where the preference was on the confluences and impoundments.
3. The lower reaches, where the survey will be done to assess the overall impact on the Great Kei River Basin.

The following implements were utilized during the survey:

a) The Geomorphological Assessment Index (GAI), which was used to assess the Present Geomorphological State of a river at a particular reach.
b) A measuring tape: to measure sediment categories on transect selected on each accessible site. The idea being to assess sediment distribution so as to predict environmental flows that would be required to meet the requirements of a recommended Environmental Management Class (EMC).
c) The Water Quality meter to measure the water quality parameters (pH, Oxygen absorbed, Water temperature and Conductivity, as well as bottles to collect samples for chemical analyses)
d) SASS trays and nets: for macroinvertebrate evaluation.
e) Fish shocker and net: for fish assessment.
f) 1: 50 000 topographic maps, 1: 250 000 toposheets and Google images. These were used to find and locate the predetermined survey sites, as well as to act as a desktop estimate at a catchment scale.
g) The Global Positioning System (GPS), to locate the sites of assessment and to navigate the directions to the site.
h) ArcView 3.2: a GIS software tool that was vital for data storage, analyses, manipulation and interpretation of data.

The maps with ecoregions, sites, geology and soils, vegetation, landuse were created using the Geographical Information System (Arcview 3.2), the GPS (Global Positioning System) readings for each site and the spreadsheet (Microsoft Excel 2003) for graphics and changing GPS co-ordinates to decimal degrees (GIS format).

**AIMS**

The main aim of the survey was to review the overall Present Ecological State of Great Kei River Basin. The results of the survey would serve as an input to the National Aquatic Environmental Health Monitoring Programme (River Health Programme), Reserve determination for Resource Directed Measures & EcoStatus model.

**COURSE OF THE SURVEY**

**Tsomo at R56 Bridge**

The site is located at Tsomo River at S31° 22' 02.2" and E27° 40' 14.6" at an altitude of 1178 masl. The site is located within the South Eastern Uplands Level I Ecoregion at S50C Quaternary catchment (refer to Figures 4 and 5). The site is located at an incised channel with flood benches. Therefore beside the sediment from upstream, the sediment from the hillslope can be trapped only on flood benches before it reaches the river channel. The river at a reach is a multiple thread, straight, pool-rapid and a mixed channel dominated by bedrock and boulders. (Pate 1). It is also an anastomosing channel, suggesting that numerous channels have developed as a result of sediment deposition accompanied by vegetation growth within the active channel itself. The site has about 80% of morphological units described on the Geomorphological Assessment Index (After Du Preez and Rowntree, in press). This means that there is a variety of habitat types for aquatic biota. The Geomorphological Assessment Index (GAI) model shows that the site is at A class in terms of its present geomorphological state. Sediment sampling could not be done due to the site's fluvial morphological state of fixed boulder and bedrock material.

Plate 1. Note the alien vegetation encroachment on the right bank.

**Tsomo at Komkulu**

The site is geographically situated at Tsomo River at S31° 36’ 33.3” and E27° 40’ 35.4” at an altitude of 1108 masl. This is basically within the South Eastern Uplands Level I Ecoregion at S50D Quaternary catchment (Figures 4 and 5). It is situated at confined valley floodplain. Most of the sediment from the hillslope can be fascinated only on floodplains. In other words, the colluviums from adjacent slopes cannot easily reach the river channel, especially if the floodplain could be rich in natural vegetation. The river at a reach is a multiple thread, sinuous, mixed, pool-riffle system, often in a flat bed reach type (Plate 1). This means that meandering at a reach scale is active, that is, alternative erosion and deposition occurs on both the river banks. The reach type is a flat bed which means a lot of fine material can be trapped in a river bed especially during periods of low flows. The river at a site has about 75% of morphological units of where the aquatic fauna and flora can survive. The Geomorphological Assessment Index (GAI) model shows that the site is at B class in terms of its present geomorphological state.

Plate 2. *Acacia meansii* is an invasive alien that occupies most of the river banks and the riparian zone.

Sediment sampling was done at a site and it shows that the river at a site is dominated by small boulders/cobbles as well as variety of deposited fine material. Figure 7 shows the distribution of sediment in the Tsomo River site at Komkhulu.

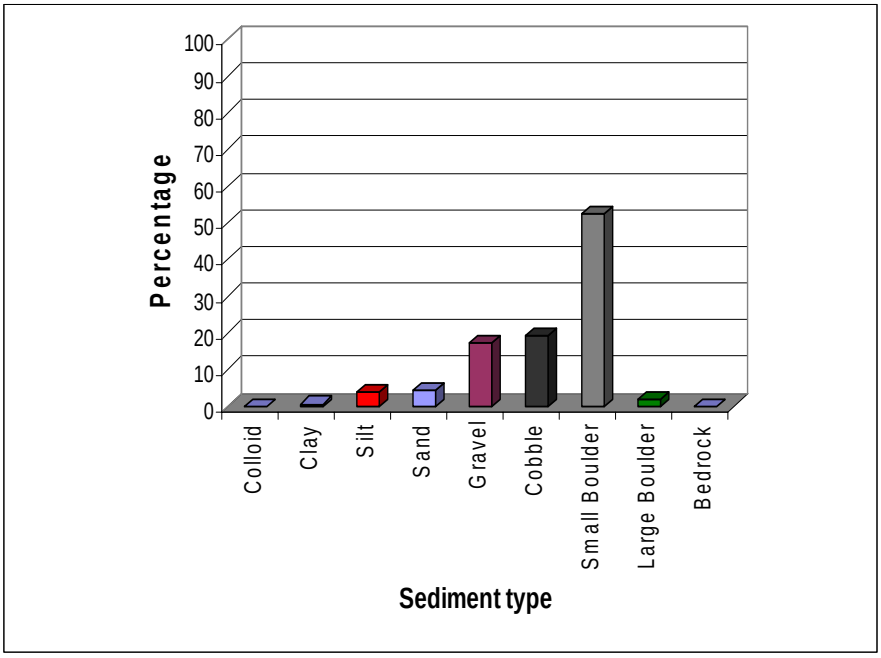

Figure 7. Fine material was also more abundant (compare with plate 2).

**Klass Smith tributary**

This site is located at Klass Smith River at S31°52’ 35.68” and E°26 23.67”. The site is located Quaternary catchment S31E. The major idea to select the site was to ground truth the reference condition of the Drought Corridor Level I Ecoregion. Unfortunately the site is located on poor vicinity with seriously modified condition. Plate 3 below shows the weir further downstream of the proposed site (S31°54’ 30.83” and E°26 37’59.58”). In addition the river has become a non-perennial one due to abstraction of groundwater and surface water (a lot of windmills and dry farm dams could be observed). Thus no assessment was done there.

Plate 3. The river was no longer flowing and a weir was designed to collect any droplet of the water.

**Black Kei at Bulhoek.**

The site is located at Black Kei River at S32° 02’ 4.3” and E26°39’ 21”. It is located in the Drought Corridor Ecoregion at S32C Quaternary catchment (Figures 4 and 5).

It is situated at incised channel, often with flood benches. The sediment from the hillslope can be deposited directly to the river channel with minimal resistance of flood benches. The river at a reach is a single thread, straight, mixed, pool-riffle system

dominated by cobbles (Pate 1). Most dominant features are cobbles that were not submerged by the water due to low flows at the period. Due to this and embededness by the fine material from eroded river bank, upstream and the hillslope, no sediment sampling could be done whatsoever. Only about 42% of morphological units could be examined for the habitat of the living freshwater plants and animals. The Geomorphological Assessment Index (GAI) model shows that the site is at A class in terms of its present geomorphological state. Therefore no significant change and human impacts could be noticed from both the hillslope and the river channel.

Plate 4. Indigenous vegetation was present along the river reach (mainly *Acacia Karoo*)

**White Kei Below Xonxa Dam**

The main idea of selecting the site below the Dam was to assess ecological impacts of impoundment. In addition, a weir immediately below the Dam could also be seen upstream of the site. The site is geographically situated in a Drought Corridor Level I Ecoregion at S10H Quaternary catchment. It is located in the White Kei River at S31º 51' 18.9" and S27º 11' 22.5" at an altitude of 886 masl. The site is positioned where the floodplain is confined on one side. Therefore most of the sediment from the hillslope can be enthralled alternatively on floodplains and flood benches on both the river banks. On a reach scale, the river is a multiple thread, straight, mixed, pool-riffle system and also an anastomosing river bed. Because the site is located right below the Dam, the

sediment observed was directly from the hillslope and the Dam acts as a trap for any material from upstream.

At the same time, the sediment hungry waters from the Dam release could remove most of the fine sediments from the river bank and the hillslope. Due to this, the dominant material at a site is a fixed boulders and a bedrock material (Plate 5). However, about 63% of morphological units could be noticed at a site. The Geomorphological Assessment Index (GAI) model shows that the site is at C class in terms of its present geomorphological state.

Plate 5.

**White Kei at St. Marks**

The site is located at White Kei River at S32° 0’ 49.6” and E27° 22’ 27.2”.

The site is situated in a Drought Corridor Level I Ecoregion at S10J Quaternary catchment. The site is in the middle reaches of the Kei River Basin in the incised channel and flood benches along the river system. The river at a site basically is a multiple thread, flat bedrock system (Plate 6). It could be observed that at a catchment scale lot of the sediment is from the hillslope and upstream of the river. Impacts of both the Lubisi (Indwe tributary) and the Xonxa dams (White Kei) both upstream of the site could have tremendous impacts on the river reach as well. This could be the result of catchment hardening due to vegetation removal occurring along the river system.

However, about 67% of morphological units could be perceived at a site. No sediment sampling could be done at a site due to its locality on a bedrock pool-rapid system.

The Geomorphological Assessment Index (GAI) model shows that the site is at B/C class in terms of its present state.

Plate 6. Note vegetation clearance on the hillslope.

**Black Kei near Mandalay**

The site is located at Black Kei River at S32° 10’ 38.2” and E27° 14’ 22.5”.

It is geographically located where the floodplain is confined on one side. The site is geographically situated in a Drought Corridor Level I Ecoregion at S32M Quaternary catchment (see Figures 4 and 5). The site consists of about 71% of morphological units described on the Geomorphological Assessment Index. The sediment from the hillslope can be deposited directly to the river channel with minimal resistance that occurs alternatively by the flood benches of both the right and left river banks. The river at a reach is single thread, straight, bedrock with some cascades Interestingly, it could be noticed that the river channel at a site is a braded one, that is, numerous channels occurring at a site area. The Geomorphological Assessment Index (GAI) model shows that the site is at A class in terms of its present geomorphological state. Therefore no significant change might have occurred as compared to the reference condition (which is

difficult to determine). No sediment sampling could whatsoever occur due to the site's identity as being dominated by bedrock and some fixed boulders.

Plate 7. Black Kei at Mandalay.

**Black Kei at Turnstream**

The site is located at Black Kei River at S32° 10' 43" and E27° 19' 49.3" at an altitude of 690 masl. It is geographically located where the floodplain is confined on one side. The site is geographically situated in a Drought Corridor Level I Ecoregion at S32M Quaternary catchment (see Figures 4 and 5). Its geographical location is where the floodplain is confined on one side. Morphological units (biotopes) observed comprise about 50%. The sediment from the hillslope can be deposited directly to the river channel with minimal resistance that occurs alternatively by the flood benches of both the right and left river banks. The river at a reach is single thread, straight, alluvial channel with boulders as dominant features. A weir immediately upstream of the reach could trap some fine sediments from upstream of the river system. The Geomorphological Assessment Index (GAI) model shows that the site is at B class in terms of its present geomorphological state. Therefore minimal local changes might have occurred as compared to the reference condition (mainly the weir). The river at a reach consists of fixed bedrock and thus no sediment sampling could be taken.

However, the base flows for maintaining the recommended EMC could be considered, that is, for both development and ecosystem requirements (the Reserve).

Plate 8. Black Kei at Turnstream: a typical alluvial scene that can be detected below impoundments.

**Great Kei at Gaika Fort**

The site is located at upstream of the bridge at S32°16' 59.8" and E27° 39' 09.1" at an altitude of 596 masl. Using the Geographical Information Systems, it can be noticed that the site is geographically situated in a Drought Corridor Level I Ecoregion at S40E Quaternary catchment (see Figures 4 and 5). Furthermore, the site is right below the confluence of the two giant horns; the Black Kei and the White Kei. The river channel at a reach is incised with flood benches. Morphological units (biotopes) observed comprise about 83%. The sediment from the hillslope can be deposited directly to the river channel with negligible resistance by the flood benches of both the right and left river banks. The river at a reach is multiple thread, straight, mixed braided channel (flat bed on upstream), with a mixture of fixed boulders and bedrock as dominant features. Plate 9 below shows the Gaika Fort site of the Great Kei Basin.

Plate 9. Note down the turbidity of the water and a vegetated mid channel bar.

Sediment sampling was done at a minimal scale where there were few cobbles available at a riffle. It could be observed that the some fine material, probably mostly from upstream could be also be obtained. The figure below shows the distribution of sediment in the Great Kei River at Gaika Fort.

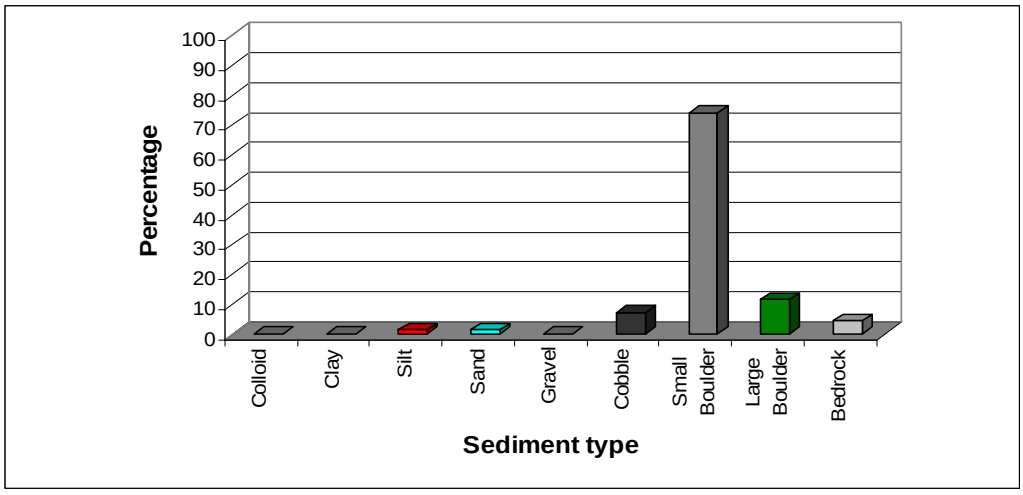


Figure 8. Percentage sediment distribution in Great Kei at Gaika Fort site.

The Geomorphological Assessment Index (GAI) model shows that the site is at B class in terms of its present geomorphological state. Therefore minimal local changes might have occurred as compared to the reference condition, possibly due to the impacts of landuse on the Black Kei and the White Kei 'horns'.

**Kubusi at Hammerhead**

The site is located at Kubusi River at S32° 33' 44.5" and E27° 37' 13.4" at an elevation of 635 masl. The site is in the South Eastern Uplands Level I Ecoregion at S60B Quaternary catchment. The river at a reach is an incised channel with flood benches. Thus the sediment from the hillslope can reach the channel after it has been resisted locally by the flood benches. Morphological units (biotopes) observed comprise about 58%. In terms of morphology, the river at a reach is single thread, straight, bedrock pool-rapid system channel, with bedrock as dominant feature. The geomorphology at the site area is influenced by the impacts of the Wriggleswade Dam (less than 10 km upstream). These include the morphology of a site area being a bedrock channel, which is not a normal feature of a river on its middle reaches. Plate 10 below shows the Kubusi River at Hammerhead.

Plate 10. Bedrock dominated Kubusi River at Hammerhead.

Therefore it is not astonishing to discover that the Geomorphological Assessment Index (GAI) model shows that the site is at C class, which is almost certainly that this was due to dam impacts. Due to the bedrock and fixed boulder material downstream, no sediment sampling could be done at a site.

**Kubusi: The Bridge**

The site is located at Kubusi River at S32° 30' 26.3" and E27° 43' 53.6" at an elevation of 438 masl. The site is in the South Eastern Uplands Level I Ecoregion at S60E Quaternary catchment. This is in a rejuvenated foothillThe river at a reach is found where the floodplain is confined on one side. Thus the sediment from the hillslope can reach the channel after it has been resisted locally by the floodplain on one side and by the flood-bench on the river bank alternatively down the river reach. Morphological units (biotopes) observed comprise about 58%. In terms of morphology, the river at a reach is multiple thread, straight, mixed alluvial pool-riffle system. Dominant features in the channel are fixed boulders and some few cobbles together with bedrock. Plate 11 below shows the Kubusi River bridge site.

Plate 11.

The GA index shows that the river at a reach is at B class and therefore impacts of the dam further upstream still exist, together with the impacts of the bridge at a site area.

**Great Kei below N2 Brige**

The site is located downstream of the bridge at S32° 30' 26" and E27° 43' 53.4" at an altitude of 148 masl. The site is in the South Eastern Uplands Level I Ecoregion at S70B Quaternary catchment (Refer to Figures 4 and 5). Its geographical location is where the floodplain is confined on one side. Morphological units (biotopes) observed comprise about 50%. The river at a reach is single thread, straight, mixed alluvial channel with boulders and cobbles as dominant features. Three bridges and a weir immediately upstream of the site could have significant impact on the river at a site (refer also to plate 12 below). The Geomorphological Assessment Index (GAI) model shows that the site is at C class in terms of its present state. Therefore a lot of local changes might have occurred as compared to the reference condition (mainly due to the weir, bridges and intensive local sediment mining). However, the natural vegetation at a reach scale is still in its near natural state, except some few of *Lantana spp*. Plate 12 shows the Great Kei River at N2 Bridge.

Plate 12. Kei River bridge site.

Sediment sampling was done at a transect in the Kei River bridge site. The results show that the most dominant sediment types are the boulders, that is, any sediment type above 256 mm (or 56 cm) in diameter. The high flows at a site area, together with the impacts of the sediment hungry waters from the weir immediately upstream could accelerate the resultant minimal or negligible fine material at a site area. Figure 9 below shows the percentage distribution of sediment types in the Kei River at N2 bridge.

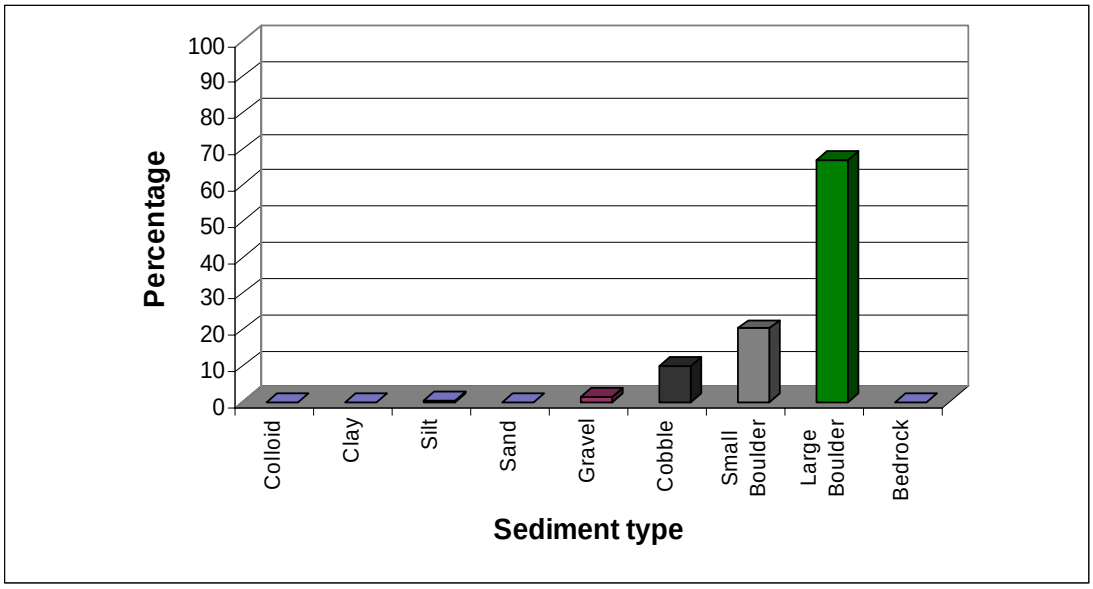


Figure 9. Showing sediment distribution in the Great Kei River at N2 bridge.

**Gcuwa at Magagasi**

The site is located upstream of the Gcuwa River S32° 16’ 58.8” and E28° 59’ 7.2” at an altitude of 154 masl. The idea to select the site was to obtain to ground truth the ecological state of the Gcuwa River system before being impacted by the urban settlement of Butterworth. If possible, the reference state could be recorded on at a site. However, due to its poor condition, no assessment was done there. In fact the site was not fully accessible due to its dense vegetation along the river banks, as well as very deep pools both upstream and downstream of a site (Plate 13).

Plate 13. Showing dense indigenous vegetation and deep a pool.

**Great Kei at Glen.**

The site is located at the Great Kei immediately below the confluence of the Great Kei and the Gcuwa tributary at S32° 32' 41.1" and E28° 11' 37.9" at an elevation of 65 masl. The site is in the South Eastern Uplands Level I Ecoregion at S70E Quaternary catchment. The site is in the lower reaches immediately above the estuary in about 24 kilometer distance (refer to 1:50 000 toposheets and Google Earth). Landuse involved at a catchment scale is a small scale commercial agriculture and stock farming, as well as a game reserve on the hillslope. The idea of selecting the site at that reach was to assess the present state of the river system after the Great Kei has been joined by the Gcuwa River, with the latter having significant impacts of the urban settlement of Butterworth (mainly sewage works, agriculture, settlements, dams etc). The river at a reach is an incised channel with flood benches. Morphological units (biotopes) observed comprise about 54%. In terms of its morphology, the river at a reach is multiple thread, sinuous, mixed alluvial, pool-riffle system, often with flat bed. Plate 14 below shows the Great Kei River site at Glen.

Plate 13.1: Note algae and turbidity of the water.

Plate 13.2: A typical alluvial channel.

Sediment distribution was also assessed at a site. The results show that dominant features in the channel are fixed boulders and some few cobbles. A bedrock channel is also present immediately below the confluence. Due to this, ii can be considered that the river at a reach is a rejuvenated foothill. The figure below shows sediment distribution assessed on a riffle at a site area.

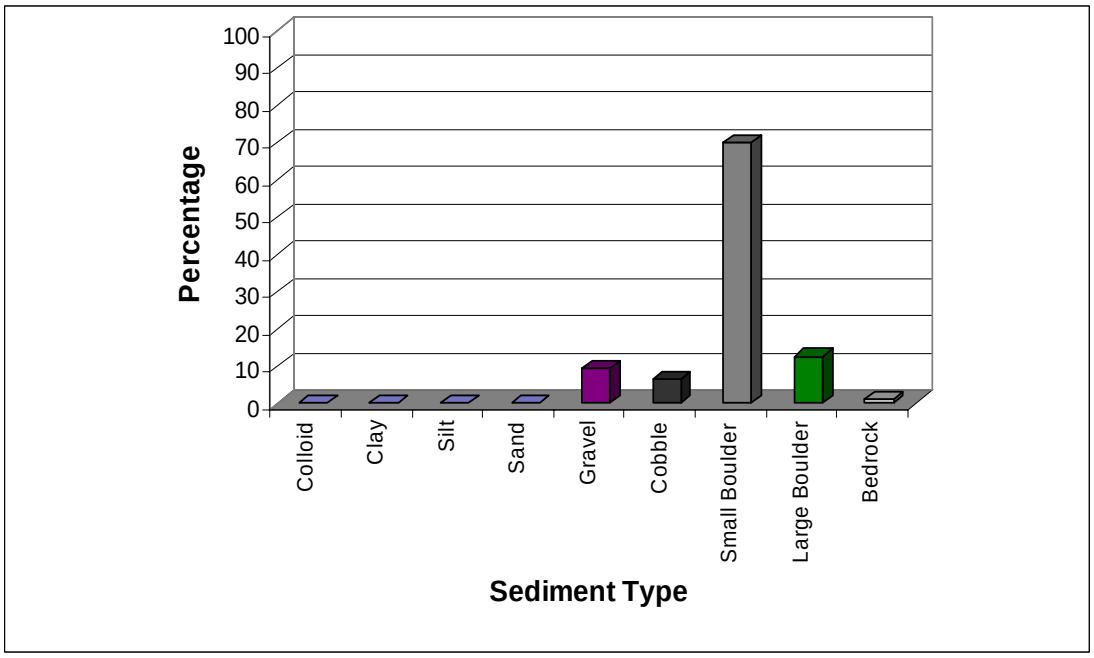


Figure 10. Distribution of sediment in the Great Kei River at Glen (Compare with Kei Bridge).

## WATER QUALITY

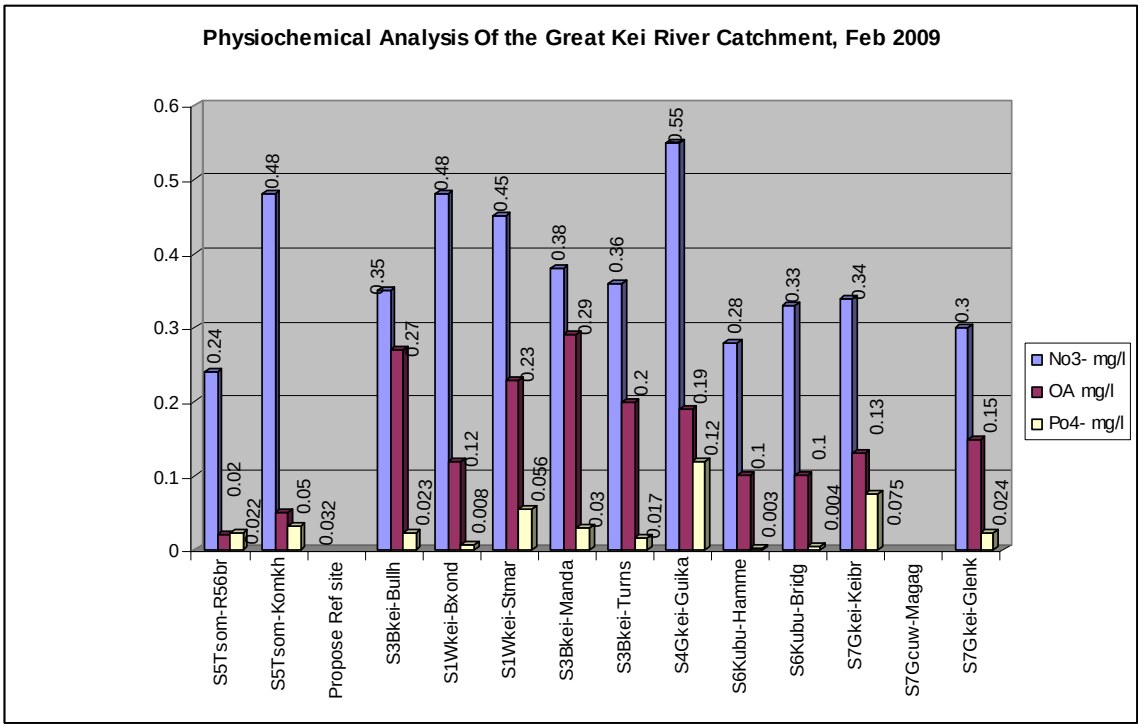


Figure. 11. Physiochemical analysis of the Kei River Basin (Nitrates, Oxygen absorbed and Phosphates).

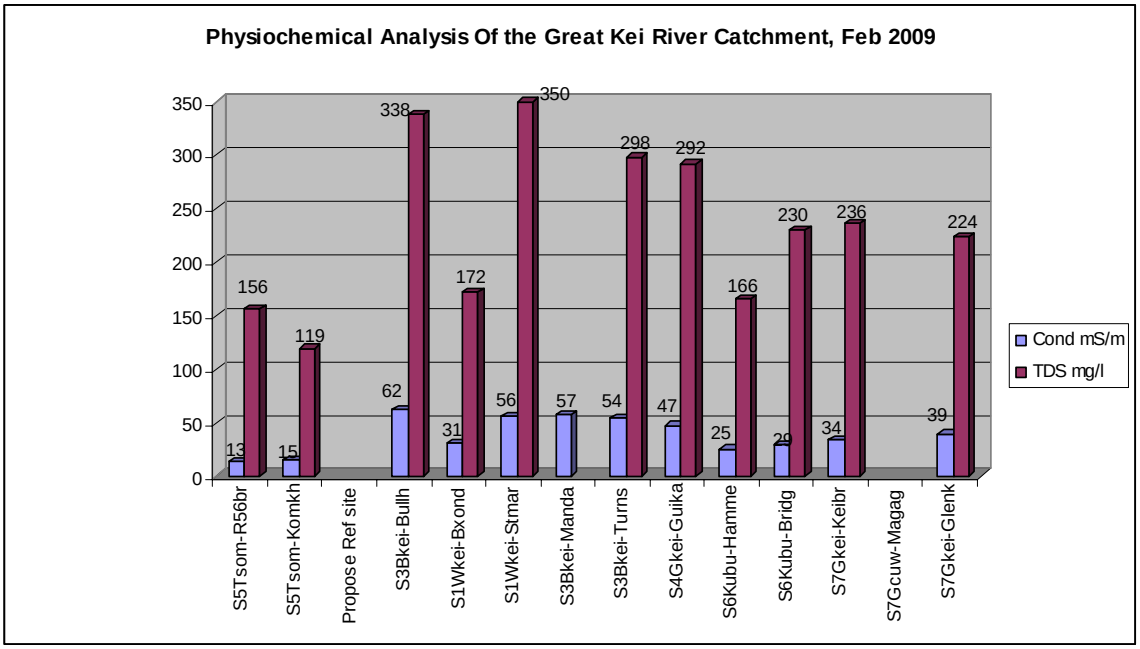


Figure. 12. Physiochemical analysis of the Kei River Basin (Conductivity and Total Dissolved Solids)

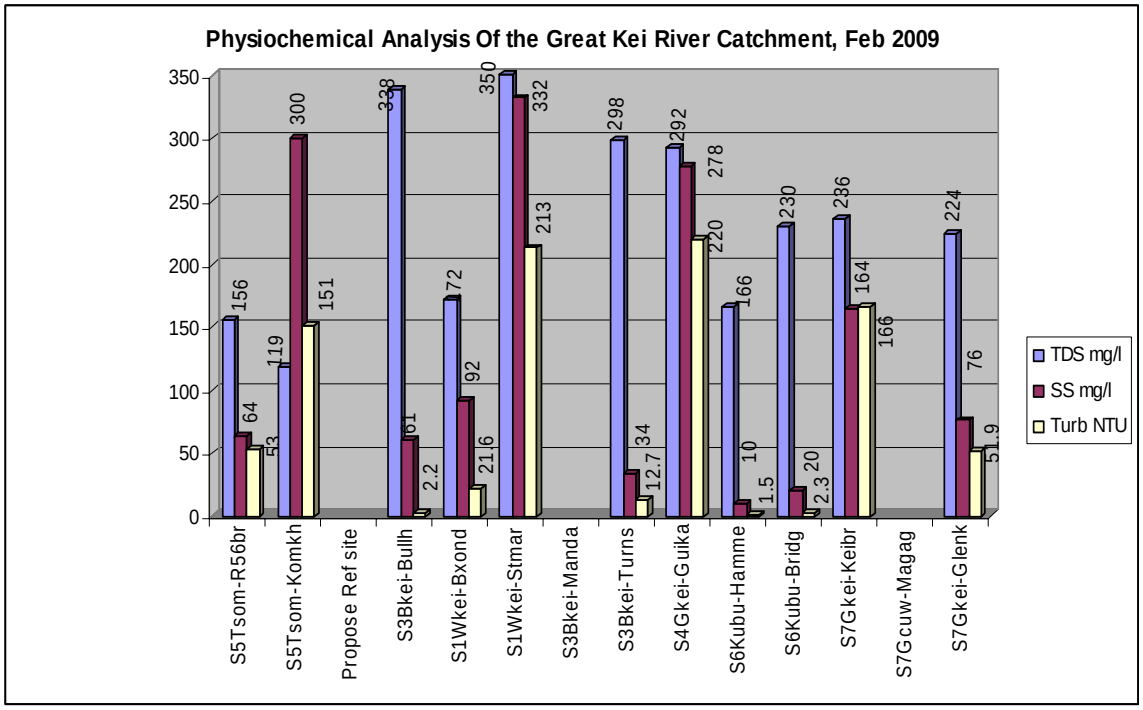


Figure. 13. Physiochemical analysis of the Kei River Basin (Total Dissolved Solids, Suspended Solids and Turbidity).

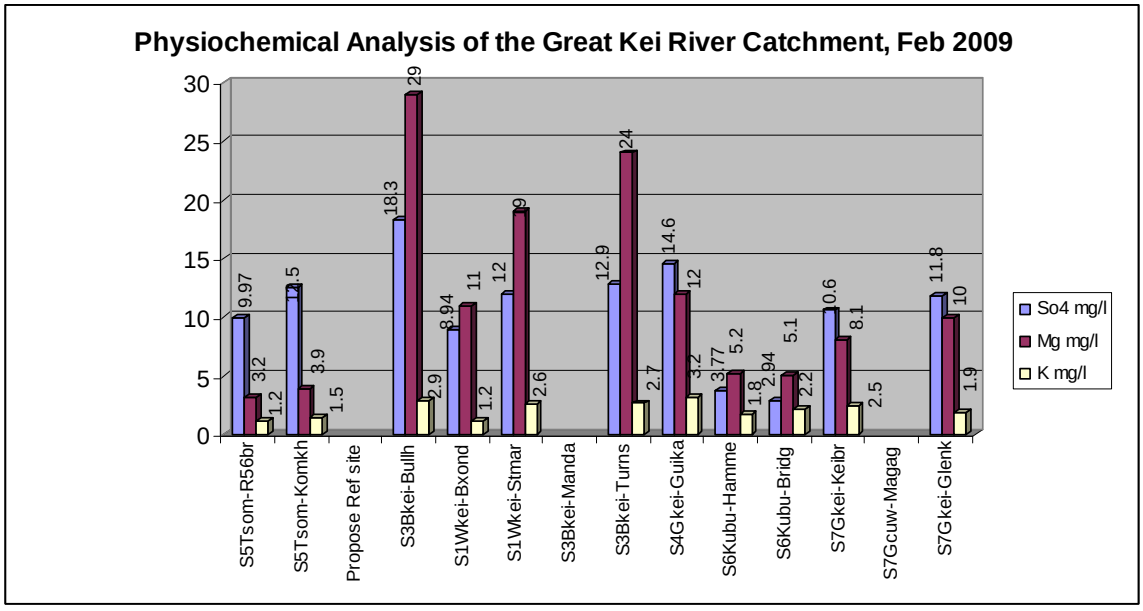


Figure. 14. Physiochemical analysis of the Kei River Basin (Sulphates, Magnesium and Potassium).

## TABLE I. MACRO INVERTEBRATES RESULTS USING SASS 5

| | Sass score | No. of Taxa | ASPT | Condition | Elevation (m) | GPS Coordinates |
|---|---|---|---|---|---|---|
| S5Tsom-R56br | 125 | 20 | 6.3 | Good | 1172 | S 31o 22' 05.4", E 27o 40' 16.7" |
| S5Tsom-Komkh | 107 | 16 | 6.7 | Good | 1110 | S 31o 36' 32.7", E 27o 40' 35.3" |
| Propose Ref site | | | | | | |
| S3Bkei-Bullh | 75 | 15 | 5 | Fair | 1102 | S 32o 02' 03.9", E 26o 39' 19.7" |
| S1Wkei-Bxond | 104 | 18 | 5.8 | Fair | 886 | S 31o 51' 18.9", E 27o 11' 22.5" |
| S1Wkei-Stmar | 61 | 14 | 4.4 | Poor | 767 | S 32o 00' 52", E 27o 22' 28.1" |
| S3Bkei-Manda | 132 | 24 | 5.5 | Fair | 754 | S 32o 10' 39.9", E 27o 14' 23.7" |
| S3Bkei-Turns | 146 | 26 | 5.62 | Fair | 670 | S 32o 11' 17.7", E 27o 22' 31.8" |
| S4Gkei-Guika | 129 | 21 | 6.14 | Good | 450 | S 32o 17' 01.1", E 27o 39' 02.2" |
| S6Kubu-Hamme | 149 | 26 | 5.7 | Fair | 635 | S 32o 33' 44.5", E 27o 37' 13.4" |
| S6Kubu-Bridg | 245 | 37 | 6.6 | Good | 439 | S 32o 30' 26.0", E 27o 43' 53.4" |
| S7Gkei-Keibr | 146 | 20 | 7.3 | Natural | 148 | S 32o 30' 33.7", E 27o 59' 06.8" |
| S7Gcuw-Magag | | | | | | |
| S7Gkei-Glenk | 188 | 31 | 6.1 | Good | 65 | S 32o 32' 41.3", E 28o 11' 37.9" |

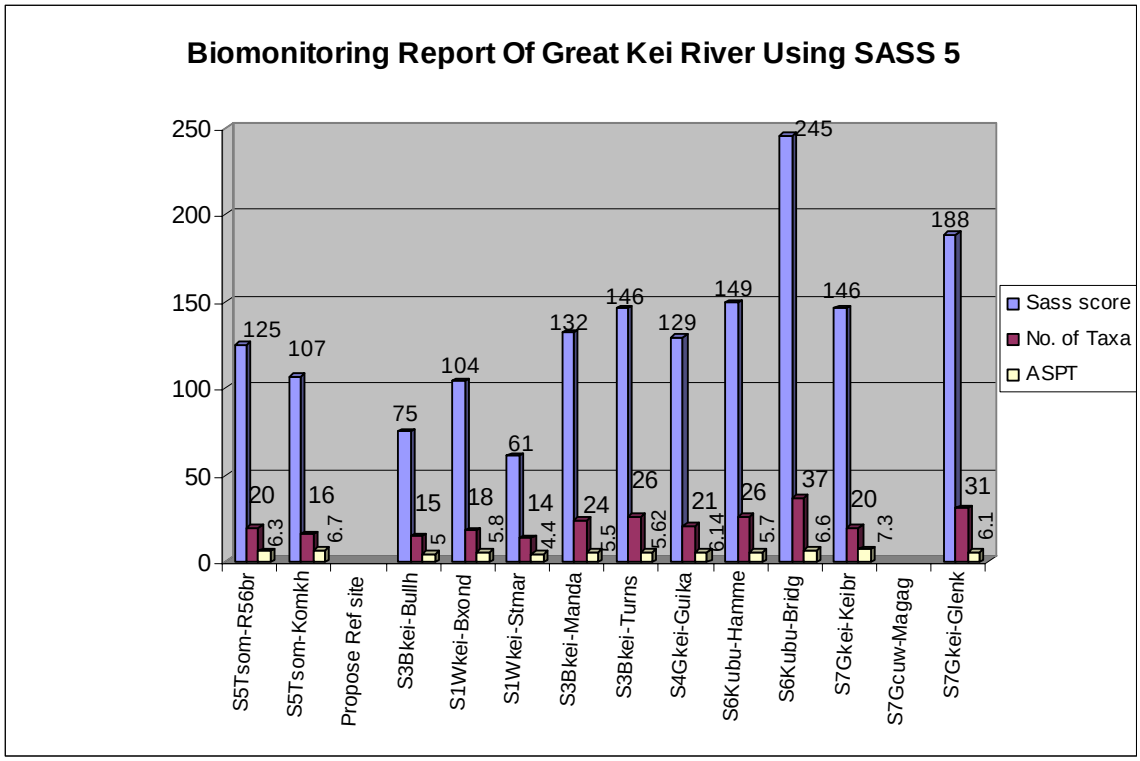


Figure. 15. SASS5 results of macroinvertebrate biomonitoring of the Kei River Basin.

## FISH

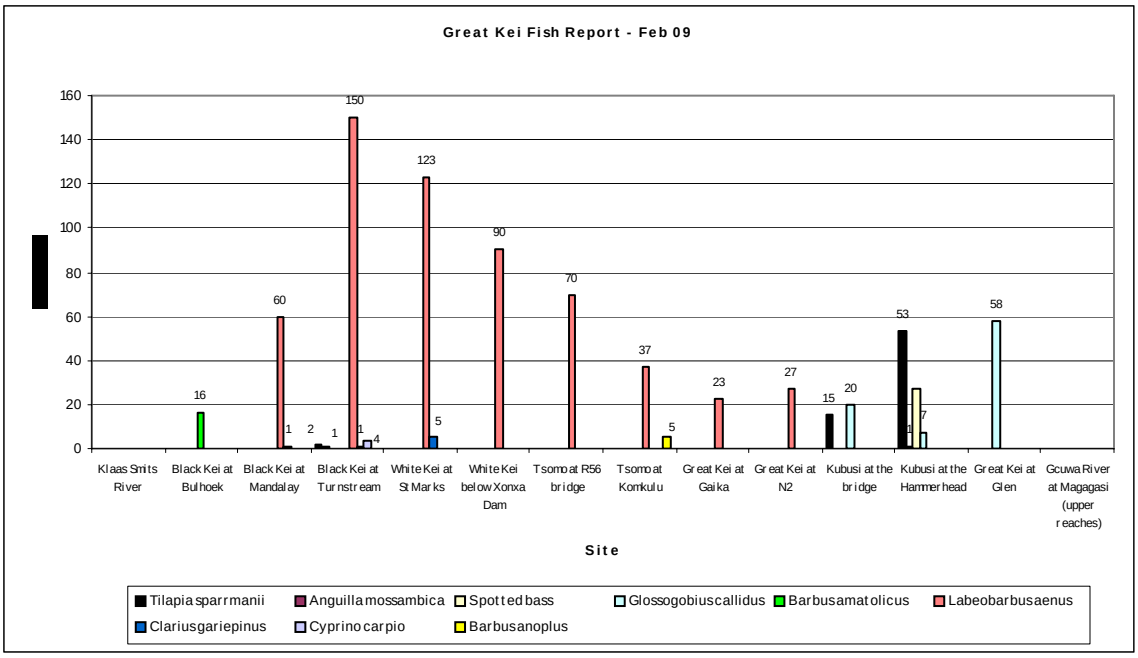


Fig 16: Histogram indicating the fish species distribution within the Great Kei River.

Table II: Illustrating the results of Fuzzy Fish Index (FFI) on the Kei River Basin.

| **DATE** | **SITE** | Fuzzy Fish Index (FFI) | **COMMENTS** |
|---|---|---|---|
| 02-02-09 | Klaas Smits River | - | Site dry. This site was not in ground-truthing survey, but was a proposed site for assessing upper reaches of the Black Kei for reference. No assessment done. |
| 02-02-09 | Black Kei at Bullhoek | C | Flows low and shallow. Sedimentation, due to erodability of the soil type. Site not good fish habitat due to sedimentation. Few significant pools where indigenous *B. amatolicus* were caught. |
| 02-02-09 | Black Kei at Mandalay. | E | Good pools, fast flows, bedrock and vegetation characterized the site. Smallmouth yellowfish and catfish led to the E. No indigenous fish caught. |
| 03-02-09 | Black Kei at Turnstream | D | Boulders, bedrock, vegetation and pools characterized the site. Indigenous knowledge expected carp, doubted on tilapia, yellowfish, barbs and eel. Indigenous knowledge confirmed by sampling fishes acknowledged were caught except barbs. Predation on indigenous is likely to happen, hence none of them were captured and D class. |
| 03-02-09 | White Kei below Xonxa Dam. | E | Although secondary channel and backwater were present, no barbs were caught. Only yellowfish found. |
| 04-02-09 | White Kei at St Marks | E | Bedrock and sediments, not suitable for barbs. Only yellowfish and catfish caught. |
| 04-02-09 | Tsomo at Komkhulu | E | Fast flows, sedimentation and bedrock dominating. Only yellofish caught. |
| 04-02-09 | Tsomo at R56 | D | Backwaters, bedrock, boulders, vegetation, fast and slow flows all are features of |

| | | | |
|---|---|---|---|
| | bridge | | this site and it is suitable for yellowfish and barbs, which were caught. |
| 04-02-09 | Gcuwa River at Magagasi | - | We did not work because the river was poor condition. Sedimentation dominated and the water very turbid. This site was not in ground-truthing survey, and it was done during the day of biomonitoring. |
| 04-02-09 | Great Kei at Glen | D | Bedrock and sedimentation (massive sand on riparian zone). Only indigenous goby caught. This site was not in ground-truthing survey, and it was done during the day of biomonitoring. |
| 05-02-09 | Great Kei at Gaika Fort | E | Most cobbles out of current, bedrock and sediments dominant. Yellow and catfish caught. |
| 05-02-09 | Great Kei at N2 | E | Secondary channel formed. Sediments and cobbles. Only yellowfish. Seine net used. |
| 07-02-09 | Kubusi at the Bridge | D | Bedrock, boulders, cobbles, pools and vegetation characterized the site. Water colour clear. Only gobies and tilapia were caught. SASS tempted to label this as reference site due to NATURAL conditions (high ASPT score). High D (57.1 % FFI). |
| 07-02-09 | Kubusi at Hammerhead | D | Bedrock, boulders, pools and vegetation characterized the site. Water colour clear. Only gobies, bass, eel and tilapia were caught. Site ecologically polluted due to dominant bass. |

## CONCLUSIONS

The Great Kei River survey was conducted from the Upper reaches to the Lower reaches although other recommended sites could not be assessed due to their 'poor' conditions for assessment. Using the GA index, it could be noticed that fluvial geomorphology of the river system gradually changes from the upper reaches with small developments, to the middle and lower reaches. For instance, both the Tsomo Bridge and the Black Kei (both in upper reaches but in different Ecoregions) are on its near natural condition (Figure 11). The results also show that the river system geomorphology immediately changes below the Dam. For example, the Kubusi at Hammerhead and the White Kei below Xonxa Dam both have C class. In addition, the river recuperates as it flows downstream, provided there are minimal anthropogenic landuse practices that occur. The gradual recovery of the Kei River from C class below the Xonxa Dam to B/C in St. Marks and C class at Kubusi River below Wriggleswade Dam to B class at Kubusi Bridge. While the river system starts to recover, (B Class), other landuse activities originate upstream of the Kei River Bridge (e.g. built up areas, cultivated areas, weirs, and bridges). The GA index reveals that the river at the Kei Bridge reach becomes a C class, until it reaches the Glen site above the estuary.

In terms of Water Quality, the results show that most affected parts are those located in a Drought Corridor Level I Ecoregion and in the Tarkastad Formation (geology) where the soil types are generally poor and easily eroded, especially if there is a lot of vegetation removal. For example, the Black Kei at St. Marks and has the greatest

percentage of Total Dissolved Solids (TDS: 350mg/l) as compared to any other site. This can be due to the fact that the site also experiences a lot of vegetation removal from both the hillslope and the riparian zone. On the other hand, the White Kei at Hammerhead has only 166mg/l as compared to that of the Black Kei a St. Marks though both the sites are located approximately on the same altitude above sea level, same ecoregion (Drought Corridor), same geological formation (Tarkastad), same vegetation type (Valley Thicket), same rainfall per year (500 – 650mm per annum). The differences are mainly landuse, whereby the Black Kei at St. Marks is characterized by the formal township and degraded vegetation, while the White Kei at Hammerhead is located where there is indigenous vegetation and some game farming. Therefore in the latter no erosion/ deposition in the river channel is expected. Interestingly, the Black Kei at St. Marks is located in the former Ciskei area while the White Kei at Hammerhead is on the former Republic of South Africa. Generally, the physico-chemical analyses show that the water quality of the Great Kei River Basin is 'fair' in the upper reaches, becoming poor in the middle reaches where a lot of anthropogenic activities occur, and gradually improves downstream, but disturbed by the contribution from the Gcuwa River downstream.

The SASS5 invertebrate data (Table I) shows that the Great Kei River Basin was in good condition in the upper reaches, becomes fair to poor in the middle reaches and improves in the lower reaches. Again the impacts of the Gcuwa River tributary can be noticed. For instance, the Great Kei at N2 Bridge was in a natural state that Great Kei at Glen that dropped to a good state. (Table I).

In terms of the fish data, it could be noticed that the Great Kei River Basin the whole catchment is dominated by an alien yellow fish hence most of the sites are in E –class. The indigenous species were mainly caught on the 'near natural, sites like the Tsomo Bridge (Table II). The indigenous species were mainly caught where no significant changes in the geomorphology and water quality of the river. For example, the *Barbus amatolicus* was caught at Black Kei at Bulhoek (upper reaches). It can be observed that the middle reaches of the Great Kei River Basin are in a poor ecological state in terms of fish. In fact no indigenous species were caught on the middle reaches where most human landuse changes occur, accompanied by the alien fish invasion. The indigenous fish species were also caught in the lower reaches where the river starts recovering from most perturbations (landuse and alien invasion). For example, a lot of the species of

*Glosogobius callidus* were caught in the Kei River at Glen Figure 16) though none were found on the Kei Bridge site probably due to yellowfish invasion together with deprived migration of fish by the upstream weir and bridges.

Generally speaking, most affected sites are those located on poor soils and vegetation and especially on the former Transkei and Ciskei areas where environmental management strategies and education could be poor. In addition, the site located in the Drought Corridor Level I Ecoregion with poor vegetation cover were most affected than their 'richer' counter parts (compare White Kei at St. Marks and the Black Kei at Turnstream).

**SUMMARY OF THE GREAT KEI RIVER SURVEY**

The figure below shows a summarised geomorphological survey of the Great Kei River Basin

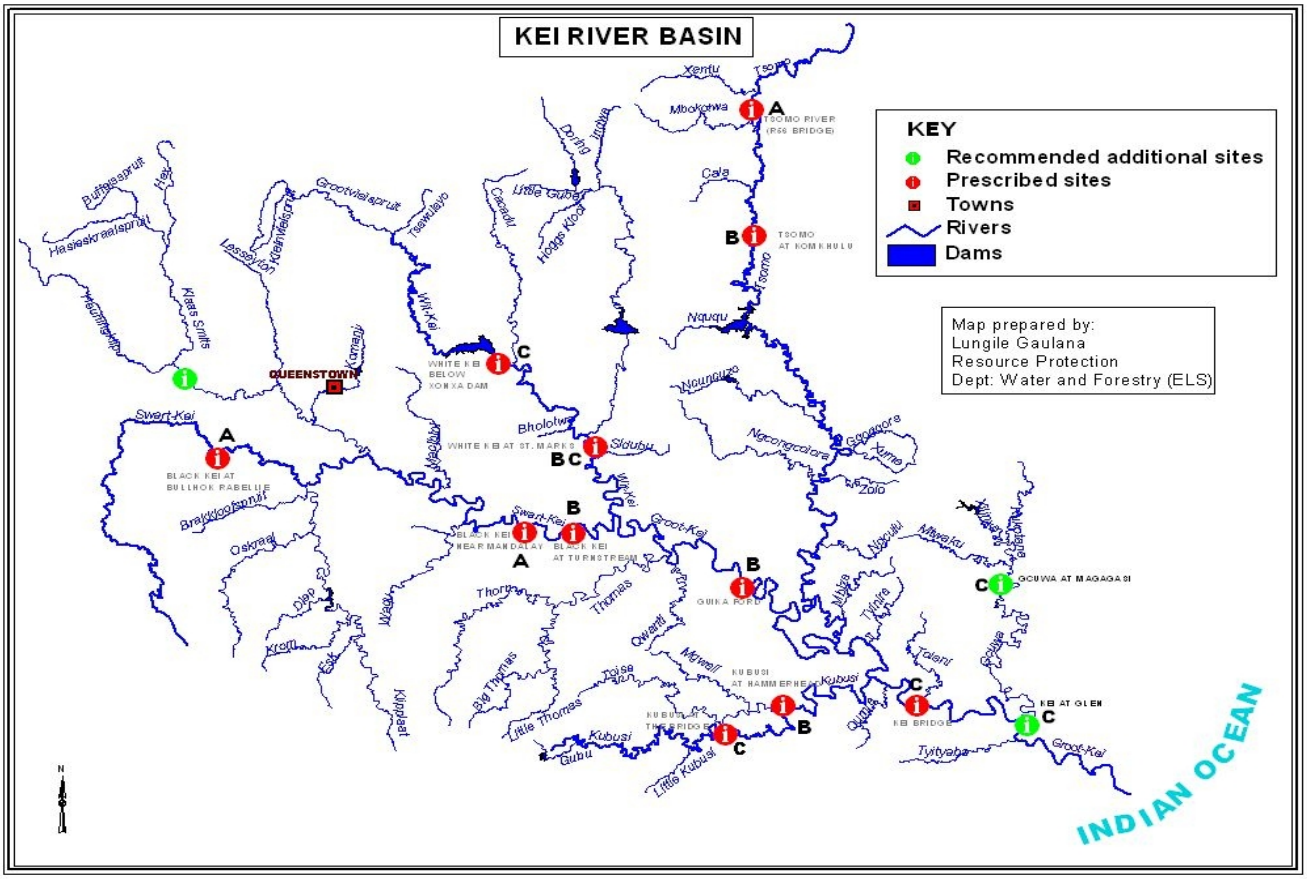


Figure17. Summary of the Kei River Basin survey (Geomorphology)

TABLE III: A summary of the Kei River Basin survey (all the components assessed)

| SITE | GEOMORHOLOGY | WATER QUALITY | INVERTEBRATES (SASS 5) | FISH (FAII) | OVERALL |
|---|---|---|---|---|---|
| Tsomo at R56 Bridge | A | C | Good | D | Good+ |
| Tsomo at Komkhulu | B | C | Good | E | Fair+ |
| Klass Smith tributary | No assessment | C | No assessment | No assessment | Poor |
| Black Kei at Bulhoek Rabelle | A | C | Fair | C | Fair+ |
| White Kei below Xonxa Dam | C | C | Fair | E | Poor+ |
| White Kei at St. Marks. | BC | NC | Poor | E | Poor |
| Black Kei near Mandalay | A | C | Fair | E | Fair |
| Black Kei at Turnstream. | B | C | Fair | D | Fair |
| Great Kei at Gaika Fort. | B | NC | Good | E | Fair |
| Kubusi at Hammerhead | C | C | Fair | D | Fair+ |
| Kubusi the Bridge | B | C | Good | D | Good |
| Great Kei at N2 Bridge | C | C | Natural | E | Fair |
| Gcuwa at Magagasi | C | No assessment | No assessment | No assessment | Fair- |
| Great Kei at Glen | C | C | Good | D | Fair |

**OBSERVATIONS AND DISCUSSION**

1. Black Kei at Turnstream can be considered as a reference condition of White Kei at St. Marks due to the following reasons:

- Both of them are within the similar altitude above sea level.
- Both of them are located in the same ecoregion (both Level I and II Ecoregions).
- Both of them have the same Potential Natural Vegetation type.

- Both of them have similar rainfall (mm per annum) and similar rainfall seasonality.
- Both of them have the same geological and soil formation.

But White Kei at St. Marks has a very poor condition than Black Kei in Turnstream. It could be observed that this could be due to different landuse practices of which the White Kei at St. Marks is located in the former Ciskei, while the Black Kei at Turnstream is located in the former Republic of South Africa. Therefore the interaction between people and the environment cannot be ignored.

2. Impacts of the dam could be clearly assessed for all the ecosystem components assessed (Geomorphology, Water Quality, Invertebrates and Fish). This can be shown by these following summarized results in the Kubusi River (Table IV below).

TABLE IV: Comparison between Kubusi at Hammerhead (closer to the Dam) and Kubusi at the Bridge (little further from the Dam).

| KUBUSI AT HAMMERHEAD | KUBUSI AT THE BRIDGE |
|---|---|
| **1. Geomorphology:** C class | **1. Geomorphology:** B |
| **2. Water Quality:** (TDS, mg/L) 166 | **2. Water Quality:** (TDS, mg/L) 230 |
| **3. Invertebrates:** SASS5: Fair | **3. Invertebrates:** Good |
| **4. Fish:** Indigenous *Glossogobius spp.* 7 | **4. Fish:** Indigenous *Glossogobius spp.* 20 |

Therefore the river gradually improves further below the Dam.

**RECOMMENDATIONS**

- Hydrology data and assessment is required as one of the vital drivers of the ecosystem, mainly environmental flows.
- The need for riparian vegetation assessment (VEGRAI model or Riparian Vegetation Index?).
- Requirements for the reference site for the Drought Corridor Level I Ecoregion. This can be found (hopefully) on the Upper reaches of the Indwe River, the Grootvleispruit, the Oskraal and the Upper Reaches of the Black Kei.
- Requirements for the reference site for the South Eastern Uplands Level I Ecoregion. This can be found (hopefully) on upper reaches of the Tsomo River,

the Krom River, the Esk, the Klipplaat, the Thomas, the Mgwali and the Qwanti rivers.

- Requirement for the assessment of  the assessment of the Eastern Coastal Belt Level I Ecoregion, e.g. estuary and wetlands (if any).

When these requirements are not met, the aerial photographs of the earliest decades as possible can be used. This data can be meaningful only for geomorphology and the riparian vegetation.

- Rehabilitation measures on affected areas could serve as an advantage. For example, construction of gabion walls in the catchment with high erosion potential and reforestation of areas with high vegetation removal.
- Community Based Natural Resource Management (for the interested and Affected Parties. This would include the involvement of local communities and securing the rights of poor and marginalized groups in sustainable management of natural resources, that is, to include the use of indigenous knowledge in proper management of the natural resources.

- Environmental Impact Assessments (where development strategies are the priority along a river reach, e.g. where the dam need to be built). This would be an assessment of the possible impact (positive or negative) that a proposed project may have on the natural environment. The purpose of the assessment could be to ensure the decision makers to decide whether to proceed with the project.
- Environmental Education and awareness campaigns to the public and local schools. This could be the organized efforts to teach about how natural environments function and, particularly, how human beings can manage their behavior and ecosystems in order to live sustainably.
- Creation of buffer zones on the riparian zone and most sensitive areas. Geographic Information Systems could serve as a tool to support this by targeting areas with potential risks.

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